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Construction Logic of Design References in Vernacular Architecture: Case Study of Muğla Yeşilyurt Village, Turkey

Lógica constructiva de las referencias de diseño en la arquitectura vernácula: estudio de caso del pueblo Yeşilyurt en Muğla, Turquía

Sevda Duygu Kolbay ¹

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Abstract

Keywords:
vernacular architecture;
shape grammar;
ontological modeling;
morphometric comparison

Vernacular architecture incorporates characteristics that reflect local identity and are based on practical experience. It reflects the collective knowledge of communities that have adapted their construction traditions in response to local climates, materials and topography. The objective of this study is to interpret technical and cognitive values to analyze the local construction principles within a settlement pattern. An ontological model is used to define the design logic of vernacular architecture, identifying the rules and relations embedded in local construction practices. Architectural language has compositional principles that can be defined by a set of specific rules. Design references are transferred into procedural modeling through grammar-based algorithms. The literature demonstrates the use of shape grammar in analyzing traditional housing typologies and generating design parameters based on vocabulary, syntax, and semantics. Within this context, this research was conducted within a grammar-based framework that enables rule-based modeling of form generation and construction logic, derived from the morphological and syntactic parameters of the vernacular architecture of Yeşilyurt, Muğla, Turkey. Constructional identifiers are classified by analyzing material selection, detailing, dimensions and geometry as tools of ontological expansion. The field survey conducted in Yeşilyurt verifies the applicability of the approach, showing that shape grammar can connect vernacular identity with design logic. The results show that the algorithm adapts to different types of data and scenarios within local identity and supports the continuity of local practices.

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Resumen

Palabras clave:
arquitectura vernácula;
gramática de formas;
modelado ontológico;
comparación
morfométrica

La arquitectura vernácula incorpora características que reflejan la identidad local y se basan en la experiencia práctica. Refleja el conocimiento colectivo de las comunidades que han adaptado sus tradiciones constructivas en respuesta a los climas, materiales y topografía locales. El objetivo de este estudio es interpretar los valores técnicos y cognitivos para analizar los principios de construcción local dentro de un patrón de asentamiento. Se utiliza un modelo ontológico para definir la lógica de diseño de la arquitectura vernácula, identificando las reglas y relaciones integradas en las prácticas constructivas. El lenguaje arquitectónico posee principios compositivos definidos por un conjunto de reglas. Las referencias de diseño se traducen a un modelado procedimental mediante algoritmos basados en gramática. La literatura demuestra el uso de la gramática de formas en el análisis de tipologías tradicionales y en la generación de parámetros de diseño basados en vocabulario, sintaxis y semántica. En este contexto, la investigación se realizó dentro de un marco basado en gramática que permite el modelado por reglas de la forma y la lógica constructiva, derivadas de los parámetros morfológicos y sintácticos de la arquitectura vernácula de Yeşilyurt, Muğla, Turquía. Los identificadores constructivos se clasifican analizando la selección de materiales, detalles, dimensiones y geometría como herramientas de expansión ontológica. El trabajo de campo en Yeşilyurt verifica la aplicabilidad del enfoque, demostrando que la gramática de formas conecta la identidad vernácula con la lógica del diseño. Los resultados muestran que el algoritmo se adapta a distintos tipos de datos y escenarios dentro de la identidad local y apoya la continuidad de las prácticas tradicionales.



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¹ Assistant Professor, Department of Architecture, Faculty of Architecture and Design, Istanbul Gedik University, Istanbul, Turkey. Contact email: duygu.kolbay@gedik.edu.tr

1. Introduction

Vernacular architecture, characterized by natural and human factors over long periods, reflects the geographical features and local traditions of settlements. Design values specific to the place define the identity of vernacular architecture. While the local building culture fulfills the need for shelter through the accumulated knowledge and experience of society, it simultaneously becomes a marker of local identity. Culture encompasses everything that humankind has developed in the context of things created by nature (Güvenç, 1991). At this point, identity is the society's means of expressing its presence in the constitution of buildings and settlements. Identity is the status of a specific character, a distinctive concept, and being recognizable among the objects (Lynch, 1981). The relationship between identity and culture is linked to the concepts of image and perception. As Rudofsky (1964) stated in 'Architecture without Architects', vernacular architecture does not go through fashion cycles. It is nearly immutable, indeed, improvable, since it serves its purpose to perfection. While traditional values that remain constant define 'vernacular identity', the transformation of settlements reflects a continual pursuit of development. Rapoport (1990) argues that in vernacular design, meaning is the most important aspect of the built environment. It is stated in his analyses that status-indicating elements such as the type of dwelling, size of house and of spaces, decoration, kind of wall cavities and protrusions, and degree of elaborateness have been preserved over time. On the other hand, innovative measures like the use of modern materials such as cement and the introduction of appliances, piped water, and electricity that were absent in traditional dwellings include the pursuit of adapting to the conditions of modernity. Norberg-Schulz (1991) addresses site specific characteristics phenomenological in connection with the concept of 'genius loci'. He anticipates the belonging of characteristic features of a built environment to the place it is present in existential terms as an inevitable need. The continuum of identity may be ensured through construction belonging to the "place." The determinants of the sense of a specific place are the reflections of natural, physical, and social realities. All these cannot be considered elements apart from each other. The qualification of culturally adapted architecture is an inseparable whole with the tradition (Pallasmaa, 1988). A set of features defining the place symbolizes the image in the physical, structural, and cultural environment.

Numerous research and documentation projects have been developed to identify and interpret vernacular identity through systematic recording and classification methods. Initiatives such as the Cultural Heritage Inventory frameworks in Europe (Council of Europe, 2001), the Vernacular Architecture Survey Programs in the United States (Glassie, 2000), and the regional documentation systems developed by UNESCO and ICOMOS (2013) have established methodological standards for identifying settlement character and construction typologies across environmental, social, and material dimensions. Within this global framework, the documentation and interpretation of vernacular identity in Turkey have been institutionalized through research programs such as the TÜBA-TÜKSEK inventories (Akin & Akin, 2002) and Ministry of Public Works and Settlement Vernacular Architecture Identity Projects (Çorapcıoğlu et al., 2008). Such inventory models transform qualitative field observations into structured databases that reveal the morphological and syntactic rules governing local architecture and enable comparative studies between different cultural contexts. These studies contribute to the broader discourse by providing a reproducible model for integrating environmental, socio-economic, and constructional parameters into the definition of local identity.

The primary objective in determining local architectural identity features is to ensure the sustainability of the identity of construction by preserving the character of settlements that emerge through local distinctions. Collection of reference information based on natural environment data of the rural texture and socio-cultural and socio-economic data is a way for the constitution of a base by identifying the rule groups in the design process. In the data collection stage, the expectation is to determine the basic elements generating the structural formation of the buildings and the comprehension of their orders and hierarchies. The data obtained from inventory forms provides a knowledge base on rural landscape character, properties of settlement and texture, rural construction techniques, and dwelling typology. In this context, cultural landscape inventories provide structured frameworks for recording, organizing, and interpreting complex spatial and cultural data, forming a methodological basis for heritage analysis and classification (Fernández Cacho, 2023). Therefore, vernacular architecture typologies constitute reference for the designs in terms of size, ratio, shape, material decisions, detail layering and structural organization. These features can be systematically recorded through inventory forms (Table 1).

Table 1. The rural inventory form for the determination of settlement and building identity

VERNACULAR INVENTORY			Structure		Inventory number:	
Settlement name:			Province:		Town:	
ENVIRONMENTAL DATA THAT AFFECTED THE SETTLEMENT ESTABLISHMENT						
Settlement Location:		☐ Coastal Settlement ☐ Plain Settlement ☐ Mountain/Slope Settlement				
Topographic Situation:		Altitude:	Climate Features:		Temperature Averages:	
Prevailing Wind:		Precipitation:	Landscape:		Flora:	
SOCIAL/ECONOMIC DATA THAT AFFECTED THE SETTLEMENT ESTABLISHMENT						
Infrastructure:		Construction Resources:		Demographic Structure:		
☐ Energy Potential		☐ Agriculture		Settlement Texture:		☐ Row Housing
☐ Transportation		☐ Livestock				☐ Detached Housing
☐ Water		☐ Tourism				☐ Grid Plan
☐ Heating		☐ Handicrafts				☐ Organic Plan
☐ Electricity				Common Service Unit:		☐ Water Supply
☐ Telephone						☐ Furnace/Oven
						☐ Mill ☐ Storage ☐ Atelier
CONSTRUCTION TECHNIQUE FEATURES						
Construction Date:		Using Status:				
Originality Status:		Health Status:		Plan Type:		☐ Plan W/O Sofa
						☐ Plan W/ Inner Courtyard
						☐ Plan W/ Outdoor Sofa
						☐ Plan W/ Outdoor, Center Sofa
						☐ Plan W/ Indoor, Center Sofa
						☐ Basement
						☐ Ground Floor
						☐ 1st Floor
STRUCTURE SYSTEM	BUILDING MATERIAL	CONSTRUCTION TECHNIQUE	BUILDING SUPPORT SYSTEM	FINISH DETAILS		
Masonry	Soil	☐ Plain Knit	☐ Roped	☐ W/O Brace	☐ Plastered	☐ Unplastered
		☐ Seam Knitting	☐ Stone			
	Stone	☐ Dry	☐ Wood	☐ W/O Bond Timber		
		☐ Rubble ☐ Mosaic	☐ Composite			
Wood	☐ Direction	☐ Rope				
		☐ Cutting	☐ Stone			
			☐ Wood			
Framing	Wood	☐ Adobe Filled	☐ Cross Supported	☐ Unsupported	☐ Coated	☐ Uncoated
		☐ Stone Filled			☐ Plastered	
		☐ Brick Filled				
Cantilever Type:	☐ Wood ☐ Stone ☐ Metal		Console Distance:			
Type Of Flooring That Sits on The Floor:	☐ Stone Coated	☐ Wood Veneered	Mezzanine Flooring Type:	☐ Floor Ceiling Cover. Wood	☐ Cobble Stone	☐ Floor Ceiling Covered
Roof Shape:	☐ Straight ☐ Crushing		Roofing Material:		☐ Soil	☐ Masonry
	☐ Crib ☐ Vault				☐ Wood	☐ Other
	☐ Dome ☐ Other					
Window Size:	Number of Wings:		Lintel:	☐ Wood ☐ Stone		
Door Size:	Number of Wings:		Lintel Height:	☐ Stone Arch		
Stair Carriage:	☐ Supported		☐ Built-In	Riser Size:		

Source: Inventory form was drawn up by taking the TUBA Culture Inventory of Türkiye (Akın & Akın, 2002) and the basis of the Project of the Determination of Vernacular Architecture Identity (Çorapçıoğlu et al., 2008) as models.

In this research, the inventory model was adapted as an analytical and generative tool supporting the ontological framework. A descriptive information record classifies data into morphological (form and proportion), syntactic (composition and organization), and constructional (material and technique) layers. This three-tiered structure defines rule sets that govern the local design logic and enables their integration into an ontological model. The characteristic features of construction form the identity and design language of vernacular architecture. Interpreting the design language of the settlement requires an ontological approach that analyses the interaction of components across multiple layers. Ontology establishes how design scope and constraints are modeled, functioning as a dynamic knowledge base (Obitko et al., 2004).

Language is a string of indicators, and each indicator operates as a coded sign within the morphological hierarchy. The components of structure and their interaction rules are encoded through the shape grammar method, making implicit spatial knowledge explicit.

Local construction principles, which transform into tradition in a long period, constitute an algorithmic method for generative design. In the discipline of architecture, language, communication's main medium of expression, is identified with the features of structure such as shape, form, colour, and texture. The rules of composition -making the distinctive features of vernacular architecture identity visible- reveal the language's grammar. Within the frame of shape grammar, analyses are performed at morphological, lexical, syntactic, semantic, and performative levels (Kunkhet, 2015). Defining meaning as an "indicator" within the design language of vernacular architecture introduces a semantic reading that bridges morphology and syntax.

At the syntactic level, the design principles shaping composition become visible through rule-based structures. "Material selection" and "Detailing" define the attributes, while "Compositional rules" determine the formation logic of the architectural form. The study constructs a semiotic and morphometric analysis of compositional diversity in vernacular architecture. This hypothesis is verified by studying the distinctive local characteristics of the neighborhood of Yeşilyurt in Muğla. Within this scope, rule-based codes were derived from design and construction data classified in the ontological model, and their validity was verified through morphometric comparison.

2. Literature review

Vernacular architecture represents a tangible synthesis of environmental adaptation, constructive knowledge, and social organization. It embodies the cultural memory and identity of place, extending beyond its formal or stylistic features. Research on this multi-layered phenomenon has increasingly focused on issues of identity representation, conservation, and the reproduction of traditional logic in design. The introduction of the shape grammar approach has provided a systematic means to analyze and regenerate the underlying rules of vernacular form. By defining generative principles rather than static geometries, shape grammar allows architectural identity to be expressed as a reproducible and measurable system of form, proportion, and order. This linguistic analogy between design and grammar traces back to Noam Chomsky's (1956) formal grammar theory, which described language as a finite set of rules capable of producing infinite expressions. In architecture, this idea has evolved into the reading of built form as a structured syntax (Stiny, 1980), where rules operate as both descriptive and generative devices (Knight, 1999).

One of the pioneering studies in this field is the research conducted by Gülsün Çağdaş (1996), which analyzed the formal language of traditional Turkish houses. Çağdaş modeled plan types, spatial arrangements and proportional relationships within a rule-based system, thereby transforming the formal language of vernacular domestic architecture into a structured framework. Subsequent studies have approached shape grammar as a descriptive tool for a generative design method. Banu Çolakoğlu (2005) transformed shape grammar into an innovative design tool by relating the formal configuration of Hayat Houses to modern housing types. This approach reinterprets and regenerates vernacular architecture within a contemporary context by identifying and adapting its underlying generative logic.

Similarly, Said and Embri (2008) analyzed traditional long-roof house types in Malaysia using a parametric shape grammar approach. In their study, regionally distinct variants were generated using rules based solely on roof forms and proportional relationships. This example demonstrates how shape grammar can represent cultural identity by focusing on specific architectural elements, such as the roof or façade, as generative components. Angelo, Ferschin and Paskavela (2012) carried out another study using shape grammar to document and analyze heritage buildings. The study proposed a rule-based model for transferring typological information from historical structures to a digital environment. It showed that shape grammar could bridge the gap between architectural conservation and design.

Another study that systematically addresses the relationship between cultural identity and spatial organization is that conducted by Eilouti and Shaar (2012) on traditional Damascene houses in Syria. They defined the relationships among courtyards, iwans, rooms and transitional spaces through sets of generative rules, thereby enabling the spatial logic to be reconstructed as an expression of cultural representation. Stouffs and Tunçer (2015) proposed a generative method for historical architecture, integrating typological descriptions with the logic of shape grammar. They argue that a rule-based approach that can be used to reproduce historical patterns in contemporary designs.

More recent studies have integrated shape grammar with digital technologies and data-driven modeling approaches. Fan, Wang and Gong (2021) analyzed facade data obtained from laser-scanned point clouds using the layout graph model method. This demonstrated that rules applicable to shape grammar could be derived through data-based processes. Salik and Aykal (2023) analyzed the façade elements of traditional U-plan houses in Diyarbakır using genetic algorithms to transform shape grammar into a recommendation system operating at the subcomponent level. This study presents a novel approach that combines shape grammar with digital design processes to enable the automatic derivation of representational values. From a broader perspective, vernacular architecture functions as a carrier of cultural identity within rural settlements, where typological continuity and spatial organization play a defining role in sustaining local architectural character (Gómez Martínez et al., 2022). In this context, vernacular patterns can be interpreted, reproduced, and transformed within contemporary design environments through the generative language provided by shape grammar.

These works indicate that shape grammar has progressed from a descriptive method to a multi-layered analytical and generative framework, capable of integrating semantic, parametric, and morphometric data. It thus provides a coherent model for interpreting vernacular architecture as both a cultural expression and a structured design system.

3. Methodology

In architectural theory, design can be interpreted as a linguistic act in which formal components function as words, and structural order gains meaning through grammatical relationships. The theoretical foundation of this approach originates in linguistics. Chomsky (1956) proposed that language is governed by a finite rule set capable of generating infinite expressions concept that allows architectural forms to be read as structured syntax. Saussure's semiotic theory (Culler, 1985) further describes language as a system of signs formed through syntagmatic and paradigmatic relationships. When translated into architectural analysis, each building component can be interpreted as a lexical unit, while their composition forms the grammatical structure through which meaning is conveyed. Petrova and Pauwels (2021) interpret algorithmic rule sets as carriers of implicit design knowledge encoded within semantic networks. In vernacular architecture, this implicit knowledge manifests through proportional, dimensional, and spatial regularities that shape construction logic. This analogy forms the basis of the shape grammar approach in architecture.

In this study, shape grammar is applied as both an analytical and generative framework, integrating ontological modeling with *Morphometric Comparison (Geometric Variance Analysis)* to reconstruct the design logic of vernacular architecture. This dual-layered structure provides both interpretive depth and quantitative verifiability.

Within this approach, an ontological model was developed to classify architectural data across three analytical layers:

- Morphological: Form, proportion, and geometric attributes,
- Syntactic: Composition, spatial relationships, and typological organization,
- Constructional: Material, technique, and structural articulation.

During the analytical phase, field-based inventory forms were utilized, and in the synthesis phase, the observed data were reconstructed through rule-based formulations. Dimensional parameters such as wall-to-opening ratio, roof slope and space adjacency were defined, and the generative logic of local design was derived from these quantitative relationships.

According to Stouffs and Tunçer (2015), ontological models serve as meta-systems that express architectural identity through structured taxonomies. Ranjgar et al. (2024) emphasize that ontologies establish hierarchical and associative relationships linking qualitative descriptions with computational models. This integration transforms field observations into a formalized, comparable, and reproducible system of architectural knowledge.

Vernacular building traditions embody algorithmic reasoning formed through long-term repetition and adaptation. Within the framework of shape grammar, this reasoning becomes visible through the rules governing interaction and transformation among components. The process combines iterative grammar, which generates new configurations through sequential rule applications, and analytic grammar, which decodes existing structural relations (Knight, 1999). This dual mechanism allows the systematic reading of the form-space-material relationship and reveals its generative syntax.

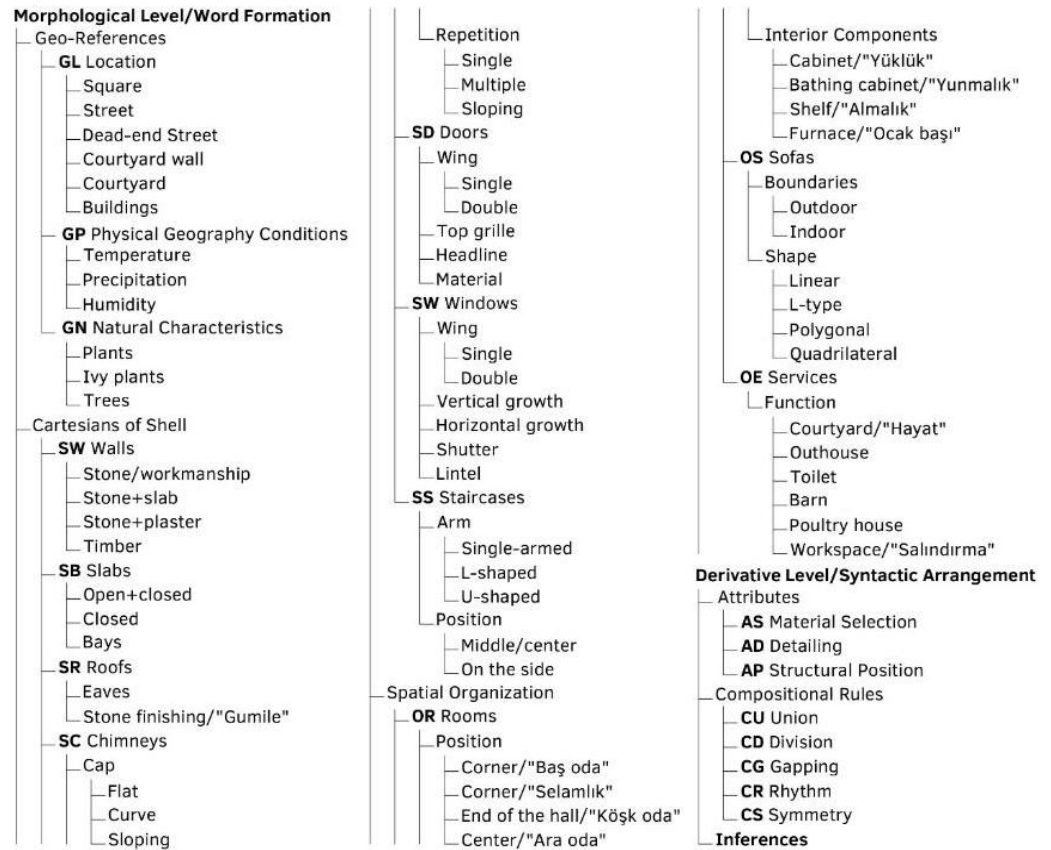
To minimize interpretive bias, a *Morphometric Comparison (Geometric Variance Analysis)* was integrated as a validation layer within the shape grammar framework. Each formal

element such as wall height-to-width ratio, window-to-wall ratio, plan module, and roof pitch was numerically measured and compiled into a morphological matrix (rows representing samples, columns representing dimensional attributes).

In this study, no direct numerical data are computed; instead, the focus is on formulating the coefficients that enable quantitative evaluation within architectural morphology and geometric pattern analysis. These coefficients are defined as rule-based parameters that can later facilitate the measurement of morphological consistency. By establishing the logical basis for quantifiable relations rather than producing numerical outputs, the study reinforces the reproducibility and transparency of the shape grammar methodology.

The integration of ontological classification and morphometric verification results in a transparent and reproducible methodological framework. The relationship between linguistic analogy, rule-based modeling, and geometric quantification transforms vernacular knowledge into a scientifically verifiable design system (Figure 1).

Figure 1. Grammar-based ontological workflow for vernacular architecture in Yeşilyurt (Muğla)



Source: Author, 2024.

3.1. Morphological Level /Word Formation

Building and environmental policies influence vernacular architectural styles. The components of vernacular architectural identity can be determined in line with data obtained from the structural, physical and natural environment. These qualifications are analyzed to provide an ontological analysis of the specific identity of the vernacular architecture in the Yeşilyurt neighborhood of Muğla.

At this level, morphometric comparison (geometric variance analysis) metrics (e.g., street width, parcel depth, wall height, roof pitch, window proportion) can be measured and transferred into a morphometric matrix as indicators of formal grammar.

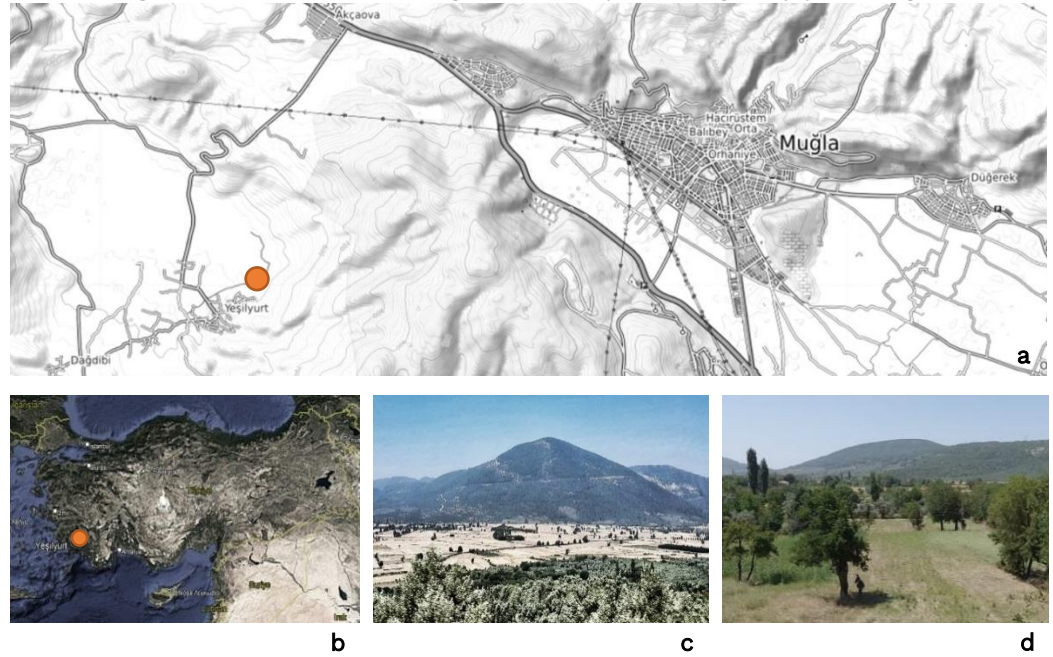
3.1.1. Geo-References

Rural buildings are sheltering areas that people have developed to adapt to their surroundings and sustain life under the conditions present at the time. For this reason, the physical and geographical features of a settlement represent the transformation of the natural landscape into a cultural landscape. The geo-references reflect the interaction between the buildings and the natural environment. GIS-based parameters, such as elevation, slope and aspect, can be extracted from digital terrain models. Ratios such as street width/wall height, plot coverage or slope gradient/building height can be defined to quantify contextual regularity. The Contextual

Fit Index ($CFI = \text{street width/wall height} \times \text{slope gradient}$) can be analyzed to reveal how the built form responds to topographical constraints.

Location [GL]: A location is a permanent and continuous feature of a settlement. The location affects microclimatic conditions depending on the topographical features. Site conditions determine the orientation of buildings. In rural areas, resource potential, transportation facilities and production activities determine the relationship between buildings and the topography (Aran, 2000). Performing an ontological analysis of the location makes all these design values apparent. Yeşilyurt is a neighborhood in the province of Muğla (Menteşe Belediyesi, n.d.). It is one of the rural settlements closest to the center of the province, at a distance of 15 km (ArcGIS Online, n.d.). In this area, where traces of the first settlements date back to after 1500 BC (T.C. Kültür ve Turizm Bakanlığı, n.d.) traces of the traditional landscape can be seen (Figure 2). The Yeşilyurt neighborhood, which covers an area of 12.20 km², is located to the south-west of the Yeşilyurt polje, which has a lowest elevation of 500 m above sea level. The surrounding agricultural areas are classified as ‘yayla’ (Ertürk & Atasoy, 2010).

Figure 2. Location and bounding limits of study area, Muğla Yeşilyurt Village



Source: a,b-Location of settlement on the maps; Menteşe Belediyesi, n.d., c,d- Surrounding landscape; Author, 2024.

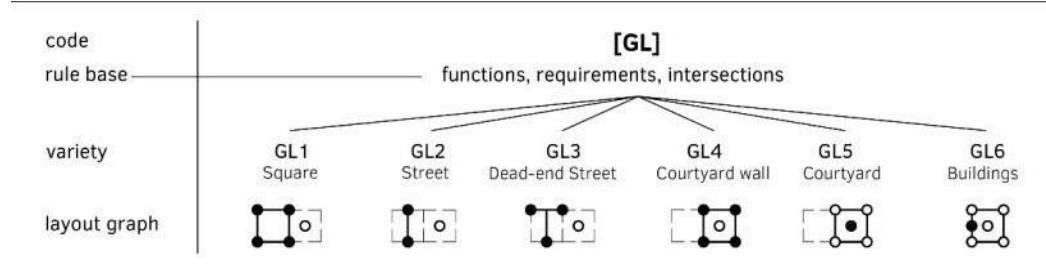
The settlement’s structure and texture consist of six significant elements: squares [GL1], streets [GL2], dead-end streets [GL3], courtyard walls [GL4], courtyards [GL5] and dwellings [GL6]. The dwellings are separated from each other by narrow streets and dead-end streets with gardens in front of them. Many of the dwellings are positioned adjacent to the garden wall and face south. Another reason for having high walls on the street side, besides privacy, is to ensure thermal comfort on the street, particularly in summer. The streets are unified by the whitewashed walls. The harmony of the tile roofs, genuine chimneys and doors on the street is remarkable. The position of neighboring buildings, as well as the shape of the plots on which they were built, were defined by a set of rules when designing the layout of the settlement (Figure 3). At this sublevel, the Spatial Orientation Ratio ($SOR = \text{façade azimuth/solar angle deviation}$) can be defined to evaluate the settlement’s climatic responsiveness. Building alignment variance can be analyzed to infer rule consistency.

Physical geography conditions [GP]: In his manifesto, ‘Form Follows Climate’ (Charles Correa Foundation, 2022), Correa deems climate to be the starting point of vernacular design. Similarly, Rapoport (1969) interprets the climate as a form-generating force. The main design input is the pursuit of local builders to enable the highest level of comfort with the fewest resources in the face of climatic problems. The main parameters that determine physical environmental conditions are air temperature [GP1], precipitation [GP2] and microclimatic effects caused by humidity [GP3].

Yeşilyurt, located close to the center of the Muğla province, exhibits characteristics of a Mediterranean climate. The summer months are arid and the winter months are rainy. Summer temperatures depend on the angle of the sun’s rays, and droughts depend on descending air movements. The precipitation observed in winter is cyclonic. Cyclonic rains are most prevalent in this climate. The highest annual average temperature was recorded in July at 26.7°C, and the lowest annual average temperature was recorded in January at 5.3°C. The neighborhood’s annual average relative humidity is 64.5% (Çevre ve Şehircilik Bakanlığı Muğla

Çevre ve Şehircilik İl Müdürlüğü, 2020). Climatic data influences numerous decisions, such as land use, building orientation, space design, and material selection.

Figure 3. Street and building patterns and vistas in location



Source: Author, 2024.

Thermal comfort indices (TCI) and wind exposure coefficients can be modeled using meteorological datasets. The correlation between roof pitch and rainfall intensity can be analyzed to test climatic adaptation. A Climatic Adaptation Ratio ($CAR = \text{roof slope} \times \text{eave depth} / \text{rainfall intensity}$) can be derived to evaluate performance against precipitation and solar gain. Lower CAR variability indicates high adaptation to regional climatic patterns.

Natural characteristics [GN]: The natural plant cover consists of short briars and scrubs. Around the highlands, Calabrian pines dominate, but cypress, sycamore, willow and olive trees also contribute to the diversity. Fruit trees are present in dwelling gardens. At highland level, plant species such as rosehip, blackberry, evergreen thorn, ivy and hackberry can be found (Ertürk & Atasoy, 2010) [GN1]. Moreover, semi-shaded areas are formed in courtyards by making use of the plant cover using winding grape vines on pergola structures [GN2]. Old sycamore trees surround the square in the Yeşilyurt neighborhood. The Calabrian pine, a species of the redwood family, is frequently encountered and has adapted to the region's climate. Olive, pomegranate and plum trees can be found in the courtyards [GN3].

Vegetation density can be derived from NDVI, while canopy diameter and distance-to-façade can be measured to model shading efficacy, which can then be related to window head height and eave depth. A Pergola Shading Coefficient ($PSC = \text{pergola depth} / \text{sofa width}$) can be expressed to evaluate semi-open comfort performance. A Courtyard Vitality Ratio ($CVR = \text{green courtyard area} / \text{plot area}$) can be analyzed against sofa typologies ($OS1/OS1'$) to evidence the ecology-space coupling.

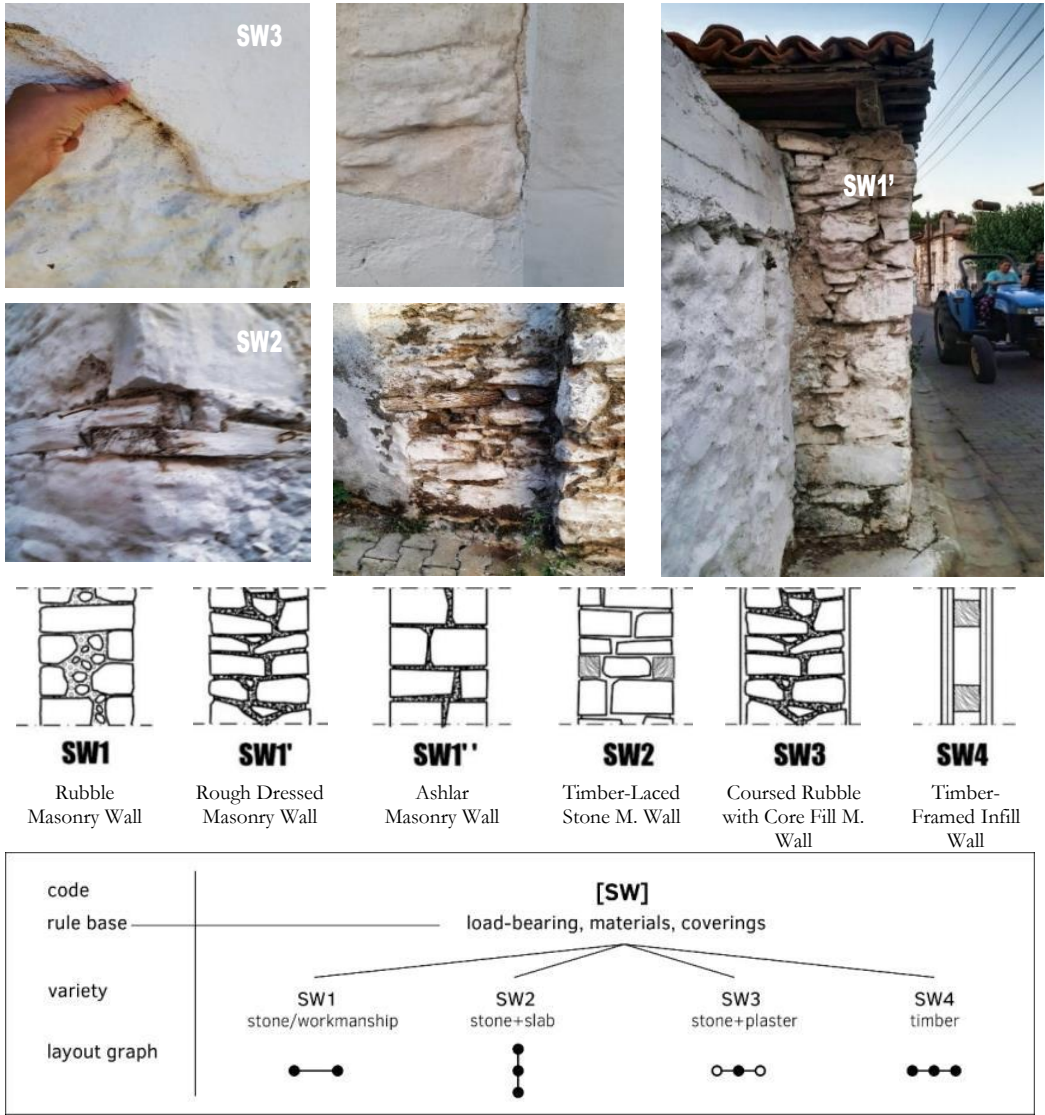
3.1.2. Cartesians of Shell

Building elements help to identify regional characteristics, either on their own or alongside their dominant features, which characterize the building. The building elements present in the façade's composition are effective in forming first impressions of the building. At this stage, the building elements that contribute to the formation of mass and environmental texture were analyzed and found to be grouped. In this context, the number of storeys, the ratio between building elements and façade organization, the height of walls, the width of roads and the position of buildings relative to the road all have a significant impact.

In traditional Yeşilyurt dwellings, the building is located on one side of the plot. The courtyard entrance and at least one side of the building are on the street boundary. This layout is the first

effective rule for the direction of the area and entrance. Access to the dwelling follows the route from the street through the private courtyard to the dwelling. The restrictive effect of the garden wall is dominant and inward facing. Few houses have windows facing the street, especially on the ground floor. Alongside single-storey buildings, most are two-storey dwellings with courtyards. The combination of the narrow streets, the garden wall, the main outer wall painted white and the tiled saddle roof creates a strong sense of harmony.

Figure 4. Wall types and coverings. SW1/rubble; SW1’/rough dressed; SW1’’/ashlar; SW2/timber-laced stone; SW3/coursed rubble with core fill masonry walls; SW4/ timber-framed infill wall



Source: Author, 2024.

At this level, dimensional and relational metrics (e.g., wall-to-roof ratio, window-to-wall proportion, floor-to-floor height) can be formulated. Coefficients of variation (CV) across these metrics can indicate rhythmic consistency and typological order.

Walls [SW]: In masonry construction systems, walls serve the functions of bearing and bordering. In vernacular architecture, the walls reflect the building’s outward orientation. Blind surfaces formed by garden walls separate the building from the street due to the need for privacy. In the Yeşilyurt neighborhood, buildings are typically two storeys high. In terms of ceiling height, an equivalent clearance of 2.20-2.50 m is noted at the lower level, and 2.50-2.80 m at the upper level. Regarding wall construction, masonry is used on the ground floor and masonry, and wooden carcass walls are used on the upper floor (Figure 4). The buildings often have a square or rectangular plan. The masonry walls, which are compactly filled in the direction of the street, have a thickness of 50-55 cm. The dimensions of the slabs and the studs bearing the roof restrict the length of the walls and the edges of the building. Consequently, the short side of the façade ranges between 3.00 m and 4.00 m, and the door and window bays do not exceed a quarter of the wall’s surface area.

The main material used to build the walls is rubble stone. The walls surrounding the courtyard and the main outer walls of the building were constructed using the masonry technique with

bonding timbers. In the case of interior walls and the enclosures of outdoor “sofas” /halls, wooden work supported with filler can be found.

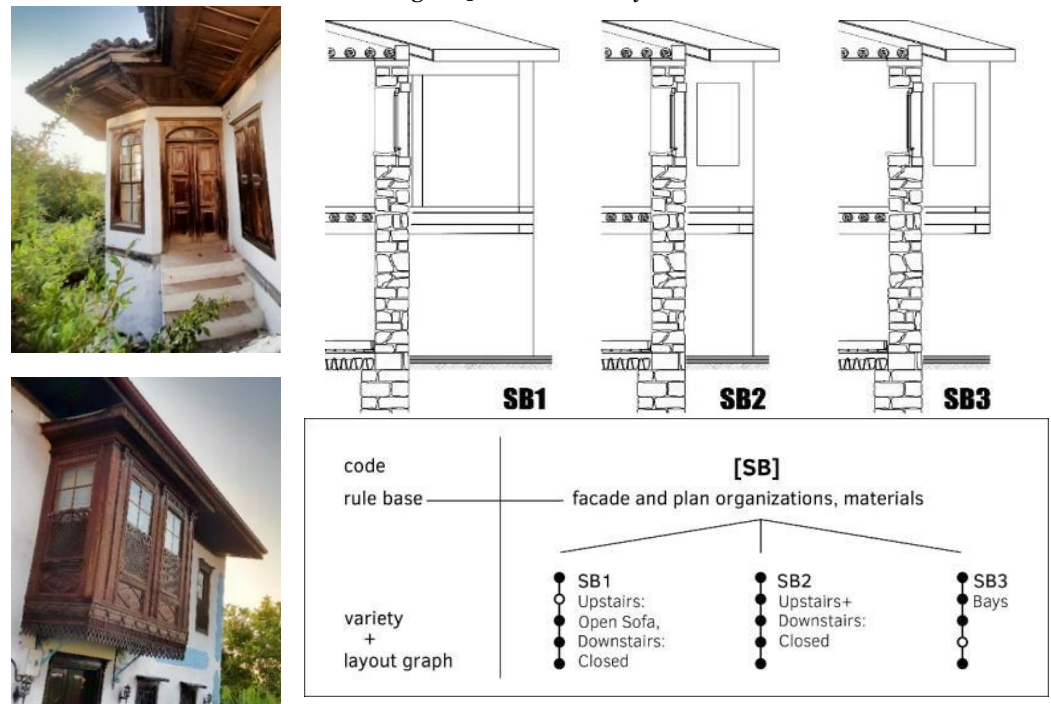
The timber framing, known as ‘çatı’, was constructed by applying amulet clearances with transverses between the 11x11 cm stud bearings (Aladağ, 2004). Occasionally, wood pieces, bark, grass, straw and other materials were used as filler. It is also observed that lime mortar reinforced with goat hair or straw was used for whitewashing (Ekinçi, 1985). Depending on the masonry technique used, the texture of the walls and surface coating enhances the vernacular identity.

Wall thickness, height, and transparency ratio (window area/wall area) can be measured. A Structural Solidity Index ($SSI = \text{wall thickness} / \text{wall height}$) (slenderness ratio) can be formulated to assess bearing stability. Material correlation with thermal mass can be analyzed through regression between SSI and orientation (N-S vs. E-W façades).

Slabs (SB): In the courtyard of Muğla houses, the initial meeting space has an earthen floor and slate coating. The building’s floor covering can be an earthen floor, stone surfacing, or a timber cover on timber joisting. In terms of the slabs between the floors, a grid was formed by placing circular or prismatic beams at specific intervals. Coverings were laid by nailing 2 cm thick, 20-25 cm wide timbers onto 11x11 cm or 7x14 cm timber beams placed 40-50 cm apart. The timber beams were made of pine and cedar/turpentine trees. The ceiling slab surfaces of the upper floors are timber-covered. The ceiling was constituted by ceiling cladding, with 5x5 cm square timbers nailed at 30 cm intervals under the fascia board. The timbers were nailed using one or two wooden frames, known as ‘hane’, following the jamb (Aladağ, 1991). The location of the projection relative to the centre of mass also identifies a rule (Figure 5). Floor-to-floor height, beam spacing, and span index ($SI = \text{clear span} / \text{joist depth}$) can be measured; the coefficient of variation of SI can indicate structural rhythm consistency.

A Flexural Efficiency Ratio ($FER = \text{beam spacing} / \text{span length}$) can be calculated to evaluate load distribution regularity.

Figure 5. Floors and bays



Source: Author, 2024.

Roofs [SF]: The form is primarily identified by the saddle roof or jerkin head formation and the intersection of roof surfaces, depending on the plan geometry. The large timber beams that bear the roof are made of black pine. Elsewhere, Calabrian pine is used. For the roofing fascia boards, “kutla/tavan ağacı” boards are placed at 130 cm intervals. King posts are then placed on top of these boards and trusses are formed. ‘Soymak/ok’ rafters are placed on the trusses at 35 cm intervals. Finally, the surface is closed with a roof board called a ‘bedavra/fistan tahtası’ (Aladağ, 1991).

In this area, it is observed that roof finishes are made using a soffit or porcupine soffit made of slate (“gumile”), as well as the placement of the soffit in one direction or all-around using timber (Değer, 2012). The form of the roof is defined by the material used, the eave detail, and the shape of the elements (Figure 6). A rarely encountered feature is the increased horizontal effect

of the façade due to the fine workmanship of the cornice. In outdoor sofa plan types, the roof covers the top of the area in question. The studs that carry the roof also create a rhythm through their placement at specific intervals. The roofing material has a significant impact on the façade in terms of color and texture.

Roof pitch, ridge length, and eave depth can be measured. A Climatic Roof Adaptability Index (CRAI = eave depth × slope angle / annual precipitation) can be established to assess climatic responsiveness. Roof alignment variance can be analyzed to evaluate rhythmic continuity along the street front.

Figure 6. Roof structure and eaves



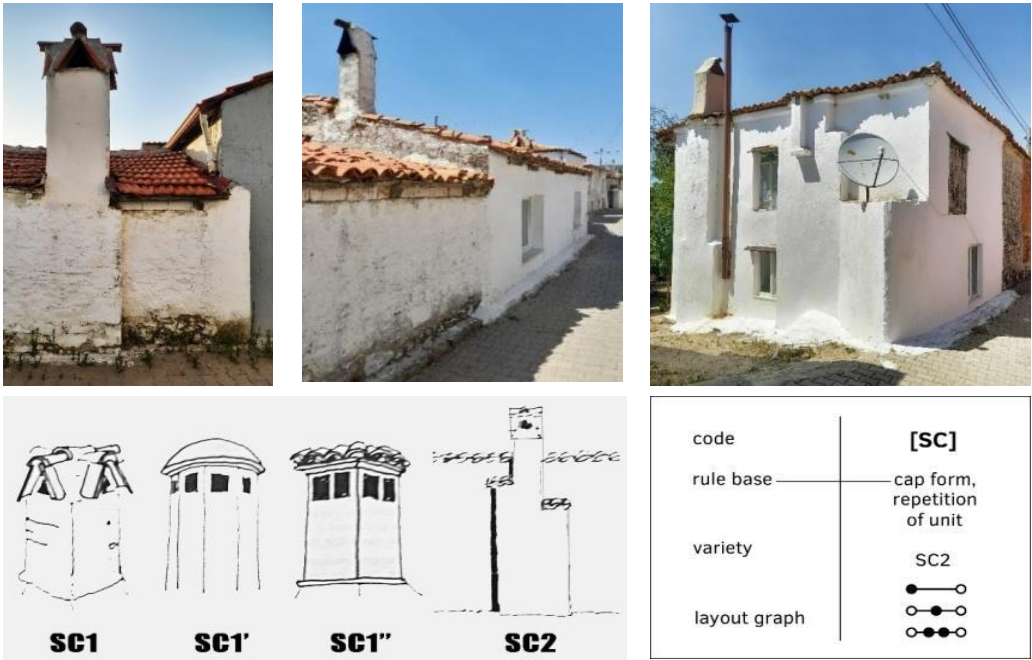
Source: Drawings; Aladağ, 1991. Photos and Schemata; Author, 2024.

Chimneys [SC]: The most characteristic feature of the buildings in Muğla is the chimneys, which make them distinct. A symbol of architectural identity, the chimneys are closed with a specific tiled cover. They are shaped by surrounding the four sides of the chimney with triangular frames first, followed by convex components back-to-back, then concave components overlapping the former, and finally closing the gaps except for the clearances with mortar (Muğla Büyükşehir Belediyesi, n.d.).

The base of the chimney walls is square. The formal diversity of the chimneys depends on their formation, the shape of the opening, the construction of the tiled cover and the presence of holes on two or four sides. Moreover, the fireplace in the rooms extends 30-35 cm from the façade, reaching the sectional width of the chimney's base before narrowing down to the soffit and ending at the ridge of the roof. Thus, the chimney is also an element that is emphasized on the façade (Figure 7).

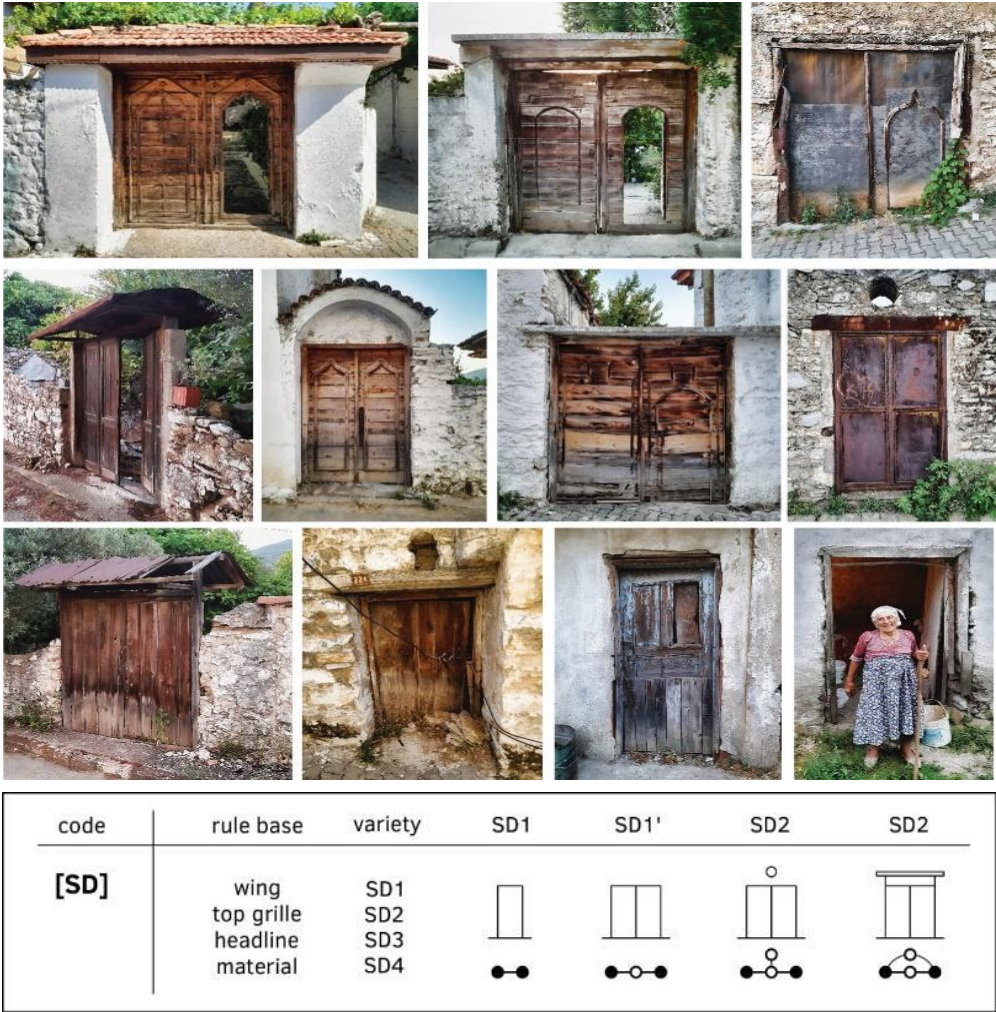
Chimney height-to-roof ridge ratio (CHR = chimney height/ridge height) can be derived to standardize visual prominence. A Morphological Diversity Coefficient (MDC = unique chimney types / total samples) can be used to evaluate typological richness in the dataset.

Figure 7. Chimneys



Source: Photos and schemata; Author, 2024. Drawings: Ekinci, 1985.

Figure 8. Doors



Source: Author, 2024.

Doors [SD]: There are two door types that identify the characteristics of the façade: the front entrance door and the building entrance door. The front-entrance door has the highest symbolic value and is used to welcome guests, so it is very magnificent. Often, the building’s courtyard is entered through double-wing doors from the street. These doors are opened by

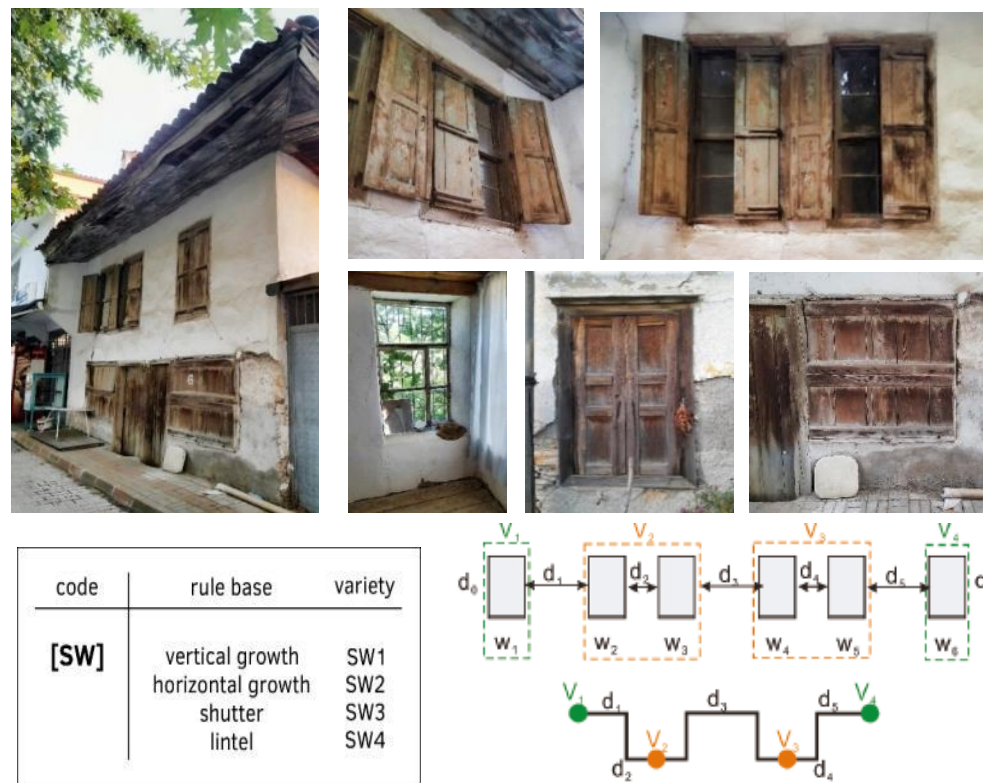
operating a component on the other wing. This mechanism allows the passage of both saddle animals and numerous people, for example at weddings and funerals. The wingspan of the doors may range between 70 and 100 cm. The doors are opened and closed using a latch system. In some cases, an air grille at the top of the door also adds to the variety of types. In terms of material preference, timber is often used, metal casings and wings also generate variation (Figure 8).

Door height-to-width ratio (DHR) and lintel-to-wall height ratio can be formulated to analyze proportional harmony. A Transitional Openness Ratio (TOR = total door area/facade area) can be analyzed against circulation patterns to interpret access typology.

Windows [SW]: The windows have flat timber lintels and open using a guillotine system. On the outer surface, there are timber shutter wings known as ‘kepenk’. These are connected to the window frames via forged iron bar hinges known as ‘piştuvan’ (Ekinci, 1985). The width of the windows ranges from 60 to 75 cm. They range in height from 1.20 to 1.50 meters, and in general, there is a proportional correlation between the height of the windows and the height of the storeys in all buildings. The balance of 1/2 in the width-to-height ratio is notable.

The rhythm of the façade depends on whether a single-wing or double-wing window is used, or on whether the number of wings in a single window bay increase. Conversely, numerous windows facing the courtyard attract attention with their variety of rhythms and rates. The window joinery is located on the exterior face of the wall on the wall axis. This creates an area that can be used for different purposes in front of the window in the interior space. Furthermore, the area in which the window wings move within the room when the window is open is eliminated. The top part of the opening wings, where the fixed window is located, is also frequently used. Window applications with opening wings, as well as wing types with vertical slides, are also found. The base of the window can be diversified according to the required use, with jambs, with or without shutters, and ornamented or plain (Figure 9).

Figure 9. Windows



Source: Photos and schemata; Author, 2024. A layout graph model for facade organizations; Fan, et al. 2021.

Window height-to-width ratio (WHR) can be measured for all façades.

The Window-Façade Ratio (WFR = total window area/wall area) can be compared to indoor lighting adequacy and privacy indicators. A Façade Rhythm Index (FRI = number of openings/facade width) can be derived to assess visual balance and repetition.

Staircases [SS]: A staircase is a vertical circulation element that connects the floors. It may be single-armed [SS1], L-shaped [SS1'] or U-shaped [SS1'']. Generally, staircases can be classified as middle or side types according to their position within the building. In houses with a central staircase, the upper exit divides the building symmetrically and in different ways. The staircase is made of wood, and the bottom section can be used for storage. It usually elevates in a U-

shape. If there is symmetry on both sides, one or two rooms are built. Where the staircase does not divide the building symmetrically, the rooms are positioned on one side of the sofa and the other side, which continues with the sofa, remains open. Generally, in houses where a sofa runs from end to end along the façade facing the courtyard, access to the upper floor is via the staircase on the side. The width of the sofa corresponds to the width of the two arms of the staircase that rise from the side of the building in a U-turn. The rooms are arranged side by side at the rear of the sofa, leaning against the back wall of the building. Each one opens directly onto the sofa.

According to Ekinçi (1985), buildings are divided into two groups due to the location of the staircase in the middle [SS2'];

- Indoor sofa plan with a staircase in the middle
- Outdoor-longitudinal sofa plan with a staircase in the middle
- Outdoor-middle sofa plan with a staircase in the middle

Types with a staircase on the side [SS2'];

- Outdoor-longitudinal sofa plan with a side staircase
- A semi-sofa plan with a staircase on the side
- "T" sofa plan with a staircase on the side

Similarly, Aladağ (1991) emphasizes that the sofa is the main factor in the design of staircases in Muğla houses, establishing a formal classification of building types as either having a central staircase [SS2] or a side staircase [SS2']:

- with a front sofa and a staircase on the side
- with a front sofa (two rooms) and a staircase in the middle
- with a semi-front sofa (three rooms) and a center staircase
- with a middle-front sofa (two rooms) having a center staircase
- with a middle-front indoor sofa (two rooms) having a center staircase

Staircase slope (rise/run), number of steps, and landing width can be measured to identify ergonomic typologies. A Circulation Compactness Ratio (CCR = staircase area/floor area) can be derived to evaluate spatial efficiency. Typological clustering [SS1-SS2'] can be analyzed through hierarchical grouping to reveal generative logic in vertical circulation.

3.1.3. Spatial Organization

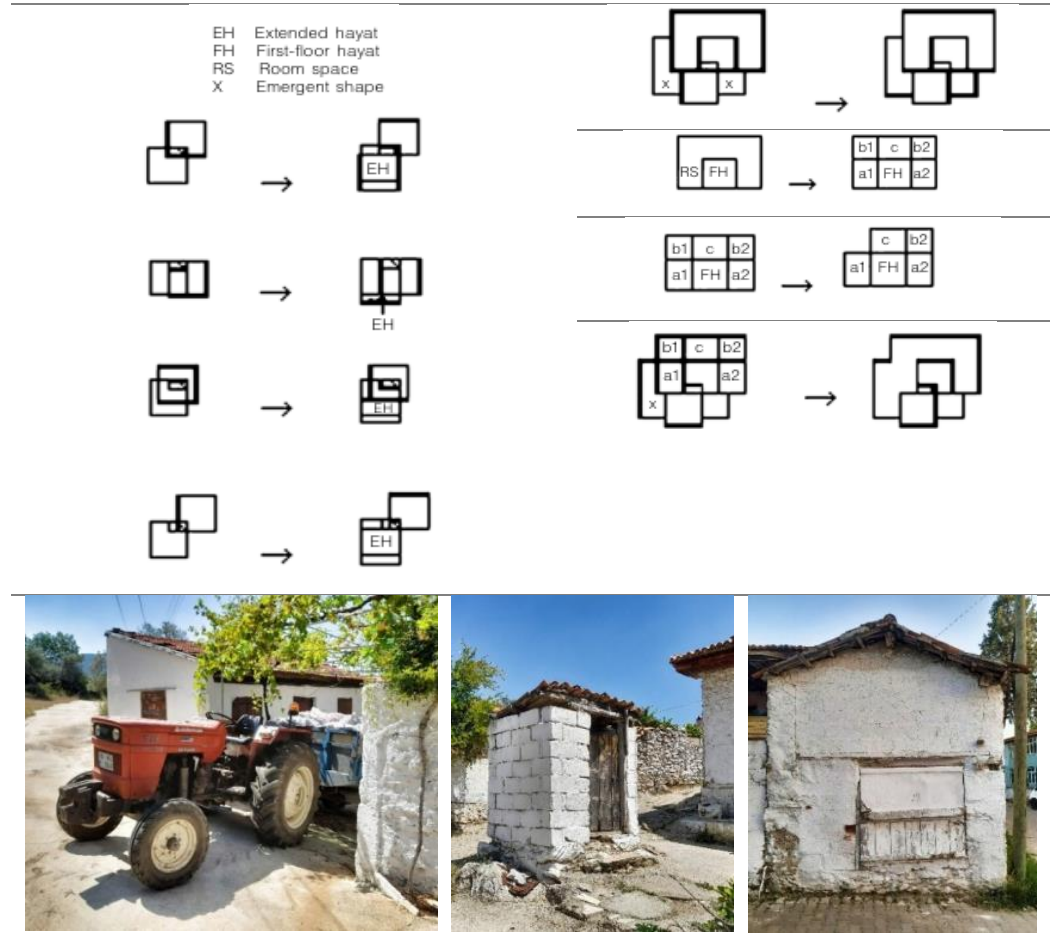
Vernacular architecture serves functions that meet requirements, even if dwellings are not designed as part of a project. Typical differences in size are not evident among the spaces in buildings, which are made up of repeated sizes that may be deemed unit modules. This modular order, based on repetition, ensures a harmonious perception of formal elements, from façade ratios to street and settlement texture at building and settlement scales. An axial composition is readable throughout the plan schemes. The sizes of the spaces are consistent with their functional use. The dwelling consists of a 'sofa'/hall, which is accessed by passing through the courtyard, and rooms that open onto the 'sofa'. Service units such as toilets, barns and outhouses can be located within the boundaries defined by the walls (Figure 10).

At this level, spatial modularity and room proportions can be measured and compared across dwellings. A Modular Repetition Index (MRI = standard deviation of room area / mean room area) can be derived to evaluate dimensional regularity. Circulation hierarchy between courtyard, sofa, and room can be analyzed through a Connectivity Ratio (CR = number of connections / numbers of enclosed spaces), indicating syntactic integration. Spatial symmetry along the plan axis can be assessed through centroid deviation analysis, where lower deviations represent high morphological discipline.

Rooms [OR]: The rooms, which constitute the fundamental unit of the building, are spaces that can fulfil specific functions within a building. Each room in the houses has been designed to serve as a setting for nearly all daily routines, such as sitting, dining, studying, and sleeping. In this context, it is noteworthy that the most salient attribute of this space is the consolidation of components necessary for the execution of diverse activities, with an intriguing interpretation (Küçükerman & Güner, 1995). In Muğla architecture, rooms are named according to their position in relation to the sofa (hall). The large corner room is called *Baş Oda* [OR1]; in some regions, the room where guests are hosted is known as *Selamlık* [OR1']. The room slightly

elevated from the floor at one end of the hall is referred to as *Köşk Oda* or *Eyyan Odası* [OR1’], while the room located at the center is called *Ara Oda* [OR1’] (Atilla & Öztüre, 2003). The fundamental spatial unit of the dwelling is the room itself, which maintains a proportional dimensional balance. Room widths generally range between 3 and 4 meters, while ceiling heights vary between 3 and 3.5 meters.

Figure 10. Open and closed spatial organizations



Source: House-variation rules schemata; Çolakoglu, 2005. Photo of various spaces and functions; Author, 2024.

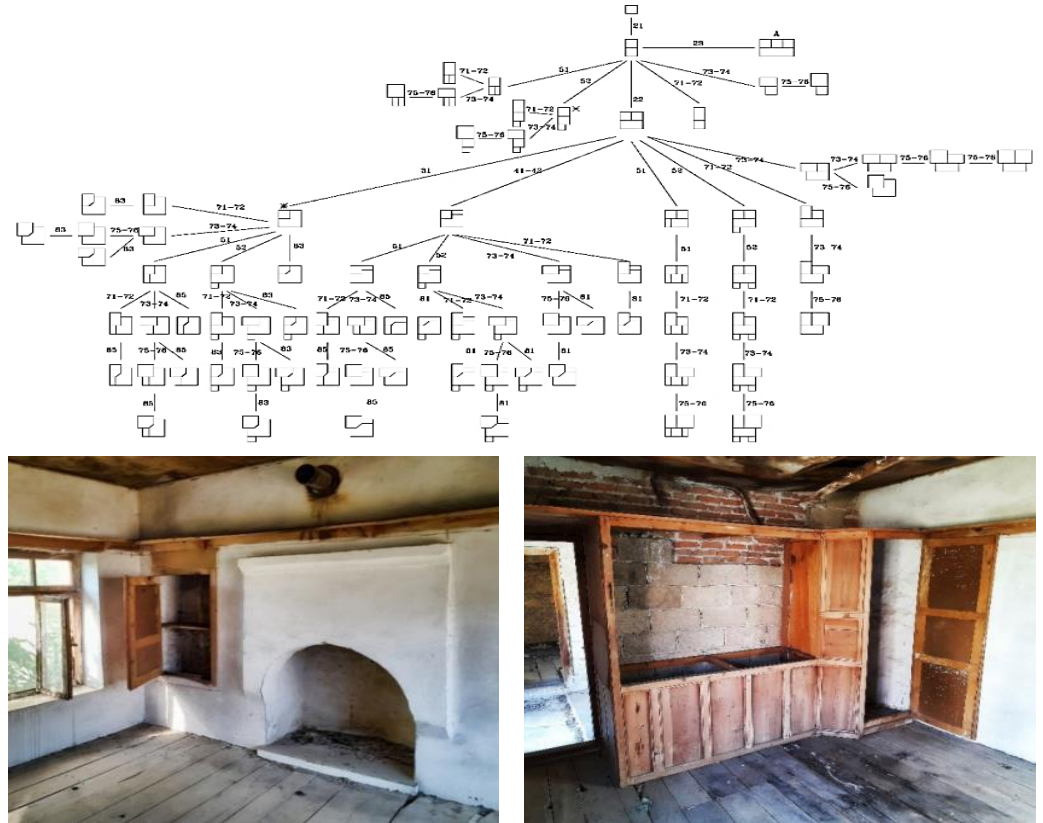
Ceiling height decreases by approximately 50 cm on the ground floor. In the room, there is built-in furniture that functionally supports daily life and accommodates all family activities. The elements providing the room’s multi-functionality are the cabinets and closets where household items especially quilts, mattresses, and pillows are stored (Figure 11).

The wooden built-in closets, called *yüklük* [OR2], are often integrated with a small bathing area known as *yunmalık* or *gusülhane* [OR2’]. Within the room, the placement of the door defines the position and boundary of these cabinets. The height of the door leaf and window sash establishes the upper border that horizontally encircles the room. The finishing is completed with a 20 cm-wide wooden shelf at the level of the door and window bays, called *tahtabaşı* or *almalık* [OR2’], which runs continuously along the blind walls of the room at the top level of the closets (Aladağ, 1991).

The furnace, the central element of the room, defines the characteristic features of the interior and is also reflected on the façade. In this spatial organization, in which each room is designed for versatile use, the furnace acquires central significance. A solid wall, niche, or cabinet arranged symmetrically, as well as a window placed in a similar order, can be found around the furnace. The general rule is based on resolving these openings symmetrically on both sides of the furnace. These areas are used to store the tools required for lighting a fire, and they are called *ocakbaşı* [OR2’] in the locality. The furnaces used for heating and cooking where the fire is lit are equipped with flues that discharge smoke. Room width, depth, and height can be measured to determine the Proportion Ratio ($PR = \text{width/height}$).

A Functional Density Index ($FDI = \text{fixed furniture area} / \text{room area}$) can be derived to assess multifunctionality efficiency. The correlation between ceiling height and window head level can be analyzed to infer visual balance and daylight distribution. Wall recesses and built-in niches can be categorized to quantify typological recurrence using a Morphological Recurrence Coefficient ($MRC = \text{repeated recess types} / \text{total recess types}$).

Figure 11. Arrangement of rooms and interior components



Source: Tree plan layout of generation of Turkish house from unit; Çağdaş, 1996. Photos: Author, 2024.

Sofas / Halls [OS]: In the formation of a dwelling, the common space to which the rooms open is called the sofa (hall). It is the area that provides circulation between rooms and accommodates daily activities. All the spatial characteristics of the sofa are more versatile than those of the rooms (Timur, 2019). The buildings' ground- and upper-floor plan types are identical, but the use of the upper floor determines whether the sofa is open or enclosed. Outdoor sofas [OS1] are semi-open spaces that connect directly to the courtyard, where communal life takes place. Wooden lintels distributing the load are positioned on the ground-floor posts supporting the sofa (Ekinci, 1985). The sofa defines the façade character through its covering and surface configuration. Indoor sofas [OS1'] may either be designed in this way from the beginning or enclosed later in time (Figure 12). In terms of plan layout, the organizational scheme varies, appearing in linear [OS2], L-shaped [OS2'], polygonal [OS2''], or quadrangular [OS2'''] forms, which determine the spatial movement and configuration of the structure, either as open or enclosed.

Figure 12. Linking function of sofa/hall in shape grammar



Source: Başoğlu Avcı & Akyüz Levi, (2014).

Sofa depth, width, and openness ratio (open side length / perimeter) can be measured to derive a Spatial Openness Index (SOI). Outdoor and indoor sofa typologies [OS1, OS1'] can be compared using a Spatial Integration Index ($SII = \text{mean axial depth} / \text{sofa width}$), indicating the degree of visual and functional connectivity with the courtyard. In semi-open sofas, pergola depth, post spacing, and orientation can be measured; a Shading Efficiency Ratio ($SER = \text{pergola depth} / \text{sofa width}$) can be formulated to evaluate comfort performance in transitional spaces.

Services [OE]: They are auxiliary units that support the functioning of the dwelling. The variety of these spaces corresponds to their specific functions. The courtyard, called *hayat* [OE1], enclosed by walls, provides the connection between the Muğla houses and the street. A single-storey outbuilding [OE2], attached to or partially aligned with the wall of the house, is usually present. Around the courtyard, which faces the front façade of the house, there are a toilet [OE3], barn [OE4], and poultry house [OE5], as well as an outdoor area called *salıncırma* [OE6] a roofed space supported by wooden posts, containing a large open furnace used for laundry and various winter preparations. In addition, there is a small kitchen, serving both as a cooking and a living area (Aladağ, 1991). Moreover, water cisterns are located either inside or outside the house. In the early Muğla houses, there was no separate kitchen; meals were cooked in the furnace and bathing needs were met within the *gusülhane* section inside the room. In the last century, these functions became integrated with the courtyard and the main building.

Courtyard area, service room footprint, and enclosure ratio (wall length / perimeter) can be measured to derive a Service Integration Index ($SIntI = \text{service area} / \text{total plot area}$). The proximity of service units (e.g., toilets, barns, kitchens) to the main structure can be analyzed using a Proximity Coefficient ($PC = \text{mean service distance} / \text{courtyard width}$). A Courtyard Vitality Ratio ($CVR = \text{green courtyard area} / \text{plot area}$) can be formulated to evaluate ecological contribution and spatial liveliness.

3.2. Derivative Level/Syntactic Arrangement

The vernacular rural dwellings, as the outcome of centuries of accumulated experience, have been strengthened against natural and environmental effects through appropriate material selection and detailed construction techniques. All these choices have played a significant role in shaping the architectural identity. Here, the remarkable point is the preservation of the fundamental structural system that constitutes the identity of Turkish houses, which has remained largely unchanged despite climatic challenges (Sözen & Eruzun, 1996). Environmental characteristics serve as key determinants in the development of form, yet they are not the sole factors underlying the evolution of local construction techniques. There are circumstances in which climatic data or socio-cultural values influence the emergence of structurally non-optimal forms (Tolun, 1977). Thus, the characteristics and diversity of architectural forms cannot be fully explained solely through material and technical aspects.

Figure 13. Generation of building elements and forms



Source: Graphics; Angelo, Fersch, & Paskavela, 2012. Photos: Author, 2024.

At this level, compositional relationships between materials, construction techniques, and environmental performance can be analyzed using generative syntax. The method defines measurable form variables and syntactic rules that can be derived to trace design logic from material to morphology. By the syntactic expansion of organization, it was intended to provide insight into the data shaping the form (Figure 13). A Syntactic Complexity Index ($SCI = \text{number of interaction types} / \text{total elements}$) can be formulated to quantify the formal richness of the building composition.

3.2.1. Attributes

The identity of local building practice is shaped by the potential of materials and construction techniques. Materials, construction methods, and technologies create diversity in architectural characteristics. In architectural design, spatial dimensions, storey heights, proportions, and finishing details are elements that vary according to the materials and construction techniques employed.

Each attribute (material, detailing, and structural position) can be evaluated through parametric indicators that can be derived to assess performance, consistency, and contextual fit.

Material Selection [AS]: The building materials within the local building culture are closely linked to the natural resources of the region. The materials familiar to local inhabitants through their accessibility and ease of processing, being both abundant and practical, have shaped construction traditions over generations. The potential and limitations of local material resources influence the community's craftsmanship and constructive expression. Materials adapt to their environment in response to the local climate and vegetation. The adaptive relationship between material properties and environmental performance has also been demonstrated through empirical studies focusing on thermal behavior and surface responses of construction systems (Pérez Cambra et al., 2024). Vernacular architecture often relies on locally sourced materials with specific thermal properties, and the interaction between these materials and the surrounding environment plays a significant role in achieving energy-efficient and climate-responsive building performance (D'amato & Kapoor, 2024). In particular, thermal mass, compatibility with natural ventilation, solar protection performance, and moisture regulation are among the primary factors influencing material selection in vernacular settlements. The vernacular building culture demonstrates the most appropriate and efficient use of materials. In Yeşilyurt, the frequently used materials are stone, earth, and timber. Stone, the predominant building material, creates different perceptual effects depending on its mode of application whether using stones of the same type and color, the same type but different colors, or in combination with other materials. Moreover, timber bonds embedded in masonry walls reinforce structural integrity, while continuous horizontal wooden bands form distinct façade lines.

The reflective property of white has been utilized for centuries in houses of the Mediterranean climate to support thermal regulation. The doors and windows of these houses, whose exterior façades are whitewashed, are traditionally painted blue. The reason for painting the doors and windows blue is related to a local belief that scorpions common in the region perceive blue as fire and thus avoid entering the house. The texture and color of materials are key factors influencing visual and perceptual experience.

In the material selection and shaping preferences of Yeşilyurt's architecture, the following factors have been effective:

- Ability to procure materials from nearby surroundings,
- Easy processing of the materials,
- Maintenance without intensive labor on the materials,
- Strength of the materials against the environment effects,
- Mechanical properties of the materials,
- Color and texture properties of the materials.

A Material Accessibility Index ($MAI = \text{distance to quarry or forest} / \text{material quantity}$) can be derived to evaluate procurement efficiency. Material diversity can be quantified through the proportional use of each material type (stone, timber, clay).

Detailing [AD]: The genuineness brought in through detailing, as well as the limitations on the building system caused by stone and wood as the materials used, are remarkable.

In the system's detailed solutions, the pursuit of the following is dominant:

- Meeting the structural or complementary function,
- Enabling acoustic, thermal, and visual comfort,
- Protecting against physical effects,
- Enabling integrity, which is effective on perception in aesthetic terms.

The details developed constitute solutions depending on the following:

- Load-bearing system's order,
- Layers of the structure,
- Components of finishing,
- Constitution of joints and fasteners.

Joint typologies, bonding patterns, and fastener density can be measured. A Detailing Complexity Ratio ($DCR = \text{number of detail types} / \text{building elements}$) can be derived to evaluate tectonic variety. Correlations between detailing frequency and façade articulation can be analyzed to understand visual rhythm.

Structural Position [AP]: The masonry building system, forming a durable whole by stacking natural stone units and assembling fragmented components. The building elements comprise load-bearing and finishing components according to their structural functions. In the vertical and horizontal articulation of the building form, the span dimensions of the spaces and the storey heights act as defining parameters.

Pursuit of managing the pressure force and tensile stress is determinant in the structural development of the components for:

- Balancing the building's vertical loads,
- Spanning the spaces.

Floor span, wall thickness, and beam depth can be measured; a Structural Efficiency Index ($SEI = \text{span} / \text{beam depth}$) and ($WSI = \text{wall height} / \text{wall thickness}$) can be derived to evaluate load-bearing efficiency.

Load transfer paths can be mapped to determine Stability Consistency Coefficient ($SCC = \text{mean deformation} / \text{element length}$).

3.2.2. Compositional Rules

The form is a key determinant in shaping the characteristic appearance of an architectural object and influencing its perception, serving as a medium through which collective memory is anchored. The structural and spatial rules that define form can be read through the compositional relationships among buildings, building elements, and components. Within the settlement, the parcel texture of dwellings reflects the relationship between the building plot and the street. The organization of design elements according to specific principles reveals a coherent composition. A composition is a unified whole formed by elements arranged toward a common purpose, and its unity is achieved through balance. This unity may be established by means of harmony, dominance, or contrast. The perceived presence of balance and unity determines whether the composition's image is accepted or rejected by the observer. Although the perception that emerges here is subjective, Zevi (2015) emphasizes the concept of scale as an essential criterion of objective judgment, asserting that the human being is the measure of all things. Thus, the proportional relationship between compositional elements and human scale as well as among the elements themselves can produce diverse effects through various modes of construction.

- [CU] Union: structure, building element intersections
- [CD] Division: structure, building element intersections
- [CG] Gapping: in-settlement organizations, openings
- [CR] Rhythm: chimneys, joinery elements
- [CS] Symmetry: plan layouts, sofa positions, openings.

These rules can be codified and analyzed through morpho-syntactic parameters. A Composition Harmony Index can be derived to measure perceptual balance. Façade rhythm, symmetry, and repetition can be evaluated through frequency analysis of window and door

intervals. A Symmetry Correlation Ratio (SCR = mirrored element count / total elements) can be formulated to reveal visual order and cognitive recognition.

4. Discussion and results

The findings of this study demonstrate that the vernacular dwellings of Yeşilyurt embody a measurable architectural logic in which spatial order, material selection, and environmental adaptation are interrelated through consistent geometric patterns. The integration of shape grammar and morphometric analysis provided a methodological pathway for transforming descriptive architectural data into an empirical framework, enabling the identification of the syntactic rules underlying local architectural identity. The resulting grammar of form reveals how vernacular construction systems sustain equilibrium between structure, climate, and culture. Building upon this framework, the analysis expanded toward the morphological level to examine how settlement geometry reflects environmental adaptation. At the morphological level, settlement layout and geo-referential parameters confirmed a strong correlation between topography and building morphology.

Table 2. Analytical framework addressing ontological parameters of Muğla Yeşilyurt

Subsection	Parameter / Index	Formula / Computation
Geo-References	Contextual Fit Index (CFI)	Street width / wall height × slope gradient
Location [GL]	Settlement Orientation Ratio (SOR)	Building orientation / dominant wind axis
	Street-Wall Proportion Index (SWPI)	Street width / courtyard wall height
Physical Geography [GP]	Climatic Adaptation Ratio (CAR)	Roof slope × eave depth / rainfall intensity
	Thermal Comfort Coefficient (TCC)	Window-wall ratio × orientation factor
Natural Characteristics [GN]	Vegetation Density (NDVI)	Satellite vegetation index
	Pergola Shading Coefficient (PSC)	Pergola depth / sofa width
	Courtyard Vitality Ratio (CVR)	Green courtyard area / total plot area
Cartesians of Shell	Building Envelope Coherence Index (BECI)	Envelope surface area / built-up area
Walls [SW]	Structural Solidity Index (SSI)	Wall thickness / wall height
	Façade Openness Ratio (FOR)	Total opening area / façade area
Slabs [SB]	Span Index (SI)	Clear span / joist depth
	Load Transfer Ratio (LTR)	Beam spacing / total span
Roofs [SF]	Climatic Roof Adaptability Index (CRAI)	Eave depth × slope angle / annual rainfall
	Eave Projection Ratio (EPR)	Eave length / wall height
Chimneys [SC]	Morphological Diversity Coefficient (MDC)	Unique chimney forms / total samples
	Vent Orientation Index (VOI)	Opening direction / prevailing wind direction
Doors [SD]	Entrance Dominance Ratio (EDR)	Door width / façade width
Windows [SW]	Window Proportion Ratio (WPR)	Window width / window height
	Window Placement Symmetry Index (WPSI)	Mirrored window count / total windows
Staircases [SS]	Vertical Circulation Ratio (VCR)	Staircase footprint / total floor area
	Symmetry Correlation Ratio (SCR)	Mirrored staircase layout / total samples
Spatial Organization	Modular Repetition Index (MRI)	SD of room area / mean room area
	Connectivity Ratio (CR)	Number of connections / enclosed spaces
Rooms [OR]	Proportion Ratio (PR)	Room width / height
	Functional Density Index (FDI)	Built-in furniture area / room area
Sofas / Halls [OS]	Shading Efficiency Ratio (SER)	Pergola depth / sofa width
	Spatial Integration Index (SII)	Mean axial depth / sofa width
Services [OE]	Service Integration Index (SIntI)	Service area / plot area
	Proximity Coefficient (PC)	Mean distance of services / courtyard width
Attributes	Material-Structure Correlation Index (MSCI)	Material × joint variety
Material Selection [AS]	Material Accessibility (MAI)	Distance to source / material quantity
	Material Diversity Index (MDI)	unique material types / total samples
Detailing [AD]	Detailing Complexity Ratio (DCR)	Number of detail types / total components
Structural Position [AP]	Structural Efficiency Index (SEI)	Span / beam depth
		wall height / wall thickness
Compositional Rules [CU-CS]	Composition Harmony Index (CHI)	sum of element proportion deviations / number of elements
	Rhythmic Consistency Index (RCI)	Opening interval / total façade length
	Symmetry Correlation Ratio (SCR)	Mirrored element count / total elements

Source: Own elaboration.

The Contextual Fit Index (CFI) and Street-Wall Proportion Index (SWPI) showed low variation across samples, implying a shared proportional rule that maintains spatial enclosure and visual harmony along sloped terrain. Similarly, the Climatic Adaptation Ratio (CAR) revealed that roof pitch and eave depth are systematically adjusted to optimize shading and drainage, reflecting a tacit climatic intelligence embedded in traditional design practices. Vegetation-related metrics such as NDVI and Pergola Shading Coefficient (PSC) illustrated that semi-open courtyards and pergolas act as passive regulators of microclimate, confirming that environmental integration is formally embedded in spatial composition.

In the Cartesians of Shell, façade and envelope analyses highlighted how material thickness, span rhythm, and opening proportions follow measurable structural and perceptual principles.

The Structural Solidity Index (SSI) and Span Index (SI) presented low coefficients of variation (CV) verifying high constructional consistency across samples. Roof parameters such as the Climatic Roof Adaptability Index (CRAI) and Eave Projection Ratio (EPR) further substantiated that environmental control is achieved through morphometric calibration rather than stylistic repetition.

At the spatial organization level, the modular repetition and syntactic coherence of interior layouts were quantified through indices such as the Modular Repetition Index (MRI) and Connectivity Ratio (CR). The consistently low variance in MRI values indicated stable modular grammar, while higher CR values signified functional hierarchy in the organization of rooms, halls, and service units. The Shading Efficiency Ratio (SER) and Spatial Integration Index (SII) confirmed that the “sofa” operates as an adaptive threshold mediating between enclosed and open domains, aligning social activity with environmental logic. Similarly, courtyard and service-space parameters such as the Courtyard Vitality Ratio (CVR) and Service Integration Index (SIntI) demonstrated a balanced coupling between ecological performance and daily spatial use.

At the derivative level, the tectonic and compositional readings of the buildings clarified the structural intelligence of the local building system. The Material Accessibility Index (MAI) and Detailing Complexity Ratio (DCR) indicated that architectural durability and aesthetic refinement emerge through locally optimized material cycles and craftsmanship diversity. The Structural Efficiency Index (SEI), derived from the ratio of span to beam depth, which corresponds to empirically balanced load distribution in construction. Compositional metrics such as the Composition Harmony Index (CHI) and Rhythmic Consistency Index (RCI) revealed that visual equilibrium and façade rhythm are statistically consistent across samples, reinforcing the collective perception of order within the settlement.

When evaluated together, these metrics confirm that the architectural identity of Yeşilyurt is defined by systematic proportional reasoning rather than by arbitrary variation. This measurable language of form ensures structural resilience, climatic adaptability, and cultural continuity within the settlement. The morphometric approach applied in this study bridges the gap between qualitative heritage interpretation and design analysis. By verifying ontological rule sets through statistical evidence, the method establishes an objective validation framework that transforms vernacular architecture from a descriptive tradition into a generative system of measurable relations.

This synthesis demonstrates that vernacular knowledge inherently operates through algorithmic logic: proportions, material hierarchies, and spatial transitions function as encoded rules refined through experience and observation (Table 2).

5. Conclusions

Within the scope of this study, the relationship between expression and tectonics was addressed in terms of the organization of vernacular architecture and the structural order of its elements through the insight of shape grammar. By integrating morphometric verification into the grammar-based framework, the research demonstrated that the formation of vernacular identity follows a measurable and rule-governed logic rather than a purely stylistic one. The conclusions obtained from the Yeşilyurt settlement indicate that the expression of architectural identity emerges from quantifiable proportional relationships between form, structure, and material, perceptible both in isolated elements and in their compositional unity.

The formal and intellectual values identified through the morphometric model reveal that representation is a geometric system encoded within the building tradition. This demonstrates that the implicit rules of proportion, modularity, and spatial hierarchy function as a generative code shaping architectural continuity.

Yücel (1982) advocates the presence of few fundamental shapes and the transformation of meaning that these shapes may acquire throughout design history. Cultural traits and

environmental contexts form the enduring foundation of traditional building practices that have persisted for centuries. Physical, cultural, and perceptual factors determine the relative significance of form, structure, space, and detail challenging deterministic interpretations that reduce vernacular identity to environmental necessity (Oliver, 2006). Within this ontological framework, the morphological system of vernacular architecture can be interpreted as a codified language that integrates social meaning with constructive logic.

Vernacular rural architectural identity, formed by centuries of cultural continuity, faces progressive transformation and partial loss under the pressures of globalized consumption and production economies. To ensure its preservation, it is essential to reinterpret the architectural identity as a living grammar that can be digitally modeled, measured, and reproduced within contemporary design discourse. However, the reinterpretation of vernacular grammar also carries the risk of turning local architectural expression into a repetitive stylistic pattern when it becomes detached from contextual and societal evolution. To overcome this limitation, the generative framework proposed in this study should be continuously updated through new datasets, parametric inputs, and computational methods, ensuring that vernacular identity evolves adaptively rather than being frozen into a static form. Thus, a morphometric grammatical methodology can be proposed as a bridge between conservation and generative design, offering a replicable model for identifying local identity through measurable architectural reasoning.

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