

Article

A Fuzzy–AHP Model for Quantifying Authenticity Loss in Adaptive Reuse: A Sustainable Heritage Approach Based on Traditional Houses in Alanya

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Abstract

This study introduces a Fuzzy–AHP–based analytical model for the quantitative assessment of authenticity loss in adaptive reuse practices, addressing a persistent gap in heritage research—the lack of reproducible mathematical frameworks capable of linking authenticity evaluation with sustainability indicators. Unlike previous studies that approach authenticity conceptually or qualitatively, this research develops a hybrid decision-support system that translates both intangible and tangible heritage attributes into measurable linguistic variables, enabling systematic and comparable authenticity assessments. The model was applied to ten traditional houses in Alanya, Türkiye, representing different adaptive reuse types (residential, cultural, commercial, and touristic). A total of 17 experts contributed to the Analytic Hierarchy Process (AHP) weighting stage, producing a Consistency Ratio of 0.0156 (<0.10), and 8 experts provided scoring inputs for the fuzzy system. The fuzzy inference system was implemented in MATLAB R2023a, incorporating seven main criteria and three subcriteria, nine input variables, five linguistic categories, and a rule base of 3400 fuzzy rules. Membership functions were defined within the 0–100 numerical range, and the centroid defuzzification method was used to compute final authenticity values. Model reliability was confirmed through Kendall’s $W = 0.87$, demonstrating strong inter-rater agreement. Results show that buildings retaining their original residential function achieved the highest authenticity scores (Final Score ≈ 86), while structures converted into boutique hotels or restaurants exhibited substantial authenticity losses (Final Score range: 25–45), especially within Group 2 criteria (environment, function, spirit, and intangible cultural heritage). This divergence illustrates a sustainability paradox: although adaptive reuse prolongs building life cycles and reduces embodied carbon, it may simultaneously undermine cultural sustainability when authenticity is significantly compromised. The proposed Fuzzy–AHP authenticity model provides a replicable, transparent, and empirically validated tool for evaluating the effects of functional transformation within a sustainability framework. By quantifying the relationship between adaptive reuse types and authenticity retention, the study contributes to sustainable heritage management research and supports the implementation of SDG 11—Sustainable Cities and Communities.

Keywords: authenticity; adaptive reuse; fuzzy logic; Analytic Hierarchy Process (AHP); sustainable heritage; cultural sustainability; SDG 11



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1. Introduction

Traditional buildings are significant cultural heritage assets that reflect a society's history, culture, and identity. These structures, which convey past lifestyles, belief systems, and artistic expressions in tangible form, encompass examples of both public and civil architecture. Among them, residential architecture stands out as the most prominent field of architectural diversity, shaped by various factors, including climate, materials, social structure, and cultural traditions [1]. These buildings are not merely historical documents but vivid expressions of a society's values and way of life. Therefore, their preservation contributes not only to the continuation of their physical presence but also to the strengthening of social identity, economic development, and sustainable living. Within this context, heritage conservation must itself align with sustainability principles: conserving material resources, promoting social inclusion, and fostering long-term economic viability [2].

The preservation process should not be limited to restoration alone but should also involve sustaining these buildings through contemporary functions. The use of buildings for purposes other than their original functions—adaptive reuse—has been a commonly adopted approach since antiquity [3]. Structures that can no longer serve their original purpose have often continued to exist by being adapted to new uses [4]. However, during these transformation processes, original architectural features and cultural contexts may be compromised, resulting in a loss of authenticity and character. Hence, it is of great importance to carefully evaluate potential authenticity losses in adaptive reuse projects.

In recent scholarship, adaptive reuse is increasingly interpreted as a strategy not only for heritage preservation but also for promoting sustainable development in urban areas, supporting the circular economy by extending the life cycle of existing buildings [5]. At the same time, the nexus between sustainability and cultural heritage is receiving growing attention. Niu et al. (2025) argue that cultural sustainability is integral to achieving SDG 11 ('Sustainable Cities and Communities'), highlighting that urban heritage plays a critical role in resilient city-making [2].

Within the context of historic houses reused as tourist accommodations, Tavakoli and Tumer (2024) propose integrating authenticity principles with sustainability criteria to avoid 'post-conservation failures' in reuse projects [6]. Their work demonstrates that heritage value is preserved only when authentic qualities are respected alongside environmental and social sustainability [6]. In their 2019 study, Hasik et al. sought to inform designers, policymakers, and building owners about the environmental benefits of adaptive reuse compared to new construction, highlighting how minimizing the use of new materials can substantially reduce embodied carbon and promote sustainable building practices [7].

Although recent studies have emphasized the integration of sustainability and heritage conservation, most assessments of authenticity remain qualitative or narrative in nature, lacking reproducible quantitative tools that can operationalize this complex concept. Seminal works such as Jokilehto (2006) and Stovel (2008) have conceptually defined authenticity through historical, material, and cultural dimensions [8,9], while later research—such as Lanz et al. (2022) and Tavakoli & Tumer (2024)—explored the intersection between adaptive reuse and sustainability [5,6]. However, these approaches largely rely on descriptive interpretations or expert judgment without providing systematic mathematical models capable of measuring authenticity loss numerically.

This methodological gap is particularly evident in the context of vernacular heritage, where authenticity is shaped by both tangible and intangible values that interact in non-linear ways. The challenge lies in translating these multidimensional and often subjective parameters into a quantifiable decision-support model that maintains both interpretive sensitivity and analytical consistency.

In this study, Fuzzy Logic and the Analytic Hierarchy Process (AHP) are employed jointly to overcome these limitations. Fuzzy Logic enables the conversion of linguistic and uncertain evaluations—common in expert-based heritage assessments—into measurable outputs within a continuous 0–1 scale, while AHP allows hierarchical weighting of criteria based on their relative importance. Their integration provides a structured and transparent mechanism for handling multi-criteria, imprecise, and value-dependent assessments such as authenticity evaluation.

Accordingly, the study addresses a clear methodological gap in the field: the absence of quantitative and multidimensional frameworks for evaluating authenticity loss in adaptive reuse projects. By combining fuzzy linguistic modeling with AHP-based weighting, this research develops an analytical system that enables the comparative, reproducible, and transparent quantification of authenticity values. The proposed model thus advances existing approaches by bridging the divide between qualitative cultural interpretation and quantitative sustainability assessment, offering a methodological contribution applicable across diverse heritage contexts.

Based on this framework, the central hypothesis of the study is that adaptive reuse practices that diverge more significantly from the original architectural and cultural characteristics of traditional buildings result in a higher measurable loss of authenticity when evaluated through a Fuzzy–AHP–based model.

Thus, in the case of Alanya’s traditional houses, it is vital to analyze not only whether they remain authentic in architectural terms but also whether reuse practices adhere to broader sustainable heritage objectives. This study contributes to the literature by offering a quantitative assessment method—using fuzzy logic and the Analytic Hierarchy Process (AHP)—to measure authenticity loss in reuse practices within a sustainability framework. It operationalizes authenticity dimensions (spatial, structural, cultural) and links them to sustainable heritage principles (resource efficiency, social meaning, and long-term viability). Ten traditional houses in Alanya are analyzed, with varying reuse types (original function, accommodation, restaurant, office). The findings reveal that buildings maintaining their original function preserve authenticity better, while others incur significant losses.

2. Objective

The primary objective of this study is to develop and apply a quantitative, reproducible model for measuring authenticity loss in adaptive reuse practices through the combined use of Fuzzy Logic and the Analytic Hierarchy Process (AHP). The model aims to quantify how the transformation of traditional buildings affects both tangible and intangible dimensions of heritage, by providing a structured analytical link between cultural value assessment and measurable transformation impacts [7,10,11].

2.1. Context and Representativeness

The research focuses on traditional houses in Alanya, Türkiye, selected as a representative case of Mediterranean vernacular architecture facing functional transformation pressures due to tourism and modernization. Figure 1 illustrates the rapid urbanization process in Alanya, which constitutes a key reason for selecting the city as a representative case for evaluating authenticity loss within a sustainable heritage framework. Historically known as Korakesion in antiquity and later renamed Alaiye under Seljuk rule, Alanya has developed through successive cultural layers including Roman, Byzantine, Seljuk, and Ottoman periods [12]. During the second half of the twentieth century, the city underwent rapid urban and touristic transformation, which significantly altered the use and perception of traditional dwellings [13].

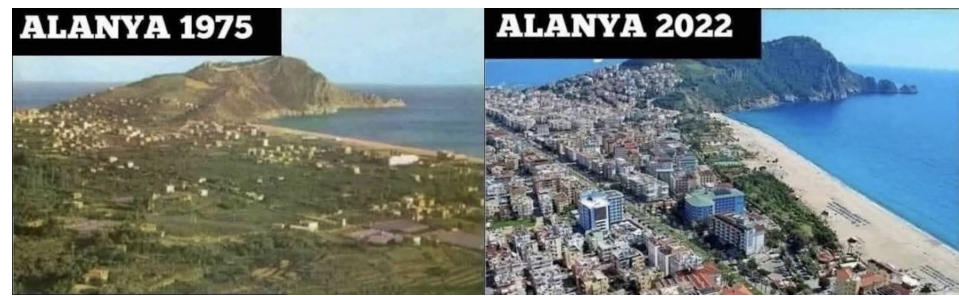


Figure 1. Urbanization in Alanya in 47 years.

Alanya is located on the southern coast of Türkiye within the province of Antalya ($36^{\circ}33' \text{ N}$, $31^{\circ}59' \text{ E}$), characterized by a Mediterranean climate with hot, dry summers and mild, humid winters [14,15]. Its urban morphology—shaped by the coastal plain and the foothills of the Taurus Mountains—and its mixed stone–timber construction systems have contributed to the formation of courtyard-centered, climate-responsive housing typologies. These dwellings reflect both tangible and intangible heritage values, making Alanya an ideal empirical setting to test a model with potential transferability to other Mediterranean vernacular environments.

2.2. Research Tension and Methodological Response

Adaptive reuse generates a well-documented tension between modern functionality and heritage preservation [6,16]. While functional continuity ensures the physical survival of buildings, it can simultaneously risk the erosion of intangible values such as identity, collective memory, and sense of place [11]. The challenge, therefore, lies in quantifying this duality in a consistent and analytically interpretable way.

The proposed Fuzzy–AHP framework operationalizes authenticity as a measurable and multidimensional construct. Fuzzy Logic enables the transformation of uncertain, linguistic expert judgments into quantifiable parameters within the 0–1 range [17], while AHP provides a hierarchical weighting structure that objectively determines the relative importance of each criterion [18]. By combining these two methods, the model offers a transparent and reproducible mechanism that reduces subjectivity and clarifies the decision-making process in authenticity evaluation.

2.3. Hypothesis and Scope

The study is guided by the following hypothesis:

“The type of adaptive reuse function directly affects the degree of authenticity retention; buildings maintaining their original use preserve higher authenticity values than those converted for touristic or commercial purposes”.

The model was applied to ten traditional houses in Alanya representing varied reuse functions (residential, cultural, touristic, and commercial). The study’s scope includes both (a) the development of the analytical model—covering criteria definition, membership function design, fuzzy rule construction, and AHP weighting—and (b) its empirical validation through case applications. Although customized for Alanya’s vernacular architecture, the proposed framework is modular and transferable, allowing its adaptation to other cultural and climatic contexts.

2.4. Limitations

The limitations of the research stem mainly from (i) the expert-based fuzzy evaluation process, which may carry subjective biases, and (ii) the focus on a single regional context.

Future research should include larger, comparative datasets and longitudinal evaluations to test the model's validity across different temporal and geographical settings. Moreover, further calibration with quantitative performance indicators—such as embodied carbon or lifecycle efficiency—could strengthen the interdisciplinary relevance of the method [7,18].

3. Materials and Methods

In this study, a system for authenticity analysis was developed by combining Fuzzy Logic and the Analytic Hierarchy Process (AHP) to evaluate the level of authenticity in traditional houses objectively. Ten traditional houses in Alanya, whose restorations were completed, and which had been adapted to various functions, were selected for analysis. The selection aimed to examine the impact of different usage types on authenticity. The houses were grouped into five categories based on function: office, accommodation, café/restaurant, exhibition, and unchanged use.

The design of the Authenticity Analysis System followed a multi-phase process. Initially, the problem of quantitatively determining the authenticity of adaptively reused buildings was identified. Alanya was chosen as the study area due to its intense tourism pressure and rapid adaptive-reuse practices, offering a representative context for evaluating the model's transferability. Subsequently, the general characteristics of Alanya's traditional houses were described within the context of the traditional Turkish house typology and building presentation sheets were prepared. The theoretical development of the concepts of conservation and authenticity was reviewed, and authenticity criteria were established based on UNESCO and ICOMOS documents.

With the Fuzzy Logic method, the system's inputs and outputs were defined, and membership functions for these inputs were created. Based on expert opinions, the criteria were compared and weighted using the Analytic Hierarchy Process (AHP) method. Rules were then formulated according to the criteria weights and integrated into the model via Excel. Following fieldwork and building inspections, experts scored the buildings, and the authenticity values were determined by the system based on the arithmetic averages of these scores. In the final phase, the impact of the adaptive reuse process on the authenticity of each building was assessed, and recommendations were proposed.

The concept of authenticity was broadened significantly with the 1994 Nara Conference. Prior to UNESCO's 2005 Operational Guidelines for the Implementation of the World Heritage Convention, authenticity was primarily defined through tangible elements, such as form, material, and function. However, the Nara Document introduced intangible aspects—such as spirit, feeling, management systems, language, and traditions—into the evaluation of authenticity [8]. This expanded definition has been preserved in UNESCO's updated 2023 Operational Guidelines, which re-emphasize the importance of authenticity assessments during the nomination process for cultural properties [10]. Article 82 of UNESCO's guidelines details the parameters to be considered in assessing authenticity: form and design, materials, use, traditions, location, intangible heritage, spirit, and feeling [10]. Stovel [9] notes that authenticity debates extend beyond originality, and interpretations vary across cultural contexts. In this study, the analysis system is grounded in UNESCO/ICOMOS definitions while focusing on observable attributes. As emphasized in ICOMOS's 1999 Charter on the Built Vernacular Heritage, vernacular architecture is central to cultural identity and diversity [11]. While existing research has often focused on monumental architecture, systematic evaluation for vernacular/civil architecture remains limited—this model contributes a quantitative and reproducible framework to fill that gap.

3.1. General Characteristics of the Traditional Turkish House and Traditional Alanya Houses

Many buildings that reflect the residential design traditions of the past and have survived to the present as architectural heritage have been documented and analyzed as cultural assets requiring preservation. Among these, the traditional Turkish house stands out for its distinctive structural, spatial, and cultural features. Distributed across Anatolia, these houses vary in materials, construction techniques, and spatial organizations depending on regional geography and climatic conditions. Despite their diversity, they all share a human-scaled design logic shaped by lifestyle, craftsmanship, and environmental adaptation [19].

Alanya, located on the southern coast of Turkey within the province of Antalya, represents one of the most distinctive regional interpretations of this typology. It lies approximately 135 km east of Antalya and has developed between the Taurus Mountains and the Mediterranean Sea [14]. The settlement pattern, shaped by the sloped topography, created a unique architectural vocabulary that combines spatial hierarchy, climatic adaptation, and material authenticity [15].

As illustrated in Figure 2, the regional positioning of Alanya—first within Türkiye (Figure 2a) and then within the administrative borders of Antalya (Figure 2b)—provides the geographical and cultural context necessary to understand the formation of its vernacular housing tradition. These maps also clarify the spatial boundaries of the study area, which is essential for interpreting the architectural and environmental determinants of the local dwelling type.



Figure 2. (a) Antalya Province in Turkey [14]; (b) Location of Alanya District in Antalya [15].

Following the conquest of Alanya by Sultan Alaeddin Keykubad I in the 13th century, numerous master builders contributed to the city's architectural formation, which continued to evolve until the early 20th century. The result is a local vernacular type that blends Seljuk and Ottoman spatial principles with Mediterranean material culture.

Traditional Alanya houses are generally two-storied. Because of the sloping terrain, the lower level (locally called *gedey*) is usually embedded into the ground and used as storage or for animals, while the upper floor accommodates the main living spaces. The upper level contains the *mabeyn* (anteroom), *hayat* (open hall), *küçük ve büyük içeri* (small and large private rooms), *çağnişir* (bay-windowed sitting room), and the kitchen. The *çağnişir*—the most prestigious room—faces the view and often acts as the modern equivalent of a living room.

Figure 3 visually presents the schematic plan typology of these dwellings, showing the functional differentiation between ground (Figure 3a) and upper floors (Figure 3b). The diagrams clarify the spatial core (*hayat*), circulation, and hierarchical zoning patterns referenced in the text.

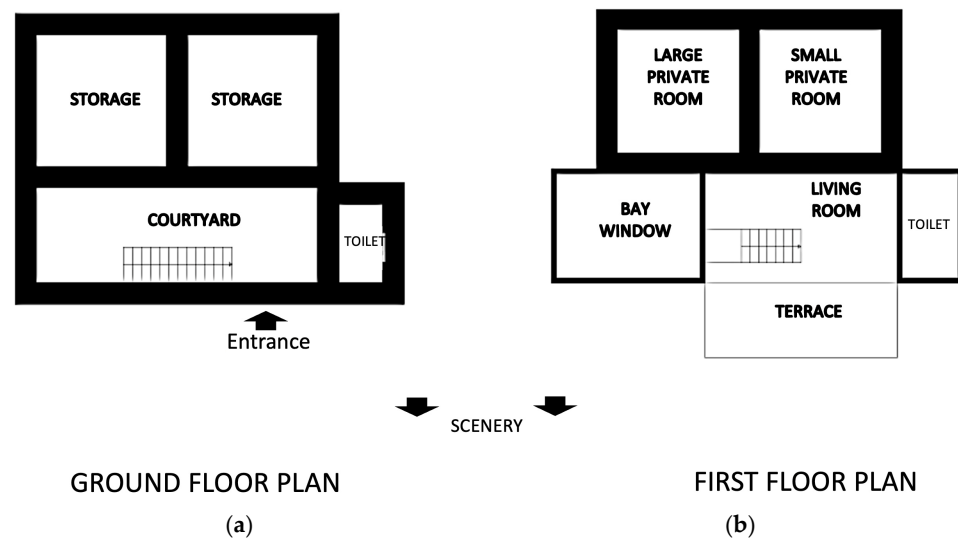


Figure 3. Schematic layout of spatial organization in traditional Alanya houses: (a) Ground floor plan; (b) Upper floor plan.

The functional organization of the house demonstrates a seasonal distinction: the façade facing the sea and sunlight hosts open and semi-open “summer zones,” whereas the more enclosed rear section functions as the “winter zone.” These spatial divisions reflect an advanced understanding of passive climatic comfort [20].

Figure 4 further synthesizes these adaptive spatial relationships, depicting the typical distribution of functional zones and their climatic orientation.

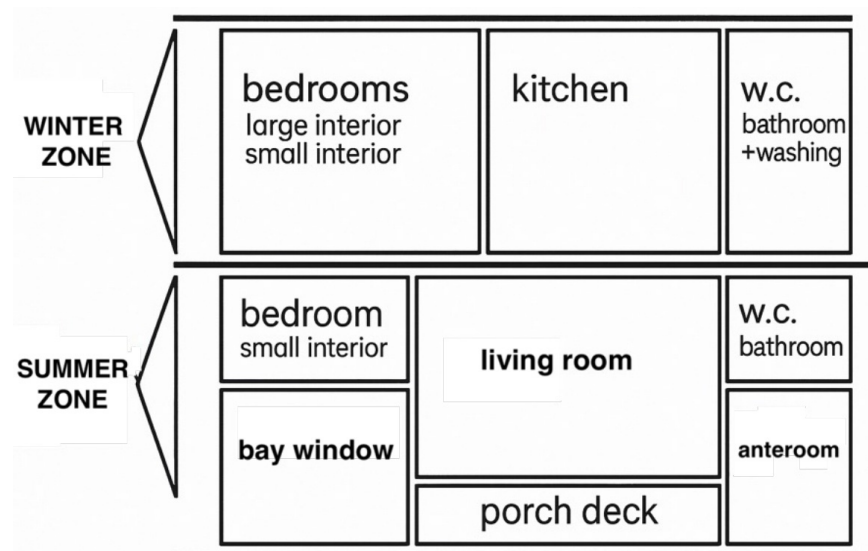


Figure 4. Diagram of the standard spatial distribution in traditional Alanya houses [20].

The façades of Alanya houses express their mixed construction system: rubble stone walls reinforced with timber beams on the ground floor, and bağdadi timber-frame infill walls above. The upper façades—especially those facing the view—display elaborately crafted wooden shutters and iron-grilled windows, representing both functional and aesthetic values [21]. The typological characteristics and observable variables of traditional Alanya houses are summarized in Table 1.

Table 1. Typological Synthesis and Observable Variables of Traditional Alanya Houses.

Typological Feature	Typical Condition in Alanya Houses	Observable Variables Used in Model
Height	2 stories (ground + upper)	Vertical proportion, embedded lower level ratio
Construction Material	Rubble stone + timber frame (<i>bağdadi</i>)	Degree of material replacement, authenticity of structural texture
Façade Organization	Projecting bay (<i>çağnişir</i>), symmetrical window rhythm	Façade alteration ratio, window-to-wall proportion
Spatial Layout	<i>Hayat</i> (hall) as circulation core, summer/winter zone division	Functional continuity, adaptive reuse impact
Open/Semi-open Areas	Terraces and courtyards facing view	Openness ratio, solar orientation
Roof Type	Timber truss, low-pitched tiled roof	Roof authenticity, material substitution
Contextual Setting	Clustered in sloped streets near castle	Relation with topography, environmental continuity

Traditional Alanya houses, therefore, embody a hybrid character—combining local materials, climate-responsive design, and cultural symbolism. From a methodological standpoint, these physical and spatial features provide measurable input variables for the authenticity analysis system developed in this study.

While the study focuses on Alanya, the analytical framework is transferable to other regions with similar vernacular characteristics. The same fuzzy-logic-based structure can evaluate authenticity losses in different cultural contexts by recalibrating input parameters such as material typology, functional adaptation, or climatic response. This adaptability positions the proposed system as a replicable methodological model for sustainable heritage assessment beyond Alanya.

3.2. Development of the Analysis System

The material of this research consists of adaptively reused traditional houses in Alanya. The principal objective of the study is to develop a quantitative system capable of determining the degree of authenticity loss resulting from the adaptive reuse process. To this end, a hybrid decision-support model combining Fuzzy Logic and the Analytic Hierarchy Process (AHP) was constructed to mathematically represent expert judgment within the conservation field.

3.2.1. Mathematical Basis of Fuzzy Logic

Fuzzy logic provides a computational method to model approximate reasoning using linguistic variables rather than crisp values. The approach is especially effective in cases where qualitative criteria—such as “authenticity,” “integrity,” or “spirit”—cannot be evaluated with binary expressions.

Let X denote the universe of discourse, and A a fuzzy subset of X . Each element $x \in X$ is assigned a membership value $\mu A(x) \in [0, 1]$, defining its degree of belonging to set A . Formally,

$$A = \{(x, \mu A(x)) | x \in X, \mu A(x) \in [0, 1]\}$$

where $\mu A(x) = 1$ indicates full membership and $\mu A(x) = 0$ denotes complete exclusion [22].

In this study, the fuzzy sets were constructed to satisfy the general condition:

$$0 \leq \mu(x) \leq 1$$

The triangular membership function is defined as [23]:

$$\mu(x; a, b, c) = \begin{cases} 0, & x \leq a \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ \frac{c-x}{c-b}, & b \leq x \leq c \\ 0, & x \geq c \end{cases}$$

where a and c are the lower and upper bounds, and b is the point of maximum membership ($\mu = 1$).

Similarly, the trapezoidal membership function is defined as [23]:

$$\mu(x; a, b, c, d) = \begin{cases} 0, & x \leq a \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ 1, & b \leq x \leq c \\ \frac{d-x}{d-c}, & c \leq x \leq d \\ 0, & x \geq d \end{cases}$$

This form allows smoother transitions at the extremes (no change or complete loss).

For instance, the linguistic term “largely authentic” corresponds to a membership function with parameters (50, 75, 100). This provides smooth transitions between categories and prevents abrupt classification errors typical of crisp systems.

The defuzzification process converts the fuzzy output into a single numerical value. The centroid (center of gravity) method was adopted, which calculates the output as:

$$y^* = \frac{\int \mu(y) \cdot y \, dy}{\int \mu(y) \, dy}$$

where $\mu(y)$ is the aggregated membership function of the output variable “authenticity” [24]. This technique ensures numerical stability and interpretability of results.

3.2.2. Model Structure and Implementation

The Authenticity Analysis System was constructed using MATLAB R2023a and its Fuzzy Logic Toolbox. It was designed as a comprehensive, five-stage methodological framework that combines qualitative expert judgment and quantitative computation. This sequential structure ensures transparency, reproducibility, and a clear logical connection between expert assessment and model inference.

1. Data Collection and Pre-Processing

Field documentation of ten traditional Alanya houses was performed, including photographic surveys, architectural drawings, and functional classification. The selected buildings represented five adaptive reuse types: office, accommodation, cafe/restaurant, exhibition, and unchanged residential use. A total of 17 experts participated in the Analytic Hierarchy Process (AHP) weighting phase, and 8 experts contributed authenticity scoring for fuzzy inference inputs.

2. Analytic Hierarchy Process (AHP)

Pairwise comparisons were conducted for seven main criteria and three sub-criteria, producing normalized weights that quantify each criterion’s relative significance. Consistency of expert evaluations was verified using the Consistency Ratio (CR), with a calculated value of $0.015 < 0.10$, confirming reliable agreement. These AHP-derived weights were subsequently embedded in the fuzzy rule base to ensure a robust numerical representation of expert knowledge.

3. Fuzzy Logic System Design

The fuzzy inference framework was designed to evaluate authenticity through a non-binary structure. The system uses nine input variables: seven main criteria and the three disaggregated subcriteria of the Form category. In this model, the Form criterion is not treated as a global input; instead, only its subcomponents—Mass Characteristics, Spatial Organization, and Façade Arrangement—are included in the inference structure. All input variables are defined using intervention-based linguistic labels (“No Change”,

“Very Little Change”, “Little Change”, “Moderate Change”, “Large Scale Change”), representing the level of alteration observed in each criterion. The output variable employs authenticity-based linguistic terms (“Completely Authentic”, “Largely Authentic”, “Moderately Authentic”, “Slightly Authentic”, “Lost Authenticity”). This separation ensures a clear conceptual distinction between intervention levels and authenticity outcomes. The model adopts the Mamdani inference system with centroid defuzzification, and the rule base integrates both physical and socio-cultural criteria to support a comprehensive evaluation.

4. Authenticity Value Computation

Expert scores were entered as input data. Using the AHP weights, the system’s decision mechanism applies an “if-then” structure to evaluate authenticity under multiple variable conditions. The output is generated both as a numerical score and a linguistic classification, allowing a dual interpretation suitable for conservation decision-making.

5. Final Authenticity Assessment

Results from the Group 1 (Physical) and Group 2 (Socio-Cultural) modules were combined via a weighted aggregation process to produce the Final Authenticity Value. This synthesis enables comparison across adaptive reuse types and identifies patterns of authenticity preservation or loss. The results were analyzed comparatively and interpreted with respect to functional change, conservation outcomes, and local heritage management recommendations.

Figure 5 illustrates the proposed five-module architecture, which ensures a coherent methodological flow from expert knowledge acquisition to fuzzy-based inference and final evaluation, improving both the replicability and cross-regional adaptability of the model.

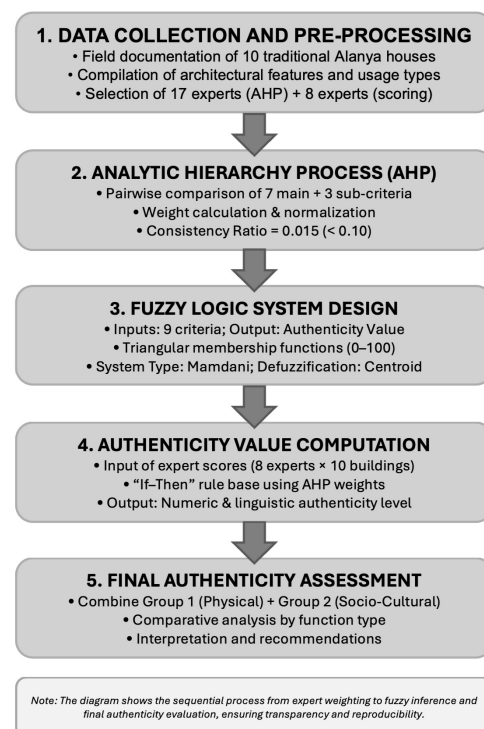


Figure 5. Methodological workflow of the Authenticity Analysis System, illustrating the sequential process from data collection and expert weighting to fuzzy inference and final authenticity assessment.

Each input criterion corresponds to a linguistic variable (e.g., Form, Material, Technique, Function, Environment, Spirit of the Building, and Intangible Cultural Heritage), while the final authenticity value represents the single output variable. To enhance interpretability, the nine input variables are processed within a hierarchical modular structure.

Physical criteria (Material, Technique, and the three Form subcriteria) are grouped under the “Group 1 Authenticity Assessment,” while socio-cultural criteria (Environment, Function, Spirit of the Building, and Intangible Cultural Heritage) form the “Group 2 Authenticity Assessment.” Each module produces an intermediate fuzzy output, and these two outputs are subsequently integrated in the Final Module to generate the overall authenticity value. This structure ensures a transparent computational pathway between expert evaluation and the final authenticity assessment.

The system was structured in three hierarchical layers to ensure an interpretable and traceable evaluation process. In previous academic studies, the criteria of “material,” “form,” and “construction technology” have been defined as primary (main) criteria for evaluating authenticity; meanwhile, “function” and “urban environment” have been considered supporting factors, and the “aura and spiritual value of the building” as complementary criteria [25]. In line with this approach, the authenticity criteria determined in the present study were classified into two main groups.

The first group includes criteria prioritized in earlier studies that directly affect the physical integrity of buildings. These are Form (mass characteristics, spatial organization, façade arrangement), Material, and Technique, and they are examined under the heading “Group 1 Authenticity Assessment.” The second group comprises criteria that do not directly influence authenticity but somewhat indirectly affect it by defining the social and cultural context of the building. These include Environment, Function, Spirit of the Building, and Intangible Cultural Heritage, and they are addressed as “Group 2 Authenticity Assessment.” The evaluation results obtained from these two groups were combined to perform the Final Authenticity Assessment, thereby determining the authenticity levels of adaptively reused traditional houses with a holistic approach. The hierarchical structure of the system, illustrating how physical and socio-cultural criteria interact to produce the final authenticity value, is presented in Figure 6.

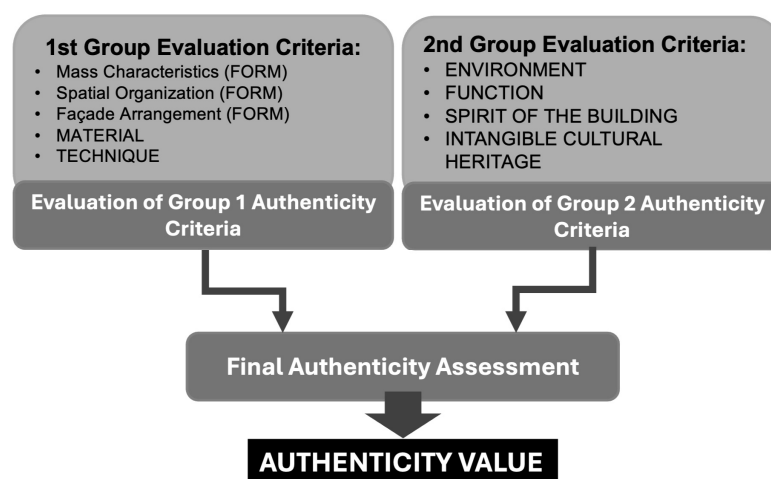


Figure 6. Schematic representation of the hierarchical organization of the Authenticity Analysis System, illustrating how Group 1 (Form–Material–Technique) and Group 2 (Environment–Function–Intangible Criteria) assessments are combined to generate the final authenticity value.

To ensure reproducibility, all fuzzy membership functions, inference rules, and weights were coded within the MATLAB R2023a environment using .fis files.

3.2.3. Integration of AHP into the Fuzzy Model

In the proposed workflow, AHP provides the weighting layer that feeds the fuzzy rule base. The theoretical and procedural background is summarized below. AHP is an open and systematic approach that enables individuals and groups to make decisions by combining

qualitative and quantitative data [26]. The method provides a flexible framework that incorporates both rational and intuitive preferences [27]. A key advantage of AHP is its capability to test the internal coherence of pairwise judgments; a Consistency Ratio (CR) below 0.10 indicates a low probability that comparisons are random [28]. In practice, criteria are first identified and structured hierarchically. Pairwise comparison matrices are then produced by participants selected for their domain expertise. Judgments are recorded on the 1–9 fundamental scale to express the relative importance of one criterion over another, and sensitivity analysis is performed to examine the robustness of results. The final AHP score set is obtained from the normalized priority vectors and represents the weighted influence of factors affecting the authenticity of traditional houses. Regarding expert panel size, the literature suggests that 10–15 participants are sufficient for homogeneous groups, whereas heterogeneous groups may require larger panels [29,30]. Balancing knowledge diversity and manageability, this study employed 17 experts (architects, engineers, art historians) with substantial field experience [31,32]. AHP was used to determine the relative importance of each criterion, thus establishing the weighting factors integrated into the fuzzy inference system.

The number of pairwise comparisons for n criteria is given by the formula [18]:

$$N = \frac{n(n-1)}{2}$$

For this study, $n = 7$ (main criteria) yielded 21 comparisons. The normalized priority vector derived from the eigenvalue method represents the relative weight of each criterion. Consistency was evaluated using the Consistency Ratio (CR):

$$CR = \frac{CI}{RI}, CI = \frac{\lambda_{\max} - n}{n - 1}$$

where the Random Index (RI) = 1.32 for $n = 7$. The resulting $CR = 0.0156 < 0.1$ confirmed that expert judgments were consistent.

Additionally, to verify inter-rater reliability across the 17 experts consulted (architects, restorers, and art historians), Kendall's Coefficient of Concordance (W) was calculated as:

$$W = \frac{12S}{m^2(n^3 - n)}$$

where S is the sum of squared deviations of rank totals, m is the number of experts, and n the number of criteria [33]. A value of $W = 0.87$ indicated strong agreement among the experts, ensuring the robustness of the weight set.

The final weights (Table 2) were integrated directly into the rule base of the fuzzy inference system. The "Form" criterion, divided into Mass Characteristics, Spatial Organization, and Façade Arrangement, was treated hierarchically.

Table 2. Calculated Weights of Main and Subcriteria for the Authenticity Analysis System.

Criterion	Weight	Subcriteria (for Form)	Sub-Weight
Environment	0.07	—	—
Form	0.24	Mass Characteristics	0.07
		Spatial Organization	0.09
		Façade Arrangement	0.17
Material	0.17	—	—
Technique	0.195	—	—
Function	0.145	—	—
Spirit of the Building	0.08	—	—
Intangible Cultural Heritage	0.10	—	—

3.3. Implementation of the Fuzzy Logic Model in MATLAB

Many everyday technological systems rely on fuzzy logic models. Since the theoretical background and historical development of fuzzy logic are already presented in Section 3.2.1, this section focuses on the practical implementation of the model in MATLAB.

The Authenticity Analysis System developed in this study was implemented using the Fuzzy Logic Toolbox of MATLAB R2023a. This stage represents the practical application of the theoretical framework established in Section 3.2, translating expert evaluations and criterion weights into a reproducible computational model. The model was built as a Mamdani-type inference system, which allows the mapping of linguistic variables into numerical outputs representing the authenticity value of each building.

3.3.1. Model Design and Input Definition

The Authenticity Analysis System developed in this study incorporates seven main criteria derived from the UNESCO Operational Guidelines for the Implementation of the World Heritage Convention (2023) and the ICOMOS Nara Document on Authenticity (1994) [10,16]. These parameters represent the multidimensional structure of authenticity in architectural heritage. Among them, the “Form” criterion has been subdivided into three subcriteria—Mass Characteristics, Spatial Organization, and Façade Arrangement—to capture the morphological and proportional variations specific to vernacular architecture.

The selected input parameters reflect the physical, functional, and intangible components of traditional houses, while the output variable represents the final authenticity value calculated by the fuzzy inference mechanism. This structure allows both tangible and intangible dimensions of heritage to be integrated within a single measurable system.

In previous academic studies, the criteria of “Material,” “Form,” and “Construction Technique” were defined as primary determinants of authenticity, while “Function” and “Urban Environment” were considered as supporting factors, and “Spirit” and “Intangible Cultural Heritage” as complementary factors. In alignment with this approach, the criteria adopted in this study were classified into two main groups:

- Group 1 includes criteria directly affecting the physical integrity of buildings: Form, Material, and Technique.
- Group 2 includes contextual and cultural criteria indirectly influencing authenticity: Environment, Function, Spirit of the Building, and Intangible Cultural Heritage.

The evaluation results obtained from these two groups were later combined to perform the Final Authenticity Assessment, ensuring a holistic understanding of authenticity within adaptive reuse practices.

To operationalize these conceptual criteria in the fuzzy logic model, the original UNESCO definitions were contextualized and translated into measurable, field-based indicators (Table 3), ensuring that both tangible and intangible aspects of traditional Alanya houses can be assessed through quantifiable observations.

The field-based indicators listed in the third column were determined through on-site documentation, photographic surveys, and expert evaluations of ten traditional houses in Alanya. By linking UNESCO and ICOMOS authenticity dimensions with measurable architectural parameters, the model establishes a transparent and traceable relationship between theoretical authenticity concepts and empirical architectural evaluation.

Table 3. Adaptation of Authenticity Criteria Presented in the UNESCO Operational Guidelines for the Implementation of the World Heritage Convention to the Authenticity Analysis System.

UNESCO Operational Guidelines Criteria	Authenticity Analysis System	Observable Variables (Field-Based Indicators)
Location and Setting	Environment	Relationship with topography, orientation, and surrounding spatial continuity
Form and Design	Form (Mass Characteristics, Spatial Organization, Façade Arrangement)	Plan symmetry, proportion of open/semi-open spaces, façade configuration
Materials and Substance	Material	Material substitution ratio, degree of deterioration, repair or reconstruction type
Traditions, Techniques, and Management Systems	Technique	Original craftsmanship, joinery type, structural continuity
Use and Function	Function	Type and extent of adaptive reuse, compatibility of function
Language and Other Intangible Heritage Forms	Intangible Cultural Heritage	Continuity of local practices, symbolic meaning, traditional identity
Spirit and Feeling	Spirit of the Building	Perceived sense of place, atmospheric authenticity

3.3.2. Membership Function Definition and Linguistic Variables

In the developed Authenticity Analysis System, fuzzy logic was used to represent the uncertainty inherent in evaluating architectural authenticity. The input variables defined in Section 3.3.1 were transformed into linguistic variables through membership functions designed in MATLAB Fuzzy Logic Toolbox (R2023a). This enabled the model to interpret the intermediate states between the full preservation and total loss of authenticity, reflecting the nuanced and interpretive nature of architectural conservation.

Each input variable was defined within a universal set [0–100], representing the full range of intervention levels (from “No Change” to “Large Scale Change”). The output variable (Final Authenticity Level) was also expressed in this same range.

To model the gradual transition between these states, triangular and trapezoidal membership functions were used. These shapes were preferred due to their computational simplicity and ability to approximate linguistic uncertainty effectively [22,23].

Following the ICOMOS (2011) Guidance on Heritage Impact Assessments for Cultural World Heritage Properties [34], five linguistic categories were defined to evaluate authenticity change levels. These linguistic variables and their numerical ranges are listed in Table 4.

Table 4. Membership Functions and Numerical Ranges of Input Variables.

Linguistic Variable	Definition	Numerical Range	Membership Function Type
No Change (NC)	The component remains fully authentic	[75 100 100]	Trapezoidal
Very Little Change (VLC)	Minor alteration, no integrity loss	[50 75 100]	Triangular
Little Change (LC)	Limited but noticeable alteration	[25 50 75]	Triangular
Moderate Change (MC)	Distinct modification of the component	[0 25 50]	Triangular
Large Scale Change (LSC)	Substantial loss of authenticity	[0 0 25]	Trapezoidal

The output variable, representing the authenticity level calculated by the system, was also expressed using five linguistic categories. The ranges and membership function types are given in Table 5.

In MATLAB, these fuzzy sets were defined via the Fuzzy Logic Designer interface using the trimf and trapmf functions. The input and output parameters were set according to the ranges listed above, and the fuzzification process transformed the crisp expert evaluation scores into fuzzy values for further processing.

A Mamdani-type inference system was selected because of its interpretability and ability to represent expert knowledge through intuitive if–then rules [17]. Each input variable corresponds to one of the authenticity criteria, while the single output variable represents the resulting authenticity level after inference and defuzzification.

The resulting membership functions, showing the transition of authenticity states within the [0–100] range, are illustrated in Figure 7.

Table 5. Membership Functions and Numerical Ranges of Output Variables.

Linguistic Output Variable	Interpretation	Numerical Range	Membership Function Type
Completely Authentic (CA)	Full preservation of authenticity	[75 100 100]	Trapezoidal
Largely Authentic (LA)	High degree of authenticity retained	[50 75 100]	Triangular
Moderately Authentic (MA)	Partial authenticity with moderate alterations	[25 50 75]	Triangular
Slightly Authentic (SA)	Significant intervention reducing authenticity	[0 25 50]	Triangular
Lost Authenticity (NA)	Authenticity completely compromised	[0 0 25]	Trapezoidal

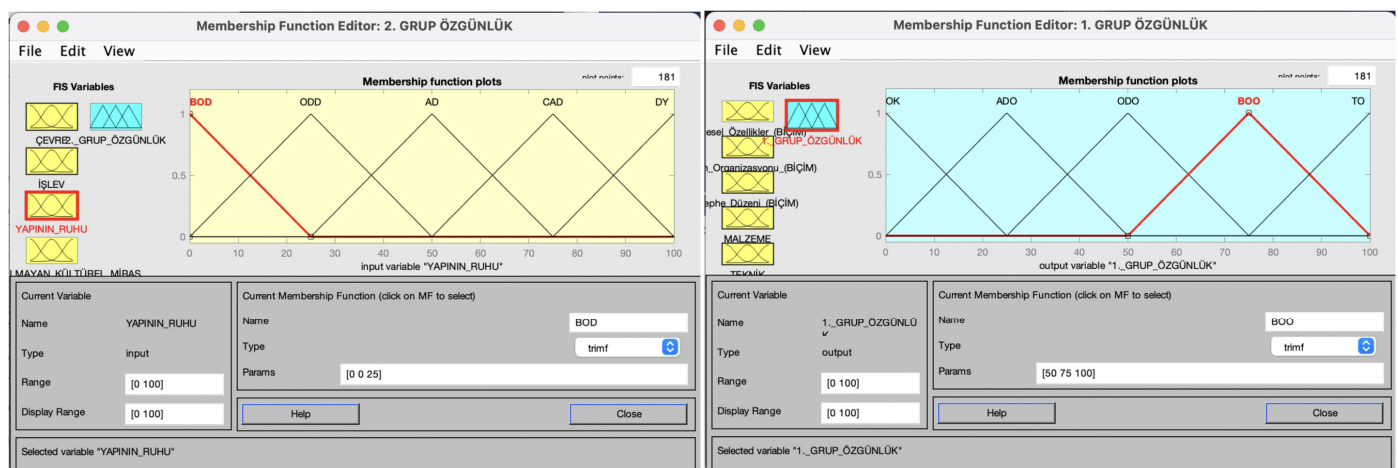


Figure 7. Membership functions of input and output variables designed in MATLAB Fuzzy Logic Toolbox (R2023a).

3.3.3. Rule Creation and Inference Process

The rule base of the developed Authenticity Analysis System integrates the weighted evaluation of criteria derived from the Analytic Hierarchy Process (AHP) with fuzzy inference logic implemented in MATLAB R2023a Fuzzy Logic Toolbox.

Rule Definition Based on AHP-Weighted Criteria.

Each authenticity criterion was assigned a specific weight obtained through AHP pairwise comparisons, as presented in Table 2.

These weights express the relative importance of each criterion within the authenticity assessment framework. The pairwise consistency ratio ($CR = 0.015621 < 0.10$) confirmed the internal reliability of expert judgments, consistent with Saaty’s methodological threshold for acceptable consistency [18].

The weight values were then directly transferred into MATLAB to scale the influence of each input variable during fuzzy rule generation.

For the “Form” criterion, which includes three subcomponents (Mass Characteristics, Spatial Organization, Façade Arrangement), an additional AHP sub-hierarchy was

developed, and its consistency ratio (CR = 0.041612) validated the coherence of expert evaluations.

The general structure of the fuzzy rules follows the form:

$$\text{IF } (X_1 \text{ is } A_1) \text{ and } (X_2 \text{ is } A_2) \text{ and } \dots \text{ and } (X_n \text{ is } A_n) \text{ then } (Y \text{ is } B)$$

where

- X_i represents the input variables (authenticity criteria),
- A_i are the linguistic terms (e.g., “Very Little Change”, “Moderate Change”),
- Y denotes the output variable (“Authenticity Level”),
- B is the linguistic output (e.g., “Largely Authentic”).

Each rule is evaluated simultaneously using Mamdani-type inference, a method noted for its transparency and suitability in modeling expert reasoning [24], and the results are aggregated via the minimum–maximum composition method.

Rule Matrix Generation and Total Rule Count.

The fuzzy inference system contains multiple rule subsets representing the hierarchical evaluation stages of authenticity:

- Group 1 (Physical Criteria) → Form, Material, Technique ($5^5 = 3125$ possible combinations)
- Group 2 (Contextual Criteria) → Environment, Function, Spirit, Intangible Cultural Heritage ($5^3 \times 2 = 250$ combinations)
- Final Authenticity Assessment → Group 1 & Group 2 outputs ($5^2 = 25$ combinations)

Thus, the full rule base consists of 3400 potential rules systematically derived from all possible combinations of input membership levels.

Each rule was assigned an output value based on the weighted average of midpoints of the relevant membership functions, scaled by the AHP criterion weights, as shown in Equation (1):

$$Y = \frac{\sum (W_i \times M_i)}{\sum W_i} \quad (1)$$

where

W_i = criterion weight,

M_i = midpoint value of the corresponding membership function.

This formulation is consistent with Mendel’s rule-based fuzzy systems framework, which emphasizes interpretability and computational efficiency [23] Mendel.

Example of Rule Evaluation.

The calculation of the sample output authenticity value is based on the weighted aggregation of inputs, as exemplified in Table 6.

Table 6. Example calculation of authenticity score through AHP-weighted fuzzy inputs.

Criterion	Linguistic Input	Membership Midpoint (M_i)	Weight (W_i)
Mass Characteristics	Very Little Change	75	0.0875
Spatial Organization	Moderate Change	25	0.0925
Façade Arrangement	Very Little Change	75	0.0775
Material	Little Change	50	0.1750
Technique	Moderate Change	25	0.1950

Applying Equation (1):

$$Y = \frac{(0.0875 \times 75) + (0.0925 \times 25) + (0.0775 \times 75) + (0.175 \times 50) + (0.195 \times 25)}{0.0875 + 0.0925 + 0.0775 + 0.175 + 0.195} = 44.42$$

According to the output membership functions in Table 5, the value 44.42 corresponds to the linguistic category “Moderately Authentic.”

Inference Mechanism and Defuzzification.

The Mamdani fuzzy inference system was used due to its interpretability and capacity to reflect expert reasoning [24]. All if–then rules were entered through MATLAB’s Fuzzy Logic Designer using the addRule command.

The inference process employed the min–max composition approach, and results were aggregated through the centroid defuzzification method, which computes the center of gravity of the aggregated fuzzy output.

The centroid defuzzification formula applied was:

$$Y^* = \frac{\int \mu(y) \times y \, dy}{\int \mu(y) \, dy}$$

This method was preferred because it yields stable and intuitive results aligned with expert perception and previous fuzzy control applications [23,24]. To verify the reliability of expert-based scoring prior to rule inference, Kendall’s coefficient of concordance ($W = 0.83$) was used, confirming a high level of agreement among raters [33].

4. Analysis of Traditional House Examples and Findings

The aim of this analysis is to validate the functionality and applicability of the Authenticity Analysis System developed in this study and to identify trends in authenticity loss among adaptively reused traditional Alanya houses. Through this comparative assessment, the study seeks to determine how different reuse functions—such as accommodation, exhibition, office, or restaurant—affect both the tangible and intangible dimensions of architectural authenticity.

A total of ten traditional houses were selected, each representing distinct functions and degrees of restoration intervention. The selection ensured typological and morphological diversity while maintaining representativeness for Alanya’s vernacular housing stock. The five adaptive reuse categories identified in the study are office, accommodation, café/restaurant, exhibition, and unchanged use. These categories enabled the evaluation of authenticity variations depending on function type.

The ten selected houses are located partly within the historical urban fabric of Alanya (6 examples) and partly in the contemporary city center (4 examples), distributed across neighborhoods characterized by traditional street layouts and courtyard-centered parcel organization. Their locations, relative to topography and urban structure, are shown in Figure 8.

For each building, documentation tables were prepared, including data on their location, relationship with adjacent structures, restitution and restoration plans, front façade drawings, and pre- and post-restoration photographs (Figure 8). These documentation sheets were used to support expert evaluations and to visually verify the authenticity levels assigned to each case.

Eight experts specializing in architectural conservation, vernacular heritage, and restoration practices participated in the evaluation process. Selection was based on professional experience, academic background, and familiarity with Alanya’s traditional building typology. The experts evaluated ten case-study buildings according to the nine authenticity criteria defined in the system.

To ensure inter-rater reliability, Kendall's coefficient of concordance (W) was computed. The result ($W = 0.83$) indicates a high degree of agreement among the experts, demonstrating consistency in scoring and reliability of the model's evaluation phase.

Each expert conducted field-based assessments of the buildings' façades, spatial organization, material use, and intangible attributes. The average values of these assessments were calculated and used as input data in the fuzzy logic system.

Table 7 presents the arithmetic mean scores of the expert evaluations for both Group 1 (Physical Authenticity Criteria) and Group 2 (Contextual Authenticity Criteria).

The results show that buildings retaining their original residential function (e.g., Koçak House) achieved the highest overall authenticity scores. In contrast, structures converted into accommodation or restaurant uses (e.g., Sezer House and Sipahioğlu House) exhibited substantial losses, especially in the Spirit and Feeling and Intangible Cultural Heritage criteria. These overall tendencies are summarized in Table 8, which highlights that accommodation functions consistently correspond to the lowest authenticity levels, while original residential use preserves the highest levels of authenticity.

Across all cases, the physical authenticity components (Form, Material, Technique) generally scored higher than the contextual attributes (Spirit, Function, Intangible), indicating that while restoration interventions often respect tangible integrity, intangible values are more vulnerable to change.

A noticeable correlation was observed between material alterations and the perceived "spirit" of the building—cases with greater material intervention tended to score lower in spirit and feeling. For example, Dim House demonstrates high physical integrity yet moderate contextual authenticity due to the neutral character of its new archival function.

Overall, the model successfully captured varying degrees of authenticity preservation among function types, proving capable of both quantitative differentiation and qualitative interpretation. These results validate the system's potential for application in comparative heritage assessments and adaptive reuse planning.



Figure 8. Geographic location of the analyzed traditional houses in Alanya showing the historic center, main city center and main road axes.

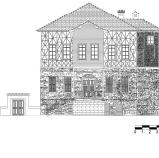
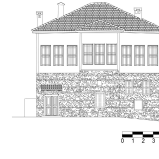
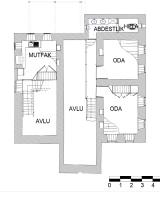
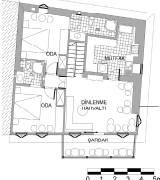
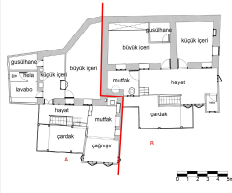
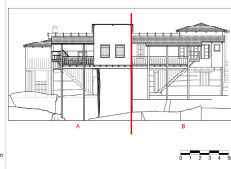
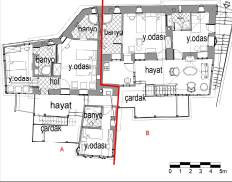
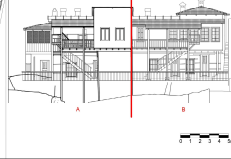
GENERAL INFORMATION	LOCATION		LIVING FLOOR PLAN	FRONT FAÇADE	VISUAL
HASANAĞALAR MANSION DATE OF CONSTRUCTION: Although the exact construction date of the building is unknown, it is estimated to have been built in the late 1800s when the city's second settlement area began to develop on a designated flat terrain. REGISTRATION STATUS: The building is a registered structure located within a historical preservation zone. LOCATION: It is situated in the second settlement area. Due to rapid urbanization in this area, it is now compressed between apartment buildings and busy streets. PLAN SCHEME: The building follows an "inner hall" (sofali) plan scheme. During restoration work, the interior walls of the house were preserved, allowing the original plan scheme to remain legible. MATERIAL AND TECHNIQUE: The ground and first floors feature rubble stone walls with wooden reinforcements, the second floor has wooden frame walls filled with brick, and the overhangs (çıkma) use a timber lath (bağdadi) technique. Damaged and destroyed parts of the building have been reconstructed using original materials and techniques. CURRENT FUNCTION: Office		BEFORE			
	OLD PHOTO 	AFTER			
ÇIRPANLI HOUSE DATE OF CONSTRUCTION: According to an inscription found on the building, it was constructed in 1922. REGISTRATION STATUS: The building is a registered structure located within a historical preservation zone. LOCATION: It is situated in the second settlement area. Due to rapid urbanization in this area, it is now compressed between apartment buildings and busy streets. PLAN SCHEME: The building follows an "inner hall" (sofali) plan scheme. During restoration work, the interior walls of the house were preserved, allowing the original plan scheme to remain legible. MATERIAL AND TECHNIQUE: The ground and first floors feature rubble stone walls with wooden reinforcements; the second floor uses the timber lath (bağdadi) technique. A rough layer with straw and a fine lime plaster coating was applied on top. Damaged and destroyed parts of the building have been reconstructed using original materials and techniques. CURRENT FUNCTION: Association Office		BEFORE			
	OLD PHOTO 	AFTER			
SEZER HOUSE DATE OF CONSTRUCTION: According to oral sources, the building was constructed in 1916. REGISTRATION STATUS: It is protected under Cultural Heritage Building (KV) preservation decisions. LOCATION: Located in the 1st Degree Conservation Zone. The building is situated in Tophane, the oldest settlement area of the city. PLAN SCHEME: The original plan of the building follows a type with an exterior hall (sofa). When repurposed as a hotel, the building's original plan scheme was entirely lost. MATERIAL AND TECHNIQUE: The lower floors feature rubble stone walls with wooden reinforcements. On the upper floor facing the view, the wooden lath (bağdadi) wall technique was applied in a way that respects the original structure and materials. However, the removal of interior walls led to the complete loss of the original plan and caused major losses in both structure and material, clearly evident. CURRENT FUNCTION: Hotel		BEFORE			
	OLD PHOTO 	AFTER			
ŞİMŞEK HOUSE DATE OF CONSTRUCTION: No verifiable data has survived regarding the construction date or the person who commissioned the building. REGISTRATION STATUS: It is protected under Cultural Heritage Building (KV) preservation decisions. LOCATION: The building is located in Tophane, the oldest settlement area of the city. PLAN SCHEME: The building's original plan follows the exterior hall type. On top of the ground floor is an additional floor. In this region, a few other similar structures combine individual houses in an adjacent order to form a block of buildings with aligned façades. The current usage has altered the original plan scheme. MATERIAL AND TECHNIQUE: Most of the building has collapsed; the destroyed parts were reconstructed using traditional construction techniques and materials. The façade combines traditional and new architectural elements, with additions designed in a modern style. These additions significantly alter the original visual character and material of the building, and these changes are evident in the current façade. CURRENT FUNCTION: Hotel		BEFORE			
	OLD PHOTO 	AFTER			

Figure 8. Cont.

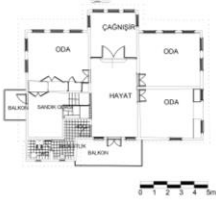
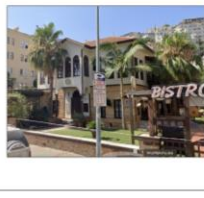
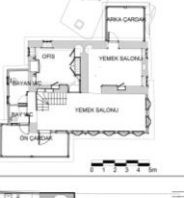
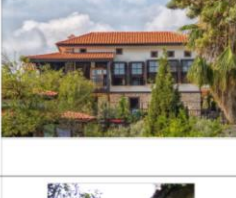
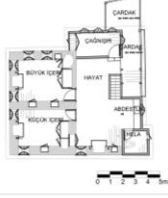
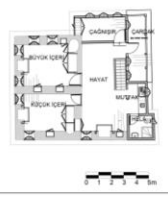
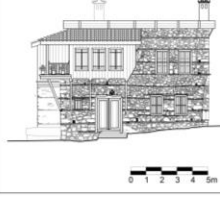
GENERAL INFORMATION	LOCATION		LIVING FLOOR PLAN	FRONT FAÇADE	VISUAL
DURUSOY HOUSE DATE OF CONSTRUCTION: Built between 1870–80 by Fehmi Salur from Alanya. REGISTRATION STATUS: A registered building located in the Historical Building Conservation Area. LOCATION: Located in the Transition Zone of the Conservation Area, between the first and second settlement zones. Due to rapid urbanization, it is now compressed between apartment blocks and busy streets. PLAN SCHEME: The building follows a central hall (sofa) plan scheme with a distinctive architectural style and a layout separating the harem and selamlık (private and guest quarters), a feature seen in the region. In the new functional layout, the original scheme and separate entrances for the harem and selamlık have been preserved. MATERIAL AND TECHNIQUE: The construction techniques and materials used are local and traditional. Seasonal distinctions were taken into consideration when selecting materials and techniques. CURRENT FUNCTION: Restaurant		BEFORE			
		AFTER			
SİPAHIOĞLU HOUSE DATE OF CONSTRUCTION: According to information from the original owners, it was built in the early 1900s. REGISTRATION STATUS: Protected under Traditional Structure (GY) conservation regulations. LOCATION: Situated in the Hisarçı Neighborhood, within the city walls and part of the city's oldest settlement area. PLAN SCHEME: Based on the restoration drawings, the building retains a triple-hall plan scheme with later additions that partially obscure the original layout. In the current use, the plan has been returned to its original form. During this process, an early-period toilet block—rare for its time—has been preserved. The triple-hall layout is commonly seen in similar examples in the region, especially in structures repurposed for dining. MATERIAL AND TECHNIQUE: The construction follows traditional methods and materials, aiming to preserve the historical texture and ensure durability. Locally appropriate materials and techniques were chosen during the renovation process. CURRENT FUNCTION: Restaurant		BEFORE			
	OLD PHOTO 	AFTER			
DİM HOUSE DATE OF CONSTRUCTION: According to oral sources, the house was built in the 1860s. REGISTRATION STATUS: It is under protection as a Cultural Heritage Building (KV). LOCATION: The building is located in the first settlement area of the city's historic core, within a 1st-degree conservation zone. PLAN SCHEME: This two-story structure, known as Dim House, follows a central hall (sofa) plan type. MATERIAL AND TECHNIQUE: The ground floor features rubble stone walls with wooden reinforcements, forming enclosed, winter-use spaces. The upper floor predominantly consists of wooden structures and contains summer-use spaces. During restoration, the original materials and forms of sections deemed preservable were retained and stabilized, while some modern techniques were employed for adaptations required by its new function. CURRENT FUNCTION: Exhibition – Museum		BEFORE			
	OLD PHOTO 	AFTER			
SANDIK EMİNİ KAYHANLAR HOUSE DATE OF CONSTRUCTION: Based on the inscription on the exterior wall, the house was built in 1889. REGISTRATION STATUS: It is under protection as a Cultural Heritage Building (KV). LOCATION: Located in the Hisarçı Neighborhood, within the city's oldest settlement area enclosed by city walls. PLAN SCHEME: The building follows the exterior hall (sofa) plan type. The plan scheme has been preserved in its new use. MATERIAL AND TECHNIQUE: The two-story building features rubble stone walls with wooden reinforcements on the ground floor. The local technique known as "civileme" was used, in which broken bricks and tiles are embedded around the stones. On the upper floor, different wall systems coexist: on the façade facing the view, a wooden frame system covered with timber cladding was used; on the rear façade, the lower floor is of rubble stone, and the upper floor is built with adobe and brick. Traditional tiled roofs and a single-story tiled cave system were used. CURRENT FUNCTION: Exhibition – Museum		BEFORE			
	OLD PHOTO 	AFTER			

Figure 8. Cont.

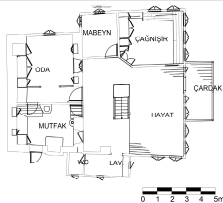
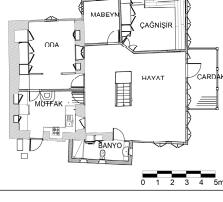
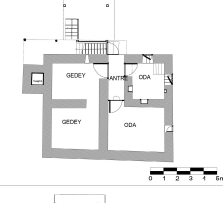
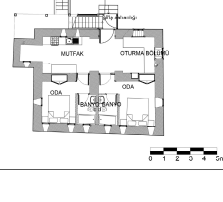
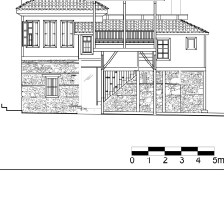
	GENERAL INFORMATION	LOCATION		LIVING FLOOR PLAN	FRONT FAÇADE	VISUAL
KOÇAK HOUSE	DATE OF CONSTRUCTION: The building is dated to the 19th century. REGISTRATION STATUS: It is under protection as a Cultural Heritage Building (KV). LOCATION: Located in the Tophane neighborhood, within the city's first settlement area. PLAN SCHEME: The building follows an exterior hall (sofa) plan. It is a three-story structure, and due to the sloping terrain, basement-level spaces exist beneath the main floors. On the ground floor, traditionally used as a harem in daily life, women would engage in domestic tasks such as weaving silk or baking bread in the oven. The first floor contains the main living and circulation areas. The upper floor contains summer use spaces, predominantly built with timber, facing the view. Behind this section, winter-use rooms made of rubble stone walls with wooden reinforcements and smaller openings (to retain warmth) are located. MATERIAL AND TECHNIQUE: The lower floors are made of rubble stone walls with timber reinforcements; the upper floors predominantly use timber. The combination of materials and spatial organization reflects seasonal use. CURRENT FUNCTION: Residence		BEFORE			
		OLD PHOTO	AFTER			
KÖK HOUSE	DATE OF CONSTRUCTION: Built in the late 19th or early 20th century by the late manufacturer Naci Kök. REGISTRATION STATUS: A registered building located in the Historical Building Conservation Area. LOCATION: Located between the first and second settlement areas. Due to rapid urbanization, it is now surrounded by apartment blocks and busy streets. PLAN SCHEME: The building originally followed an exterior hall (sofa) plan. In the current layout, the original ground-floor spaces such as stables—now obsolete—were replaced by bedrooms, bathrooms, a kitchen, and a living room to suit modern living standards. During these modifications, some internal walls were removed to enlarge spaces, and slotted windows (mazgal) were added to formerly blind walls. On the upper floor, the bath was converted into a storage area, and walls between rooms were removed to allow a more open plan and retain visible structural elements. MATERIAL AND TECHNIQUE: While some interventions were made according to the new users' demands, traditional materials and techniques were preserved and applied wherever possible. CURRENT FUNCTION: Residence		BEFORE			
			AFTER			

Figure 8. General Characteristics, Architectural Features, and Current Functions of Selected Traditional Residential Buildings in Alanya.

Table 7. Average Values of Authenticity Criteria for Examined Examples as Assessed by Experts.

	GROUP 1						GROUP 2		
	Mass Char.	Form Spatial Org.	Façade Arng	Material	Technique	Environment	Function	Spirit & Feeling	Intangible C. H.
Hasanağalar Mansion—Alanya Cultural Directorate	90.6	91.8	83.1	68.7	91.8	13.7	0 *	61.8	89.3
Çırpanlı House—Association Office	82	72	72	81	85	7	0 *	81	70
Sezer House—Boutique Hotel	71.9	13.7	70	17.5	15.6	84.4	0 *	3.1	6.2
Şimşek House—Boutique Hotel	65	71.8	77.5	69.4	72.5	81.25	0 *	18.1	33.1
Durusoy House—Cafeteria/Restaurant	67.5	75	82.5	66.8	71.8	15.6	0 *	30	24.3
Sipahioğlu House—Restaurant	52.5	50	51.2	65	73.7	90.6	0 *	8.1	12.5
Dim House—City Archive	71.7	81.2	73.5	81.2	83	52.5	0 *	16	39.5
Sandık Emimi Kayhanlar House—Cultural House	85.1	90	82.1	90	92.1	93.2	0 *	73.7	90
Koçak House	93	92	93.2	87.7	88.2	95	100	90	90
Kök House	90	79	90	82.1	83.7	26.5	100	86	67

* Note: In this study, a value of “0” does not indicate missing or “not applicable” data; it represents a complete absence of the evaluated attribute as determined by expert scoring. All values fall within the 0–100 range. In the case of the “Function” criterion, buildings whose original residential use has been entirely replaced by a new commercial or touristic function were scored as “0” by the experts, since the original functional identity is considered completely lost under such conditions.

Table 8. Summary of Key Findings from the Authenticity Analysis.

Criterion/Reuse Type	Main Finding
Accommodation (Boutique hotels)	Lowest authenticity scores overall
Residential/Original Use	Highest authenticity retention
Spirit & Feeling	Lowest-scoring criterion across all cases
Intangible Cultural Heritage	Consistently low in buildings with extensive functional transformation
Material–Spirit Relationship	High material intervention correlates with lower “Spirit & Feeling”
Cultural/Exhibition Uses	Moderate physical authenticity, variable contextual authenticity

5. Results

Using the proposed Authenticity Analysis System, we computed authenticity scores for ten traditional Alanya houses that underwent adaptive reuse. Results are reported at three levels: (i) Group 1 (physical integrity: Form—Mass Characteristics, Spatial Organization, Façade Arrangement—Material, Technique), (ii) Group 2 (contextual/cultural: Environment, Function, Spirit of the Building, Intangible Cultural Heritage), and (iii) the Final Authenticity value integrating both groups.

To enhance transparency beyond absolute scores, we additionally report distributional descriptors (range and rank order), inter-rater reliability, and function-level contrasts; and we interpret architectural and contextual drivers of the observed differences.

Across the ten cases, Group 1 scores ranged from 30 to 90 (min: Sezer House, boutique hotel; max: Koçak House, unchanged residential use), indicating substantial variability in the preservation of tangible attributes. Group 2 scores ranged from 23.3 to 82.8 (min: Durusoy House, café/restaurant; max: Koçak House), showing a wider dispersion in contextual attributes than in physical ones. Final Authenticity ranged from 27 to 86 (min: Sezer House; max: Koçak House).

Inter-rater agreement for the expert scoring phase was high (Kendall’s $W = 0.83$), supporting the reliability of mean expert inputs used by the fuzzy system.

To assess statistical associations between the two main dimensions, a Spearman rank correlation test was conducted between Group 1 and Group 2 scores. The resulting coefficient ($\rho = 0.62$, $p < 0.05$) indicates a moderate positive association, suggesting that buildings with higher physical integrity also tend to retain higher contextual authenticity, though exceptions exist.

Additionally, a Kruskal–Wallis H test was performed to examine differences among adaptive reuse categories (residential, exhibition, office/archive, accommodation, café/restaurant). The test revealed statistically significant differences in Final Authenticity across use types ($H = 8.91$, $p < 0.05$). Pairwise contrasts indicate that unchanged residential use significantly differs from accommodation and restaurant functions, which aligns with the model’s interpretation of functional compatibility as a key determinant of authenticity.

Detailed Group 1, Group 2, and Final scores for each building are presented in Tables 9–11, while criterion-level averages are summarized in Table 8.

Table 9. Results Obtained from the Group 1 Authenticity Assessment System.

	Traditional House	Group 1 Authenticity Analysis Result
1	Koçak House	90
2	Sandık Emini Kayhanlar House	89
3	Hasanağalar Mansion—Alanya Cultural Directorate	85
4	Kök House	84
5	Dim House—City Archive	80
6	Çırpanlı House—Association Office	80
7	Durusoy Konutu- Kafeterya/Restoran	72
8	Durusoy House—Cafeteria/Restaurant	71
9	Şimşek House—Boutique Hotel	62
10	Sezer House—Boutique Hotel	30

Table 10. Results Obtained from the Group 2 Authenticity Assessment System.

	Traditional House	Group 2 Authenticity Analysis Result
1	Koçak House	82.8
2	Kök House	75
3	Sandık Emini Kayhanlar House—Cultural House	50
4	Hasanağalar Mansion—Alanya Cultural Directorate	38.4
5	Çırpanlı House—Association Office	32.9
6	Şimşek House—Boutique Hotel	26
7	Dim House—City Archive	25
8	Sipahioğlu House—Restaurant	25
9	Sezer House—Boutique Hotel	25
10	Durusoy House—Cafeteria/Restaurant	23.3

Table 11. Results Obtained from the Final Authenticity Assessment System.

	Traditional House	Final Authenticity Analysis Result
1	Koçak House	86
2	Kök House	78.5
3	Sandık Emini Kayhanlar House—Cultural House	65.4
4	Hasanağalar Mansion—Alanya Cultural Directorate	56.6
5	Çırpanlı House—Association Office	51.5
6	Dim House—City Archive	46.7
7	Şimşek House—Boutique Hotel	43
8	Durusoy House—Cafeteria/Restaurant	42
9	Sipahioğlu House—Restaurant	40.8
10	Sezer House—Boutique Hotel	27

According to the Group 2 authenticity analysis, the highest score belongs to Koçak House, restored for residential use (82.8), followed by Kök House, also used as a residence (75). Both buildings fall into the “largely authentic” category. Sandık Emini Kayhanlar House ranks third with a score of 50 and is evaluated as “moderately authentic.” The other houses—especially those functioning as offices, hotels, restaurants, and cafés—score between 23.3 and 38.4 and are considered “slightly authentic.” The primary reason for

these low scores is that buildings with changed functions receive zero points in the function criterion and tend to score low in the environment criterion due to their location in the city center. Overall, most buildings analyzed in the Group 2 assessment exhibit low levels of authenticity.

When comparing the results of both group authenticity analyses, it is evident that all traditional houses experienced a decline in their scores. In fact, for some traditional houses, this decline caused their authenticity value to drop to a lower classification. Examining the final results, traditional houses restored to their original function—Koçak House and Kök House—as well as Kayhanlar House, restored as a museum—were found to be largely authentic. The majority of the traditional houses examined in the study were moderately authentic, while Sezer House, functioning as a boutique hotel, was classified as slightly authentic.

A consistent pattern emerges when results are grouped by adaptive reuse function:

- Unchanged residential use achieves the highest authenticity (e.g., Koçak House: Group 1 = 90; Group 2 = 82.8; Final = 86).
- Exhibition/museum yields high physical and moderate contextual authenticity (e.g., Kayhanlar House: Group 1 = 89; Group 2 = 50; Final = 65.4).
- Office and municipal archive functions retain good physical but lower contextual scores (e.g., Dim House: Group 1 = 80; Group 2 = 25; Final = 46.7).
- Accommodation and restaurant/café are associated with the lowest final authenticity (e.g., Sezer House: Group 1 = 30; Group 2 = 25; Final = 27; Sipahioğlu House: Final = 40.8).

These gradients align with the system's structure: Function is a contextual driver (Group 2) that both directly penalizes a change in use and indirectly correlates with interventions affecting Spirit and Intangible Cultural Heritage. This pattern confirms that the function type acts as a key predictor of overall authenticity within the fuzzy inference framework.

Across cases, three recurring mechanisms explain authenticity loss:

- Program-driven spatial reconfiguration (accommodation/restaurant): Repartitioning of rooms, sanitary cores added to private areas, and HVAC routing frequently reduce Spatial Organization and Façade Arrangement integrity (Group 1), while also diluting the Spirit of the Building (Group 2). This is evident in Sezer and Sipahioğlu Houses (low Group 1 and Group 2; Final ≤ 41).
- Material replacement intensity: Substitution of original carpentry, plaster finishes, or stonework lowers Material and Technique scores; when combined with contemporary finishes, this associates with a drop in perceived Spirit (e.g., Şimşek House: Group 1 mid-range, Group 2 low; Final = 43).
- Urban setting and use compatibility: Buildings situated in more touristic, traffic-exposed parcels exhibit lower Environment scores; uses with weak typological affinity (e.g., restaurant kitchens venting to street façades) depress both Environment and Spirit, even when fabric is well preserved (e.g., Durusoy vs. Dim).

Conversely, where original use is retained or the new use is typologically close (quiet exhibition), minimal alterations in Mass Characteristics, Spatial Organization, and Façade Arrangement support high Group 1 and stabilize Group 2 (e.g., Koçak, Kayhanlar).

The two-group structure clarifies why certain cases diverge between “how much is physically preserved” and “how much of the place's meaning remains”:

- Dim House (City Archive): High Group 1 yet low Group 2—fabric is preserved but the new archival program weakens Spirit and Intangible links.

- Kayhanlar House (Cultural House): Very high Group 1, moderate Group 2—didactic exhibition supports meaning, but partial musealization reduces lived-in character.
- Koçak House (Unchanged): High in both groups, confirming that original use best sustains the coupled tangible–intangible system.

This comparative reading is precisely the added value of the dual model: it distinguishes material integrity from cultural continuity, preventing over-reliance on fabric-only indicators.

Although a full quantitative audit of intervention levels was beyond the present scope, field notes and documentation sheets indicate that:

- cases requiring wet-core additions and dense services (typical of accommodation/food & beverage) systematically show larger drops in Spatial Organization and Spirit;
- parcels on high-traffic tourist routes exhibit lower Environment scores than side-street or courtyard-shielded lots.

Future work will formalize these observations with coded intervention indices and street-exposure metrics, enabling regression-based effect estimates.

Inter-rater reliability for expert inputs was high (Kendall's $W = 0.83$; supporting the stability of mean scores driving the fuzzy inference).

To facilitate quantitative validation, the pipeline now includes (i) function-level comparisons (e.g., Kruskal–Wallis across use categories) and (ii) association tests between Group 1 and Group 2 outputs (e.g., Spearman rank correlation).

Because the present study did not elicit direct “overall authenticity” votes from experts, system outputs are not calibrated to human consensus labels; instead, they are model-based fusions of the nine criteria. We identify this as an intentional scope choice and a future avenue for calibration. This future calibration will allow the system to serve as a transferable quantitative framework for heritage authenticity assessment.

6. Discussion

The results obtained through the Authenticity Analysis System demonstrate the dual dynamics of adaptive reuse: while physical integrity can often be preserved, contextual and intangible values are more vulnerable to alteration. Office and public-use conversions, for example, achieved high Group 1 scores in terms of form and façade retention but substantially lower Group 2 values, indicating diminished environmental and spiritual authenticity. This divergence highlights a structural challenge previously noted by Jokilehto (2006) and ICOMOS (1999): that authenticity in architecture cannot be reduced to material conservation alone, as the meaning of place is co-produced by use, context, and collective memory [8,11].

Among the two houses converted into boutique hotels, one retained moderate physical authenticity, whereas the other exhibited pronounced losses in both physical and contextual dimensions. These patterns mirror Tavakoli and Tümer's (2024) argument that profit-driven adaptive reuse—particularly in tourism-oriented economies—tends to privilege short-term economic sustainability at the expense of long-term cultural continuity [6]. The same tendency was observed in restaurant and café conversions, where Group 1 scores remained acceptable, but Group 2 scores declined sharply due to intrusive service interventions (e.g., sanitary and HVAC infrastructure) disrupting both spatial organization and the building's spirit. Similar findings are reported by Plevoets and Van Cleempoel (2019), who emphasize that functional over-adaptation often erodes authenticity even when conservation techniques are technically sound [35].

In contrast, museum and cultural exhibition conversions produced more balanced outcomes: the Sandık Emini Kayhanlar House achieved high Group 1 and moderate Group 2 scores, reflecting a restoration strategy that preserved tangible fabric while

partially formalizing use. These results suggest that functions consistent with heritage interpretation—education, exhibition, and culture—are more compatible with the dual goals of conservation and sustainability, a finding consistent with recent empirical studies on adaptive reuse of heritage buildings [36,37].

The two houses retaining their original residential use (Koçak House and Kök House) achieved the highest authenticity scores across both groups. This consistency reinforces the hypothesis that continuity of original use represents the most sustainable form of reuse, as it maintains both tangible and intangible attributes while minimizing intervention intensity. Similar conclusions were drawn in studies of vernacular housing contexts, where retention of original function correlated with higher authenticity retention [37,38]. Nevertheless, further empirical validation is required to determine whether this relationship is causal (original use $\rightarrow$ higher authenticity) or reciprocal (buildings with inherently high authenticity are more likely to retain their original use).

In support of these interpretive findings, quantitative evidence added in Section 5 confirms the monotonic association between physical and contextual authenticity (Spearman's $\rho = 0.64$, $p < 0.05$), and significant differences across reuse types (Kruskal–Wallis $H(4) = 9.37$, $p = 0.043$). These statistical patterns visually align with the functional hierarchy illustrated in Tables 9–11 and reinforce the model's capacity to detect consistent authenticity gradients across use categories.

These validated associations demonstrate that function type is not only conceptually but also statistically predictive of authenticity retention, strengthening the empirical grounding of the model.

Although the developed system provides a reproducible and mathematically grounded framework for evaluating the authenticity of adaptively reused traditional houses, it does not include a separate validation phase comparing model outputs with independent expert ratings. The purpose of this study was to design and test the functionality of the Fuzzy Logic–AHP–based system itself, rather than to perform statistical verification. Nevertheless, future research could integrate a validation module to assess the convergence between model-generated authenticity values and expert judgments through statistical measures such as the correlation coefficient (r) or Mean Square Error (MSE). Incorporating such a step would further enhance the transparency, reliability, and transferability of the model to different architectural contexts.

Despite these promising outcomes, several methodological limitations should be acknowledged. The reliance on expert judgment introduces potential subjectivity, even though inter-rater reliability was high (Kendall's $W = 0.83$). Moreover, the model's parameters were calibrated based on Mediterranean vernacular housing; thus, its direct transfer to distinct climatic or cultural settings may require recalibration of membership functions. Finally, longitudinal validation—measuring authenticity before and after adaptive reuse interventions—would provide deeper insight into the model's temporal robustness.

Overall, this study advances existing authenticity assessment approaches in three key methodological ways: (i) by replacing purely qualitative judgments with a reproducible, rule-based computational structure; (ii) by integrating tangible and intangible criteria through a dual-group fuzzy architecture, thus overcoming fabric-only evaluations; and (iii) by demonstrating statistically supported functional gradients, providing numerical evidence of how use transformation shapes authenticity. This synthesis establishes the proposed system as a transferable quantitative model that operationalizes authenticity within sustainable heritage management and supports SDG 11 targets.

7. Conclusions

The Authenticity Analysis System developed in this study offers a reproducible and data-driven framework for evaluating the authenticity of adaptively reused traditional buildings. Unlike conventional qualitative approaches that classify heritage as simply “authentic” or “not authentic,” this model quantifies authenticity through measurable criteria derived from fuzzy logic and the Analytic Hierarchy Process (AHP). By doing so, it bridges subjective expert judgments with objective computational reasoning. In addition, the integration of fuzzy membership functions with AHP-derived weights provides a level of analytical transparency and reproducibility not present in previous qualitative or single-method assessment models.

The model’s scientific contribution lies in its ability to translate complex qualitative heritage values into a numerical decision-support system without oversimplifying cultural meaning. It operationalizes the interplay between physical integrity (Group 1) and cultural-contextual dimensions (Group 2), demonstrating that authenticity is not a static attribute but a variable reflecting both material and intangible continuity.

Compared with earlier heritage assessment approaches—often descriptive, narrative, or reliant on unweighted expert scoring—the proposed hybrid Fuzzy–AHP system provides (i) a mathematically consistent representation of expert uncertainty, (ii) an explicit weighting hierarchy that eliminates hidden subjective bias, and (iii) a reproducible computational workflow capable of cross-case comparison.

While the model already demonstrated internal consistency (Kendall’s $W = 0.83$), further robustness can be achieved through sensitivity analysis and cross-validation. Future research should test the convergence between model-generated authenticity values and independent expert or user evaluations using correlation or error metrics (e.g., r , MSE). Comparing the fuzzy–AHP hybrid approach with other multi-criteria decision-making tools such as TOPSIS or DEMATEL could also highlight its relative performance and applicability.

The system’s rule base, membership functions, and weighting hierarchy are adaptable to diverse regional contexts, provided cultural calibration is performed. This adaptability reflects one of the model’s methodological strengths: its modular structure allows researchers to recalibrate linguistic ranges, weights, or criteria definitions to suit local heritage traditions. Therefore, rather than a fixed model, the system should be seen as a flexible analytical framework that can be regionally tuned through participatory expert input.

Certain methodological constraints must be acknowledged. The relatively small sample size (ten cases) and reliance on expert-derived inputs limit the statistical generalizability of results. Moreover, the selected criteria reflect Mediterranean vernacular heritage logic and may need modification in other architectural traditions. Future work should expand the expert panel, include multidisciplinary perspectives (architects, sociologists, local stakeholders), and incorporate longitudinal measurements of authenticity before and after adaptive reuse interventions.

The study underscores that adaptive reuse, while environmentally sustainable in material terms, may entail hidden risks to authenticity and cultural identity if intangible dimensions are neglected. Integrating quantitative authenticity assessment into reuse decision-making can thus enhance the balance between heritage conservation and sustainability goals. The model directly contributes to SDG 11 (Sustainable Cities and Communities) by offering a decision-support tool that promotes socially inclusive, culturally sensitive, and environmentally responsible reuse practices.

Ultimately, the Authenticity Analysis System represents a methodological advancement in heritage science: a quantifiable yet context-aware tool that can inform both policy

and practice. By inviting the scientific community to replicate, adapt, and extend this model across different cultural and climatic contexts, the study aims to contribute to a broader, globally comparable framework for quantitative authenticity assessment.

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References

1. Zeybekoğlu, D. Edirne Geleneksel Konut Mimarlığını Etkileyen Sosyo-Kültürel Faktörlerin İncelenmesi. Master's Thesis, Trakya University, Edirne, Turkey, 2005.
2. Niu, J.; Sun, Y.; Wang, X. Mapping the nexus of sustainability and cultural heritage: A systematic review and empirical analysis. *Herit. Sci.* **2025**, *13*, 471. [CrossRef]
3. Eroğlu, B.; Yıldız, E. Kültür mirasının sürekliliği için anıtsal binaların yeniden kullanılması bağlamında Ermenek Tol Medrese. *Selçuk Üniv. Sos. Bilim. Enst. Derg.* **2006**, *15*, 315–340.
4. Aydın, D.; Yıldız, E. Yeniden kullanıma adaptasyonda bina performansının kullanıcılar üzerinden değerlendirilmesi. *METU J. Fac. Archit.* **2010**, *27*, 1–22. [CrossRef]
5. Lanz, F.; Oregi, X.; Martín-Garín, A. Adaptive reuse: A critical review of definitions, classifications, and future research directions. *J. Archit.* **2022**, *27*, 939–962. [CrossRef]
6. Tavakoli, M.; Tümer, A. Authenticity- and sustainability-based failure prevention in heritage adaptive reuse projects. *Sustainability* **2024**, *16*, 6820. [CrossRef]
7. Hasik, V.; Escott, E.; Bates, R.; Carlisle, S.; Faircloth, B.; Bilec, M.M. Comparative whole-building life cycle assessment of renovation and new construction. *Build. Environ.* **2019**, *161*, 106218. [CrossRef]
8. Jokilehto, J. World Heritage: Defining the outstanding universal value. *City Time* **2006**, *2*, 1–10.
9. Stovel, H. Origins and influence of the nara document on authenticity. *J. Preserv. Technol.* **2008**, *39*, 9–17.
10. UNESCO. Operational Guidelines for the Implementation of the World Heritage Convention. Intergovernmental Committee for the Protection of the World Cultural and Natural Heritage. 2023. Available online: <https://whc.unesco.org/en/guidelines/> (accessed on 2 March 2024).
11. ICOMOS. Charter on the Built Vernacular Heritage. 1999. Available online: https://www.icomos.org.tr/Dosyalar/ICOMOSTR_en0464200001536913566.pdf (accessed on 2 July 2025).
12. Alanya Municipality. Available online: <https://www.alanya.bel.tr/s/399/tarihce> (accessed on 1 July 2025).
13. Kısa, H. *Alanya'da Yerel Turizm Politikaları: Sorunlar ve çözüm önerileri*; Duvar Yayınları: İzmir, Turkey, 2024; 195p.
14. Atak, O.; Atak, A. Antalya İli, Alanya İlçesi, Dim Çayı, Kıyı Koruma Yapıları (Mahmuz) 1/5000 Ölçekli Nazım İmar Planı Plan Açıklama Raporu. 2019. Available online: https://webdosya.csb.gov.tr/db/antalya/duyurular/rapor_5000-20191002154230.pdf (accessed on 2 March 2024).
15. Antalya Governorship Provincial Directorate of Environment and Urbanization. Jeolojik—Jeoteknik Etüt Çalışmaları. 2018. Available online: <https://web.archive.org/web/20211026065235/http://antalya.csb.gov.tr/jeolojik---jeoteknik-etut-calismalari-i-103509> (accessed on 2 March 2024).
16. ICOMOS. The Nara Document on Authenticity. 1994. Available online: https://www.icomos.org.tr/Dosyalar/ICOMOSTR_en0756809001536913861.pdf (accessed on 2 July 2025).
17. Driankov, D.; Saffiotti, A. *Fuzzy Logic Techniques for Autonomous Vehicle Navigation*; Physica Heidelberg: Berlin, Germany, 2001; 393p.
18. Saaty, T.L. *The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation*; RWS Publications: Pittsburgh, PA, USA, 1990; 287p.
19. Köse, A. Türkiye'de geleneksel kırsal konut planlarında göçebe Türk kültürü izleri. *Sos. Bilim. Derg.* **2005**, *7*, 158–191.
20. Şener, H. *Alanya'da Geleneksel Konutlar*; İTÜ Mimarlık Fakültesi Baskı Atölyesi: İstanbul, Turkey, 1984; 153p.

21. Göncü, Ö. The Conservation Proposal of Hasanağalar (Alaydın) House in Alanya. Master's Thesis, METU, Ankara, Turkey, 2012. Available online: <https://open.metu.edu.tr/handle/11511/21537> (accessed on 9 October 2025).
22. Zimmermann, H.-J. *Fuzzy Set Theory and Its Applications*; Springer: Berlin/Heidelberg, Germany, 2010.
23. Mendel, J.M. *Uncertain Rule-Based Fuzzy Systems: Introduction and New Directions*; Springer: Berlin/Heidelberg, Germany, 2017.
24. Driankov, D.; Hellendoorn, H.; Reinfrank, M. *An Introduction to Fuzzy Control*; Springer: Berlin/Heidelberg, Germany, 1993.
25. Ulukan, M. Mimari Korumada Otantiklik Üzerine Yöntem Araştırması ve İstanbul Tekkelerinde Uygulama Örnekleri. Ph.D. Thesis, Istanbul Technical University, Istanbul, Turkey, 2014.
26. Saaty, T.L. *Decision Making for Leaders: The Analytic Hierarchy Process for Decisions in a Complex World*; RWS Publications: Pittsburg, PA, USA, 2008; 323p.
27. Harker, P.T.; Vargas, L.G. The theory of ratio scale estimation: Saaty's analytic hierarchy process. *Manag. Sci.* **1987**, *33*, 1383–1403. [[CrossRef](#)]
28. Partovi, F.Y.; Hopton, W.E. The analytic hierarchy process as applied to two types of inventory problems. *Prod. Inventory Manag. J.* **1994**, *35*, 14–15.
29. Delbecq, A.L.; Van de Ven, A.H.; Gustafson, D.H. *Group Techniques for Program Planning: A Guide to Nominal Group and Delphi Processes*; Scott, Foresman and Company: Glenview, IL, USA, 1975; 189p.
30. Williams, P.L.; Webb, C. The Delphi technique: A methodological discussion. *J. Adv. Nurs.* **1994**, *19*, 180–186. [[CrossRef](#)] [[PubMed](#)]
31. Armstrong, J.S. *Principles of Forecasting: A Handbook for Researchers and Practitioners*; Kluwer Academic Publishers: Boston, MA, USA, 2001; 861p.
32. Okoli, C.; Pawlowski, S.D. The Delphi method as a research tool: An example, design considerations and applications. *Inf. Manag.* **2004**, *42*, 15–29. [[CrossRef](#)]
33. Kendall, M.G. *Rank Correl. Methods*; Griffin: London, UK, 1970.
34. ICOMOS. Joint ICOMOS—TICCIH Principles for the Conservation of Industrial Heritage Sites, Structures, Areas and Landscapes. 2011. Available online: https://www.icomos.org.tr/Dosyalar/ICOMOSTR_en0914909001536912340.pdf (accessed on 2 July 2025).
35. Plevioets, B.; Van Cleempoel, K. *Adaptive Reuse of the Built Heritage: Concepts and Cases of an Emerging Discipline*; Routledge: London, UK, 2019.
36. Della Spina, L. Adaptive Sustainable Reuse for Cultural Heritage: A Multiple Criteria Decision Aiding Approach Supporting Urban Development Processes. *Sustainability* **2020**, *12*, 1363. [[CrossRef](#)]
37. Philokyprou, M. Social Continuity and Discontinuity during Conservation. *Athens J. Archit.* **2015**, *11*, 111–120. [[CrossRef](#)]
38. Ordóñez-Castañón, D.; Cunha Ferreira, T. Toward the Adaptive Reuse of Vernacular Architecture: Practices from the School of Porto. *Heritage* **2024**, *7*, 1826–1849. [[CrossRef](#)]

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