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Soundscape Heritage in Historic Environments: Implications for Authenticity-Oriented Sustainable Conservation

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Abstract

Heritage conservation has traditionally privileged what can be seen, yet the continuity and authenticity of historic environments also depend on what can be heard. Place-specific sounds can embody cultural memory, everyday practices, and local character, but their role in heritage experience remains insufficiently understood. This study examines Xixinan Village, China, by integrating archival research, acoustic measurements, and an on-site visitor survey. Structural equation modeling (SEM), necessary condition analysis (NCA), Mantel tests, and correlation analysis were used to investigate the perceptual significance of historically and culturally meaningful sounds. Perceived soundscape authenticity(PSA) was positively associated with soundscape eventfulness(EV) (β = 0.682), soundscape pleasantness(SP) (β = 0.412), perceived landscape authenticity(PLA) (β = 0.404), and sense of place(SOP) (β = 0.317), with the strongest relationship observed for eventfulness. NCA further identified perceived soundscape authenticity as a necessary, though not sufficient, condition for achieving high levels of soundscape pleasantness (d = 0.233, $p < 0.001$) and sense of place (d = 0.226, $p < 0.001$). At the sound-source level, water sounds, birdsong, and traditional everyday-life sounds were consistently associated with favorable evaluations, whereas road traffic, construction, and electronic-device sounds showed negative associations. These findings indicate that soundscape heritage depends not simply on reducing noise, but on maintaining culturally congruent auditory environments. Sustainable conservation should therefore recognize place-specific sounds as heritage resources and protect the ecological, spatial, and everyday-life settings that sustain their continuity.

Keywords: traditional village; soundscape authenticity; soundscape heritage; sense of place; sound-source perception; SEM

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1. Introduction

Traditional villages are important carriers of historic cultural landscapes. They preserve not only diverse forms of tangible cultural heritage but also rich place-specific intangible cultural heritage [1]. Through long-term historical development, these settlements have evolved into distinctive cultural landscape systems. In China, interactions among production and everyday life practices, clan culture, folk rituals, and the natural environment have generated numerous place-specific landscapes, including the Eight Views of Yanjing, the Eight Views of Hongcun, and the Ten Views of Pingshan [2]. These landscapes embody the interweaving of regional culture, human activity, and environmental experience. They have persisted through collective perception, memory, and cultural transmission [3]. As heritage conservation has expanded beyond the physical fabric, scholars have increasingly

recognized that the value of traditional villages also lies in everyday practices, cultural activities, and environmental perception. Within this broader understanding, sound is a key medium of environmental experience. It contributes to shaping the atmosphere of place and preserving cultural memory [4].

As an interactive element within traditional village environments, the soundscape links material settings with folk cultural practices. The concept was first introduced by the Finnish geographer Granö to describe an acoustic environment centered on the listener. Schafer later popularized the term in the 1970s and described the soundscape as the "music of the environment." Since then, soundscape research has expanded beyond objective acoustic measurement to encompass soundscape perception and environmental experience. It has been widely applied in urban planning [5], landscape design [6], and cultural heritage conservation [7]. In traditional village studies, the soundscape is increasingly recognized as an important perceptual dimension that reflects regional culture and productive activities. Some studies have examined soundscape quality through soundscape assessment, including the development of the Principal Components Model of Soundscape Perception and related rating scales for urban acoustic environments [5]. Others have explored how soundscapes affect visitors' emotions, place identity, sense of place, and tourist experience [8].

Traditional village soundscapes in China contain sounds of historical and cultural value that warrant conservation. These sounds reflect the cultural meanings formed through long-term interactions between people and their environments [9]. From a sustainable heritage perspective, the historical continuity and cultural authenticity of traditional village soundscapes remain underexplored. Existing studies of historic environments mainly focus on acoustic characteristics and immediate soundscape evaluation [10]. Less attention has been paid to how historical sounds persist, how visitors form judgments of soundscape authenticity, and how such judgments influence place experience. Therefore, this study uses Xixinan Village as a case study to examine traditional village soundscape heritage from three aspects: historical continuity, authenticity perception, and sound-source associations.

This study addresses four research questions:

Q1: How is perceived soundscape authenticity (PSA) related to soundscape pleasantness (SP), eventfulness (EV), and perceived landscape authenticity (PLA)? Does PSA represent a distinct perceptual dimension beyond general soundscape perception?
Q2: Is sense of place (SOP) more strongly related to the local cultural meanings conveyed by the soundscape, or to immediate perceptions such as pleasantness and eventfulness?
Q3: Which perceptual factors are necessary for achieving high levels of soundscape pleasantness and sense of place, and how do their constraining effects differ?
Q4: How are different sound sources associated with perceived soundscape authenticity, and which sounds strengthen or weaken visitors' authenticity judgments?

By addressing these questions, this study places perceived soundscape authenticity within the broader relationships among soundscape perception, landscape authenticity, and sense of place. It also links authenticity judgments to historical sound evidence and contemporary sound sources. This provides soundscape authenticity with a traceable historical and environmental basis. The study therefore helps explain how environmental sounds become heritage cues with place-specific meaning. It also supports a shift in soundscape conservation from acoustic quality improvement toward the maintenance of historical continuity and cultural congruence [11].

2. Theoretical Framework and Hypothesis Development

2.1. Authenticity

Authenticity is a central concept in heritage and tourism research. Early discussions focused primarily on whether cultural objects retained their original attributes. The concept was later extended to more subjective dimensions, including tourist experience, place perception, and cultural representation [12]. Wang distinguished three forms of authenticity: objective, constructive, and existential authenticity. Objective authenticity concerns the authentic attributes of the object itself. Constructive authenticity refers to judgments formed by audiences within a specific cultural context, whereas existential authenticity emphasizes the experience of an authentic self through tourism activities [12]. In the context of heritage conservation, the Nara Document on Authenticity further broadened this understanding. It suggested that authenticity judgments should consider not only form, materials, and the preservation of original conditions, but also function, tradition, setting, spirit, and feeling within their specific cultural contexts [13]. Heritage authenticity is therefore not a purely material criterion. Rather, it is a multidimensional concept involving object-related evidence, cultural context, and perceptual construction [12,13]. As heritage conservation has expanded from the preservation of physical fabric to multisensory experience and intangible cultural values, sound has increasingly been recognized as an important heritage cue carrying local history, cultural memory, and social life. Acoustical heritage lies at the intersection of sound, culture, and history. Its value derives not only from the physical properties of sound but also from its historical context and cultural meaning [9]. Building on this perspective, Hu introduced authenticity into soundscape research in historic districts [14]. They found that soundscape authenticity was closely related to original sound, soundscape memory, and cultural characteristics. Place-specific dialect conversations, traditional hawking, and other sociocultural sounds not only form the acoustic environment but also serve as auditory cues linking the past with contemporary local life. Hu further treated soundscape authenticity as a multidimensional construct that can be quantified through perceptual evaluation [15]. Based on audiovisual simulations and perceptual experiments, they identified two core evaluation dimensions and emphasized the congruence among sound, spatial type, and cultural context. Further research suggests that sound authenticity is not an inherent or static property of sound itself. Rather, it is a contextual judgment formed through the relationships among sound, space, culture, and auditory experience [16]. Accordingly, soundscape authenticity has moved beyond the verification of individual sound sources. It now refers to an overall assessment of whether a soundscape demonstrates historical continuity, cultural congruence, and contextual appropriateness [14,15].

Research on soundscape authenticity in historic environments has so far focused mainly on conceptual development, the identification of evaluation dimensions, and authenticity-oriented sound selection. However, limited empirical evidence explains how visitors form perceived soundscape authenticity from specific sounds with historical continuity and local cultural meaning, or how such judgments further influence soundscape experience and sense of place. To address this gap, this study introduces perceived soundscape authenticity (PSA) to describe visitors' overall judgment of how well the contemporary soundscape corresponds to local history and culture. The concept links historical sound-source evidence, contemporary sound-source perception, and visitors' place experience. It also provides a basis for distinguishing general soundscape quality from the heritage value of soundscapes. In this study, PSA refers to an individual's overall judgment, based on specific sound sources and their historical and spatial contexts, of whether the current soundscape is congruent with the local character, cultural meaning, historical continuity, and traditional ways of life of a heritage place. PSA is therefore conceptualized

as a form of constructive authenticity grounded in objective heritage cues [12]. It is also distinct from existential authenticity. Existential authenticity concerns whether tourism enables visitors to experience an authentic sense of self. By contrast, this study examines whether the contemporary soundscape is perceived as a culturally and historically congruent expression of the place. Traditional village soundscapes are not static remnants of the past. They continue to evolve through social transformation, functional change, and tourism development. Their authenticity therefore cannot be assessed solely by the extent to which an original condition has been preserved [14,15].

In addition to perceived soundscape authenticity, this study considers authenticity at the landscape level [1,17]. According to Wang's classification, authenticity is not limited to whether an object has been preserved in its original form. It also includes judgments formed through object-related cues, cultural expectations, and the specific context of place [12]. Perceived landscape authenticity (PLA) should therefore be distinguished from an objective assessment of whether a landscape is genuine. Park et al. further demonstrated that visitors' perceived authenticity of heritage destinations can shape enjoyment, loyalty, and perceptions of heritage value [1]. This suggests that authenticity has extended beyond the material attributes of individual objects to encompass the perceptual appraisal of the heritage environment as a whole. In traditional villages, PLA is primarily informed by architectural character, spatial configuration, cultural symbols, and environmental atmosphere. It reflects visitors' judgments of whether the overall heritage landscape corresponds to their expected image of the place and is congruent with its historical and cultural character [18,19]. PLA is therefore conceptualized as an object-related form of constructive authenticity operating primarily through visual cues. Although grounded in observable landscape elements, it also depends on how visitors interpret, compare, and culturally construct these elements [12,20]. Accordingly, the following hypothesis is proposed:

H1. *Perceived soundscape authenticity (PSA) has a significant positive effect on perceived landscape authenticity (PLA).*

2.2. Soundscape Assessment

This study considers soundscape perception as the subjective understanding and overall experience of an acoustic environment in context [21]. Using principal component analysis, Axelsson showed that soundscape perception can be represented by a small number of core dimensions [5]. Among these, pleasantness and eventfulness are the most stable and explanatory. Pleasantness indicates whether an acoustic environment is perceived as comfortable, pleasant, and calm. Eventfulness reflects its liveliness, richness, and dynamic character [22]. As soundscape theory and methods developed, the pleasantness–eventfulness circumplex was incorporated into the ISO 12913 framework for organizing and interpreting responses to affective soundscape descriptors [23]. It has therefore become a widely used framework for soundscape assessment. In studies of historic spaces in China, Liu found that soundscape pleasantness and eventfulness played distinct roles in shaping visitors' experiences of Three Lanes and Seven Alleys and West Lake Park in Fuzhou [24,25]. The perceived occurrence and dominance of specific sound sources, together with their contextual congruence, also influenced soundscape assessment. Soundscape research should therefore consider both overall perceptual dimensions and the characteristics of individual sound sources.

Drawing on established affective soundscape assessment scales and studies of historic and cultural spaces, this study defines soundscape pleasantness and soundscape eventfulness as visitors' overall appraisals of the affective attributes of the soundscape. Soundscape pleasantness was measured using four descriptors: calm, pleasant, comfortable, and relax-

ing. The inclusion of relaxing as a pleasantness-related attribute was informed primarily by Ye et al. and Herranz-Pascual et al. [26,27]. Soundscape eventfulness was measured using the descriptors lively, rich, and interesting. This operationalization is broadly consistent with the prevailing pleasantness–eventfulness framework in soundscape research [5,22]. Accordingly, the following hypotheses are proposed:

H2. *Perceived soundscape authenticity (PSA) has a significant positive effect on soundscape eventfulness (EV).*

H3. *Perceived soundscape authenticity (PSA) has a significant positive effect on soundscape pleasantness (SP).*

H4. *Perceived landscape authenticity (PLA) has a significant positive effect on soundscape eventfulness (EV).*

H5. *Perceived landscape authenticity (PLA) has a significant positive effect on soundscape pleasantness (SP).*

H6. *Soundscape eventfulness (EV) has a significant positive effect on soundscape pleasantness (SP).*

2.3. Sense of Place

Theories of place emerged from human-geographical debates over the distinction between space and place. Tuan described place as "experienced space" formed through experience, emotion, and meaning [28]. Relph later emphasized the lived experience of place and sense of belonging from a phenomenological perspective [29]. From the perspective of environmental psychology, Canter argued that place is not merely a physical setting. Rather, it arises from the interaction of physical attributes, activities, and people's conceptions of the environment [30]. This formulation moved place research from geographical philosophy toward an analyzable psychological and behavioral framework. Proshansky et al. subsequently introduced place identity and showed how place experience becomes incorporated into the structure of the self [31]. As research developed, scholars began to quantify the relationships between sense of place and human behavior. This work differentiated several related constructs, including sense of place, place attachment, place identity, and place dependence. It also showed that person-place relationships involve cognitive, affective, and conative components rather than a single emotional response [32]. Scannell and Gifford synthesized this literature in the Person–Process–Place Framework, which explains place attachment through the interaction of people, psychological processes, and place [33]. More recent studies have sought to integrate place identity, place meaning, place attachment, and place experience within a broader person–place framework. This approach helps reduce conceptual overlap among these related terms [34]. It also emphasizes that person–place relationships are dynamic and context-dependent. Such relationships are continually reconstructed through mobility, migration, environmental change, and social transformation [35]. In tourism and heritage research, sense of place is therefore increasingly understood as visitors' subjective understanding of place meaning, cultural character, and affective bonds. It is no longer treated simply as environmental preference or landscape pleasantness [36].

Recent studies have also moved beyond visually dominated approaches by recognizing the role of multisensory cues in the construction of place meaning. Natural sounds, traditional livelihood sounds, and cultural activity sounds have stronger positive associations with sense of place than road-traffic noise and equipment noise [37]. This suggests that sense of place is shaped not only by spatial form but also by environmental experiences

that are congruent with local life and historical memory. Research in historic and cultural districts further indicates that soundscapes can strengthen sense of place through cultural representation, memory evocation, and emotional connection. They can also shape the person–place relationships formed by residents and visitors [38]. Jorgensen and Stedman conceptualized sense of place as a global attitude expressed through place identity, place attachment, and place dependence [32]. This framework provides a basis for the theoretical definition and quantitative measurement of sense of place. Chen et al. incorporated place identity and place attachment into soundscape research in historic cultural districts and confirmed their applicability in cultural heritage settings [38]. Based on this literature, the present study defines sense of place (SOP) as an overarching latent construct capturing visitors' identification with, emotional attachment to, and perceived dependence on a traditional village. Accordingly, the following hypotheses are proposed:

H7. *Perceived soundscape authenticity (PSA) has a significant positive effect on sense of place (SOP).*

H8. *Perceived landscape authenticity (PLA) has a significant positive effect on sense of place (SOP).*

H9. *Soundscape eventfulness (EV) has a significant positive effect on sense of place (SOP).*

H10. *Soundscape pleasantness (SP) has a significant positive effect on sense of place (SOP).*

The theoretical model developed from these hypotheses is shown in Figure 1.

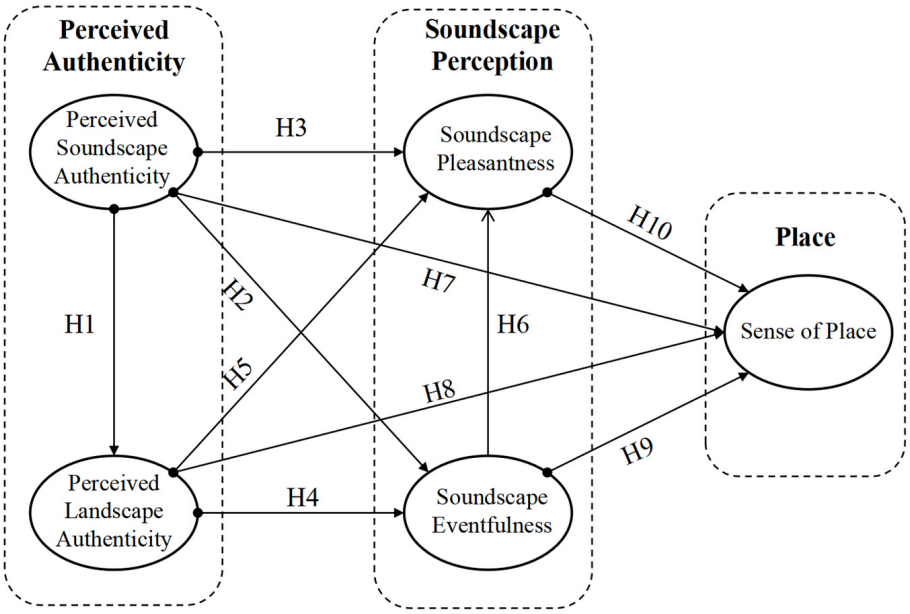
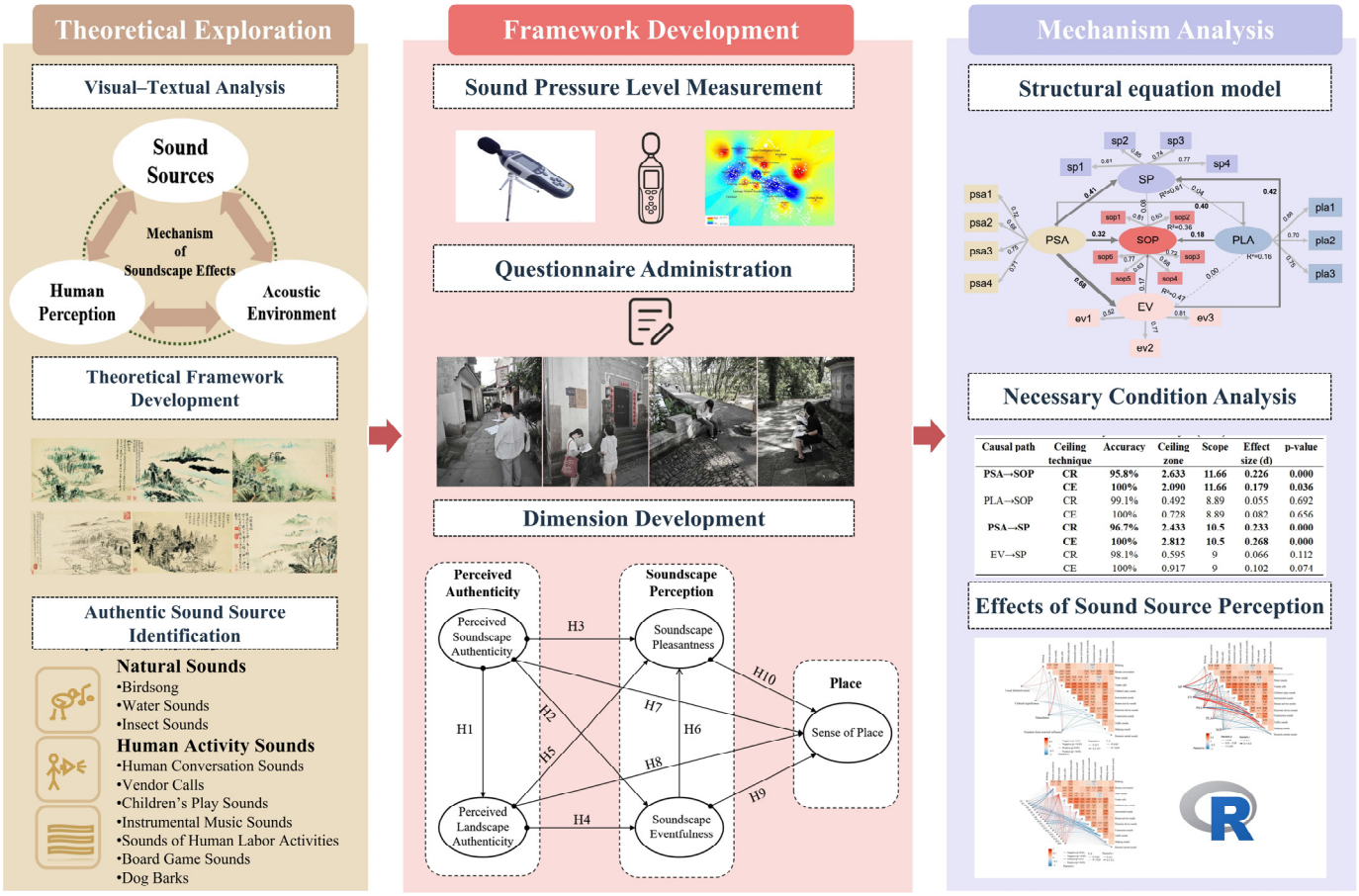


Figure 1. Proposed research model and hypotheses.

3. Materials and Methods

Xixinan Village in Huangshan, China, was selected as the case study. The research was conducted at three analytical levels: sound sources, soundscape perception, and underlying mechanisms. Historical materials, including local gazetteers, poems describing the Eight Views, and historical images, were examined to identify authentic sound sources characterized by place specificity and historical continuity. This analysis established the environmental basis of soundscape authenticity in the traditional village. Objective acoustic measurements were then combined with an on-site questionnaire survey to develop a perceptual assessment framework comprising authenticity, sense of place, and soundscape

assessment. Structural equation modeling (SEM) was used to test the structural paths among the constructs, while necessary condition analysis (NCA) identified the constraining effects of key variables on the attainment of major outcomes. The relationships between specific sound-source types and subjective perceptual indicators were subsequently examined. This integrated approach clarifies the sound-source basis of perceived soundscape authenticity and the perceptual pathways through which perceived soundscape authenticity shapes soundscape perception and sense of place. The methodological framework is presented in Figure 2.



Causal path	Ceiling technique	Accuracy	Ceiling zone	Scope	Effect size (d)	p-value
PSA→SOP	CR	95.8%	2.633	11.66	0.226	0.000
	CE	100%	2.090	11.66	0.179	0.036
PLA→SOP	CR	99.1%	0.492	8.89	0.055	0.692
	CE	100%	0.728	8.89	0.082	0.656
PSA→SP	CR	96.7%	2.433	10.5	0.233	0.000
	CE	100%	2.812	10.5	0.268	0.000
EV→SP	CR	98.1%	0.595	9	0.066	0.112
	CE	100%	0.917	9	0.102	0.074

Figure 2. Methodological framework of the study.

3.1. Data Collection

3.1.1. Study Area

Xixinan Village in Huangshan, China, was selected as the study area (Figure 3). The village is located on the southern bank of the Fengle River, in the upper reaches of the Xin'an River, and has a history of more than 1200 years [39]. It was included in the third national list of Traditional Villages of China. The village retains the remains of Guoyuan and Diaoxue Garden, four historic irrigation weirs, including the Tiao, Long, and Lei weirs, and more than one hundred buildings dating from the Ming and Qing dynasties. It also contains Lürao Pavilion and Laowuge, both designated as Major Historical and Cultural Sites Protected at the National Level. Place-specific landscapes in Xixinan were first documented during the Yuan dynasty. By the Ming and Qing dynasties, more than forty historic landscape records had been documented. At present, Xixinan Village covers approximately 7.34 km^2 and has about 4300 residents, with a population density of approximately 584 persons/km^2. The terrain is generally flat, with elevations ranging from approximately 128 to 170 m. Residential areas are concentrated in the village core and along

the main roads, including traditional dwellings and some newly built residential areas. Large areas of farmland and vegetable plots remain around the village periphery (Figure 4). Bamboo forests, wetland forests, and other woodlands are also distributed around Xixinan, with a relatively intact wetland forest along the Fengle River. The study area focused on the core of the traditional settlement, where population and buildings are concentrated. The village is readily accessible, approximately 3 km from the nearest expressway entrance and 22 km from the nearest civil airport.



Figure 3. Aerial view of Xixinan Village, Huangshan City, China.

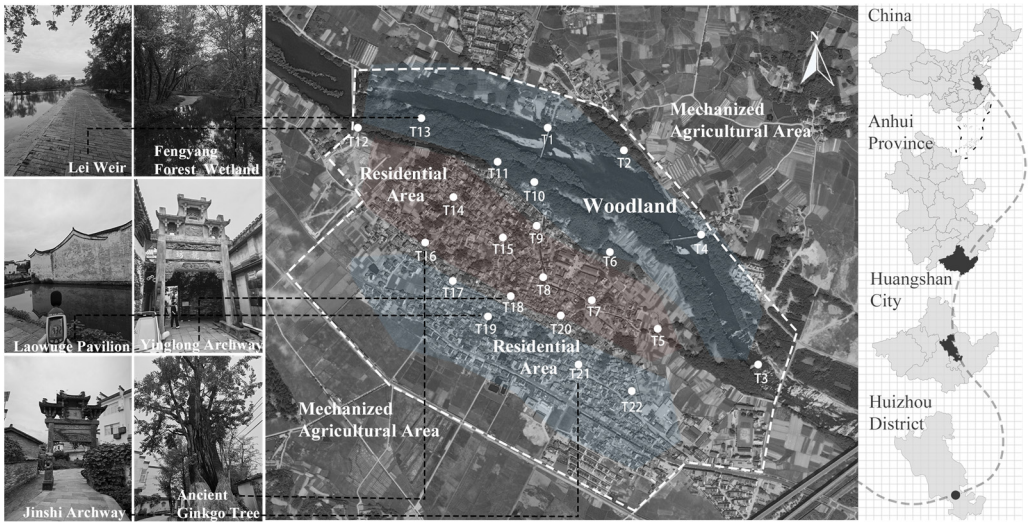


Figure 4. Study area and representative heritage landscape elements in Xixinan Village. Twenty-two measurement points (T1–T22) were established at representative historic nodes, tourist gathering areas, and residents' activity nodes within the village.

Xixinan Village retains a relatively intact traditional spatial pattern. Historic weirs, canals, traditional dwellings, and waterfront spaces remain part of the present-day village environment. The Huizhou E Barrages, which include the traditional weirs in Xixinan, were recognized as World Heritage Irrigation Structures in 2024. Many sound sources recorded in local gazetteers and other historical documents therefore still have identifiable present-day sources in the village. At the same time, tourism development and changes in village functions have introduced new sounds, including mechanical noise and visitor activity sounds. Traditional and modern sound sources thus coexist within the village environment. This setting allows us to compare how different sound sources correspond to the local historical and cultural context, and to further examine the formation and effects of visitors' perceived soundscape authenticity (PSA).

3.1.2. Identification of Authentic Sound Sources

Intangible cultural heritage, including customs, rituals, music, and drama, depends on tangible settings for its expression and transmission. The continuity of traditional village soundscapes likewise relies on the physical environments and material carriers through which sounds are produced. This study identified authentic sound sources by cross-validating historical texts and visual materials. Local gazetteers, poems, and village historical records were systematically reviewed to extract references to sounds. Historical paintings and other visual records were then examined to identify the settings, participants, physical carriers, and environmental contexts associated with these sounds. Sound-related evidence from different sources was subsequently cross-validated. Sound types demonstrating historical continuity, place-specific cultural relevance, and representativeness of their settings were classified as authentic sound sources.

Xixinan Village has rich soundscape heritage documented from the Yuan through the Ming and Qing dynasties. The historical sources examined included the Republican era Fengnan Gazetteer, Shitao's Eight Views of Xinan, Zhu Zhishan's Poems on the Eight Views of Fengxi, and poems describing the Eight Views of Xinan from different historical periods. Comparative review identified 36 place-specific landscape records from the Yuan, Ming, and Qing dynasties. These records were then examined through combined textual and visual interpretation to identify their sound-source categories. Sixteen place-specific sound sources were extracted, including water sounds from the four weirs, sounds of Nuo opera, and wind through pine trees. These were classified as authentic sound-source categories of Xixinan Village.

3.1.3. Objective Acoustic Measurement

The village was divided into a spatial grid, and 22 measurement locations were selected to represent its principal spaces (Figure 4). Objective surveys were conducted during autumn on both weekdays and weekends. Measurements were taken on clear, calm mornings and afternoons. At each location, researchers used a CEM DT-8851 professional sound level meter (Shenzhen Everbest Machinery Industry Co., Ltd., Shenzhen, China) to record the A-weighted equivalent continuous sound pressure level over 10 min (LAeq, 10 min).

Before the formal questionnaire survey, a preliminary field survey was conducted to identify sound sources that could be perceptually recognized in the contemporary village environment [40]. The survey covered representative areas, including the historic water system and landscape zone, the core of the traditional settlement, and areas with concentrated visitor activity. At each location, researchers conducted on-site auditory observations and recorded the acoustic environment. Identifiable sound sources were documented according to their origins and associated activities.

The resulting sound-source list was then organized with reference to the source-based classification framework of ISO/TS 12913-2:2018 [23]. Historical sound sources identified from textual and visual materials were compared with those observed in the present environment. Sounds with historical evidence that remained perceptible were retained. Sources with similar origins and perceptual characteristics were combined, while historical sounds that could not be consistently perceived during ordinary visits were excluded from the formal questionnaire. Contemporary sounds identified during the preliminary survey were also added. This process resulted in 12 sound-source categories for the formal visitor survey (Appendix A).

3.1.4. Questionnaire Survey

The measurement items were adapted primarily from established scales published in leading international journals. Seven experts in architecture, environmental studies, and tourism reviewed the items for clarity, relevance, and representativeness. Their feedback indicated that the items were appropriate and adequately reflected the intended constructs. A small-scale pilot study was conducted before the main survey. Respondents generally understood the items as intended.

The main survey was administered in Xixinan Village on 20, 21, 26, and 27 September 2025. Visitors were randomly recruited at multiple locations. Before completing the questionnaire, researchers explained the survey items to respondents in detail and asked them to listen to the surrounding acoustic environment for 1 min before beginning the survey. A total of 230 questionnaires were distributed. After invalid responses were excluded, 215 valid responses were retained, yielding a valid response rate of 93.4%.

The questionnaire comprised three sections. The first recorded five sociodemographic characteristics: age, gender, educational attainment, place of origin, and employment status. The second assessed the core perceptual constructs related to soundscape perception, perceived authenticity, and sense of place. The third assessed the Perceived Occurrences of Sound (POS) and Perceived Loudness of Sound (PLS) for each of the 12 sound-source categories identified in the preceding stage. All measurement items were rated on a five-point Likert scale.

The authenticity measures were adapted from studies of constructive authenticity in tourism [41,42] and adjusted to the context of traditional villages. Drawing on established measures of perceived regional cultural authenticity [1] and perceived landscape authenticity, the measurement focus was extended from visual cultural representations, such as architectural landscapes and everyday-life scenes, to the auditory environment of traditional villages. The adapted perceived soundscape authenticity (PSA) scale captured visitors' judgments of local distinctiveness, cultural significance, naturalness, and degree of external influence within the village soundscape. PSA and perceived landscape authenticity (PLA) therefore represent context-specific adaptations of the measurement logic of constructive authenticity. Research on place theory suggests that sense of place (SOP) can be treated as an overarching construct involving cognitive, affective, and conative components. It may be expressed through related dimensions such as place attachment, place identity, and place dependence [32]. Some studies measure these dimensions separately, whereas others integrate them into an overall sense-of-place construct. Following Jorgensen and Stedman, Chen et al., and Boley et al. [32,38,43], the relevant items were specified as observed indicators of SOP. Their factor structure was subsequently examined through factor analysis. Previous research has shown that soundscape descriptors can provide an efficient assessment of an acoustic environment [21]. Based on the Principal Components Model of Soundscape Perception developed by Axelsson et al. [5] and the soundscape descriptor framework summarized by Aletta et al. [22], soundscape perception was represented by soundscape pleasantness (SP) and soundscape eventfulness (EV). SP captured whether the acoustic environment was perceived as calm, pleasant, comfortable, and relaxing. EV captured whether it was perceived as lively, rich, and interesting.

3.2. Data Analysis

Structural equation modeling (SEM) integrates the measurement model and structural model within a single analytical framework. It can estimate relationships among multiple observed and latent variables simultaneously [44]. Latent constructs that cannot be measured directly are represented by sets of observed indicators. This makes SEM well suited to the analysis of complex relationships among perceptual and psychological constructs.

Necessary condition analysis (NCA) is a complementary method for identifying conditions that must be present for an outcome to reach a specified level [45]. NCA estimates the ceiling line of the outcome distribution and calculates the effect size of each antecedent. It therefore determines whether an antecedent constitutes a necessary condition and the extent to which it constrains outcome attainment.

In this study, SEM was used to test the structural paths between the authenticity constructs and the other perceptual constructs. NCA was subsequently applied to assess the constraining effects of selected antecedents on the attainment of key outcomes. For the sound-source perception data, Mantel tests and Pearson bivariate correlation analyses were conducted to examine positive and negative associations between specific sound sources and subjective perceptual indicators. These analyses were used to identify the environmental basis of PSA [46].

4. Results

4.1. Spatial Distribution of Sound Pressure Levels

The measured A-weighted equivalent continuous sound pressure levels (LAeq, 10 min) were imported into Arc Map 10.6 to analyze their spatial distribution (Figure 5). Relatively high sound pressure levels were observed along the Fengle River, where the acoustic environment comprised water sounds, human conversation, birdsong, and road-traffic noise. The village's main entrance is accessed from the opposite bank, and most visitors initially follow the riverside route. Tourist activity was therefore concentrated along the river corridor. By contrast, the interior of the village was relatively quiet. Most tourism related facilities were clustered near the riverside entrance, while the inner settlement retained a largely undisturbed residential environment. Visitor movement through this area therefore caused limited disturbance to the existing acoustic environment. Sound pressure levels increased again toward the southern edge of the village, which is adjacent to a county road. This area was characterized by prominent road-traffic noise, together with construction activities at several guesthouses and restaurants. Overall, the village exhibited a relatively quiet interior and noisier peripheral areas. Measurement locations with higher noise levels were largely associated with tourism-related development.

The spatial distribution of sound pressure levels in Xixinan Village reflected the combined influence of the river system, visitor activities, residents' everyday life, and road traffic. However, higher sound pressure levels did not necessarily indicate poorer soundscape quality. Although the Fengle River corridor had relatively high LAeq, 10 min values, its acoustic environment also contained flowing water, birdsong, and moderate human activity. In contrast, the elevated sound pressure levels near the southern road and construction areas were dominated by road traffic, construction, and equipment noise. Sound pressure level alone is therefore insufficient for evaluating the perceived quality of traditional village soundscapes. Sound-source types, their local cultural meanings, and visitors' subjective perceptual assessments must also be considered. Accordingly, the subsequent analyses examine both subjective perception and sound-source composition. SEM and NCA are used to test the relationships among PSA, SP, EV, and SOP. Analyses of individual sound sources are then used to clarify the environmental basis of perceived soundscape quality.

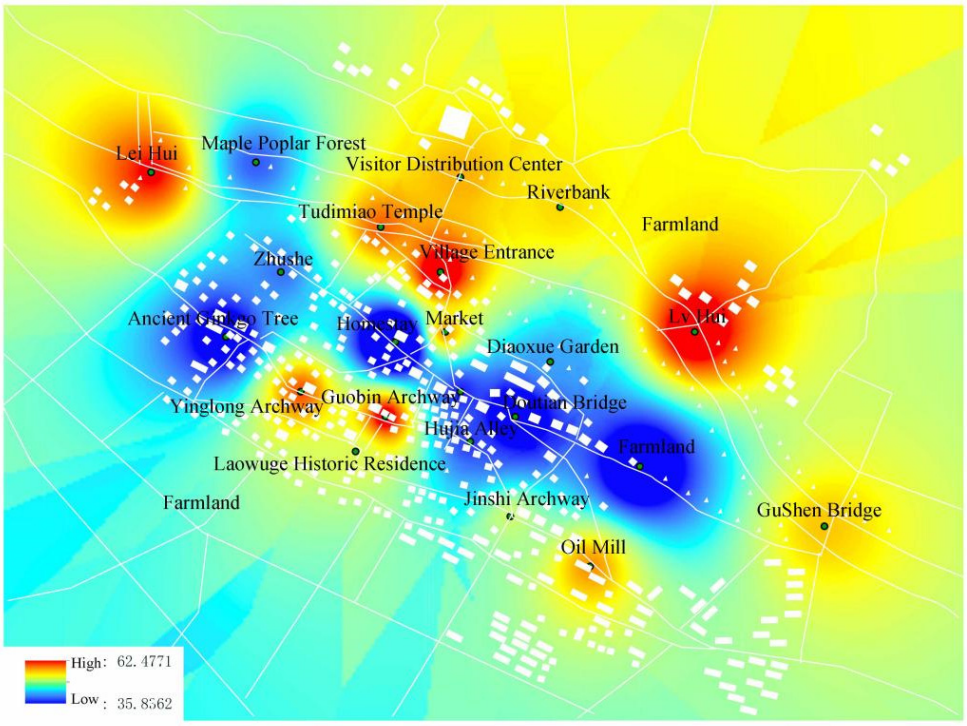


Figure 5. Spatial distribution of A-weighted sound pressure levels (LAeq) in the village.

4.2. Sample Characteristics

Descriptive statistics were calculated for the 215 valid responses. Respondents aged 18–30 formed the largest age group, accounting for 78.6% of the sample. Men represented 41.0% of respondents, while women accounted for 59.0%. Regarding place of origin, visitors from other provinces accounted for 66.0%, whereas those from elsewhere in Anhui Province represented 25.1% and local visitors 8.8%. Respondents with an undergraduate education constituted the largest educational group, accounting for 67.0% of the sample. In terms of employment status, employed respondents formed the largest group, representing 61.4%. Detailed demographic characteristics are presented in Table 1.

Table 1. Demographic characteristics of respondents.

Category		Perc%	Category		Perc%
Age	Under 18	2.3	Educational Attainment	Primary School	0.5
	18–30	78.6		Junior High School	2.8
	31–40	13.5		Senior High School	7
	41–55	5.1		Undergraduate	67
	Above 55	0.5		Postgraduate	22.8
Gender	Male	41	Employment Status	Student	32.6
	Female	59		Unemployed	5.6
Place of Origin	Local Visitors	8.8		Employed	61.4
	Other Provinces	66		Retired	0.5
	Anhui Province	25.1			

4.3. Structural Equation Model Assessment

4.3.1. Common Method Bias Assessment

To assess potential common method bias (CMB), Harman's single-factor test was conducted [47]. All 20 measurement items representing the five core perceptual constructs were entered simultaneously into an unrotated principal component analysis. Five factors with eigenvalues greater than 1 were extracted. The first factor accounted for 34.413%

of the total variance, below the 40% threshold [48]. These results indicate that no single factor dominated the covariance structure of the data. Common method bias was therefore unlikely to pose a serious threat to the main findings of this study (Appendix B).

4.3.2. Reliability and Validity

Although the five-construct structure was specified a priori on the basis of established theories and previously validated measurement scales, exploratory factor analysis (EFA) was initially conducted to assess whether the contextually adapted items exhibited the expected empirical structure in the traditional village setting. The analysis was performed using IBM SPSS Statistics 27.0. The Kaiser–Meyer–Olkin measure was 0.879, exceeding the recommended threshold of 0.70, and Bartlett's test of sphericity was statistically significant ($\chi^2 = 1888.004$, $p < 0.001$), confirming the suitability of the data for factor analysis (Table 2). Principal component analysis identified five components that jointly accounted for 65.83% of the total variance, with the first component explaining 34.41% (Table 3). The resulting component structure was broadly consistent with the theoretically specified five-construct framework, providing preliminary empirical support for the proposed measurement structure and a basis for subsequent confirmatory factor analysis.

Table 2. KMO and Bartlett's Test of Sphericity. KMO = Kaiser–Meyer–Olkin measure of sampling adequacy; Bartlett's test of sphericity was conducted to examine whether the correlation matrix was suitable for factor analysis.

KMO	Approx. Chi-Square	df	Sig.
0.879	1888.004	190	<0.001

Table 3. Exploratory Factor Analysis. Extraction method: Principal Component Analysis. Rotation method: Varimax rotation with Kaiser normalization. Factor loadings greater than 0.50 are shown.

Item	SOP	SP	PSA	PLA	EV	Variance Explained
L15	0.732					34.41%
L16	0.735					
L17	0.797					
L18	0.728					
L19	0.672					
L20	0.735					
L1		0.745				11.00%
L2		0.741				
L3		0.793				
L4		0.7				
L8			0.737			8.51%
L9			0.766			
L10			0.672			
L11			0.63			
L12				0.767		6.39%
L13				0.823		
L14				0.791		
L5					0.794	5.51%
L6					0.73	
L7					0.622	

Confirmatory factor analysis (CFA) was subsequently performed using AMOS 26.0 to evaluate the measurement model identified through EFA. Internal consistency reliability

was assessed using Cronbach's α and composite reliability (CR), whereas convergent validity was evaluated using standardized factor loadings and average variance extracted (AVE) (Table 4). CR values above 0.70 are generally considered acceptable [49]. All CR and Cronbach's α values exceeded 0.70, indicating satisfactory internal consistency. The standardized factor loadings were all greater than 0.50, demonstrating that the observed indicators adequately represented their intended constructs. In addition, all AVE values exceeded 0.50, providing evidence of satisfactory convergent validity. Discriminant validity was further assessed using the Heterotrait–Monotrait (HTMT) ratios, which provide a sensitive criterion for distinguishing among latent constructs [50,51]. As shown in Table 5, the HTMT values ranged from 0.299 to 0.691 and were all below the conservative threshold of 0.85 proposed by Henseler et al. [50]. The five constructs therefore demonstrated satisfactory discriminant validity.

Table 4. Results of Reliability and Validity Analysis. *** $p < 0.001$; the loading of the first item of each construct was fixed at 1 for model identification.

Item	Factor	UnStd	S.E.	t	*p*	Std.	SMC	CR	AVE	α
PSA_1	PSA	1				0.722	0.521	0.806	0.510	0.806
PSA_2		1.004	0.113	8.915	***	0.675	0.456			
PSA_3		0.996	0.102	9.773	***	0.748	0.560			
PSA_4		1.165	0.125	9.335	***	0.71	0.504			
PLA_1	PLA	1				0.68	0.462	0.753	0.505	0.753
PLA_2		1.13	0.148	7.628	***	0.698	0.487			
PLA_3		1.201	0.155	7.735	***	0.751	0.564			
EV_3	EV	1				0.813	0.661	0.751	0.511	0.747
EV_2		0.895	0.086	10.42	***	0.775	0.601			
EV_1		0.63	0.088	7.116	***	0.52	0.270			
SP_1	SP	1				0.609	0.371	0.832	0.556	0.831
SP_2		1.289	0.141	9.159	***	0.847	0.717			
SP_3		1.26	0.149	8.435	***	0.737	0.543			
SP_4		1.174	0.135	8.687	***	0.771	0.594			
SOP_6	SOP	1				0.767	0.588	0.858	0.504	0.856
SOP_5		0.956	0.106	9.027	***	0.633	0.401			
SOP_4		0.885	0.091	9.751	***	0.68	0.462			
SOP_3		0.954	0.092	10.408	***	0.722	0.521			
SOP_2		0.868	0.096	9.048	***	0.634	0.402			
SOP_1		1.028	0.088	11.677	***	0.805	0.648			

Table 5. Discriminant validity assessment: Heterotrait–Monotrait (HTMT) ratios.

	PSA	PLA	EV	SP	SOP
PSA	/				
PLA	0.401	/			
EV	0.676	0.299	/		
SP	0.691	0.336	0.672	/	
SOP	0.552	0.362	0.457	0.451	/

4.3.3. Overall Model Fit

The fit of the structural equation model was assessed using multiple indices (Table 6). The chi-square to degrees-of-freedom ratio was 1.718, below the recommended value of 3.00. The comparative fit index (CFI), incremental fit index (IFI), and Tucker–Lewis index (TLI) were 0.935, 0.936, and 0.923, respectively, all exceeding the recommended threshold of

0.90 [52]. The goodness-of-fit index (GFI) and adjusted goodness-of-fit index (AGFI) were 0.885 and 0.849. The root mean square residual (RMR) was 0.029, and the root mean square error of approximation (RMSEA) was 0.058, both below the acceptable criterion of 0.08. Taken together, the indices indicated an acceptable overall fit and supported subsequent testing of the structural paths.

Table 6. Model fit indices of the structural model.

Fit Indices	χ^2/df	CFI	GFI	AGFI	RMR	RMSEA	IFI	TLI
Value	1.718	0.935	0.885	0.849	0.029	0.058	0.936	0.923
Criterion	<3.00	≥0.9	≥0.8	≥0.8	<0.08	<0.08	≥0.9	≥0.9

4.3.4. Hypothesis Testing

The structural model was estimated using IBM SPSS AMOS 26.0 to test the hypothesized relationships among the latent constructs, and the results are presented in Table 7. Six of the ten hypothesized paths were supported. The overall effects of the model paths are presented in Figure 6. PSA had significant positive effects on EV (β = 0.682), SP (β = 0.412), and SOP (β = 0.317), with all three paths reaching statistical significance ($p < 0.05$). Among these relationships, PSA had the strongest standardized effect on EV. This finding suggests that visitors who perceived the soundscape as more authentic were also more likely to perceive it as lively, rich, and interesting. PSA also had a significant positive effect on PLA (β = 0.404, $p < 0.001$). This result is consistent with Gan et al., who suggested that the acoustic environment can influence visitors' cognition and appraisal of visual landscape characteristics through cross-modal interaction [53]. PLA had a significant positive effect on SOP (β = 0.182, $p < 0.05$), whereas its effects on EV and SP were not significant ($p > 0.05$). These results suggest that perceived landscape authenticity contributes primarily to the construction of place meaning rather than directly shaping visitors' affective appraisal of the soundscape. EV had a significant positive effect on SP (β = 0.424, $p < 0.001$), indicating that a more eventful soundscape was also perceived as more pleasant. However, the direct effect of EV on SOP was not significant ($p = 0.195$), and SP likewise had no significant direct effect on SOP ($p = 0.556$). Overall, the structural model identifies PSA as a central construct in the formation of traditional village soundscape experience. In this model, SOP was directly associated with the authenticity of both the soundscape and the landscape, rather than with soundscape pleasantness or eventfulness alone.

Table 7. Results of structural model analysis and hypothesis testing. β represents standardized path coefficients. *** $p < 0.001$, * $p < 0.05$.

Hypothesis	Path	β	S.E.	C.R.	*p*
H1	PSA → PLA	0.404	0.081	4.313	***
H2	PSA → EV	0.682	0.128	6.842	***
H3	PSA → SP	0.412	0.107	3.572	***
H4	PLA → EV	0.002	0.127	0.026	0.979
H5	PLA → SP	0.037	0.078	0.516	0.606
H6	EV → SP	0.424	0.08	3.855	***
H7	PSA → SOP	0.317	0.14	2.358	*
H8	PLA → SOP	0.182	0.1	2.179	*
H9	EV → SOP	0.165	0.103	1.295	0.195
H10	SP → SOP	0.076	0.145	0.589	0.556

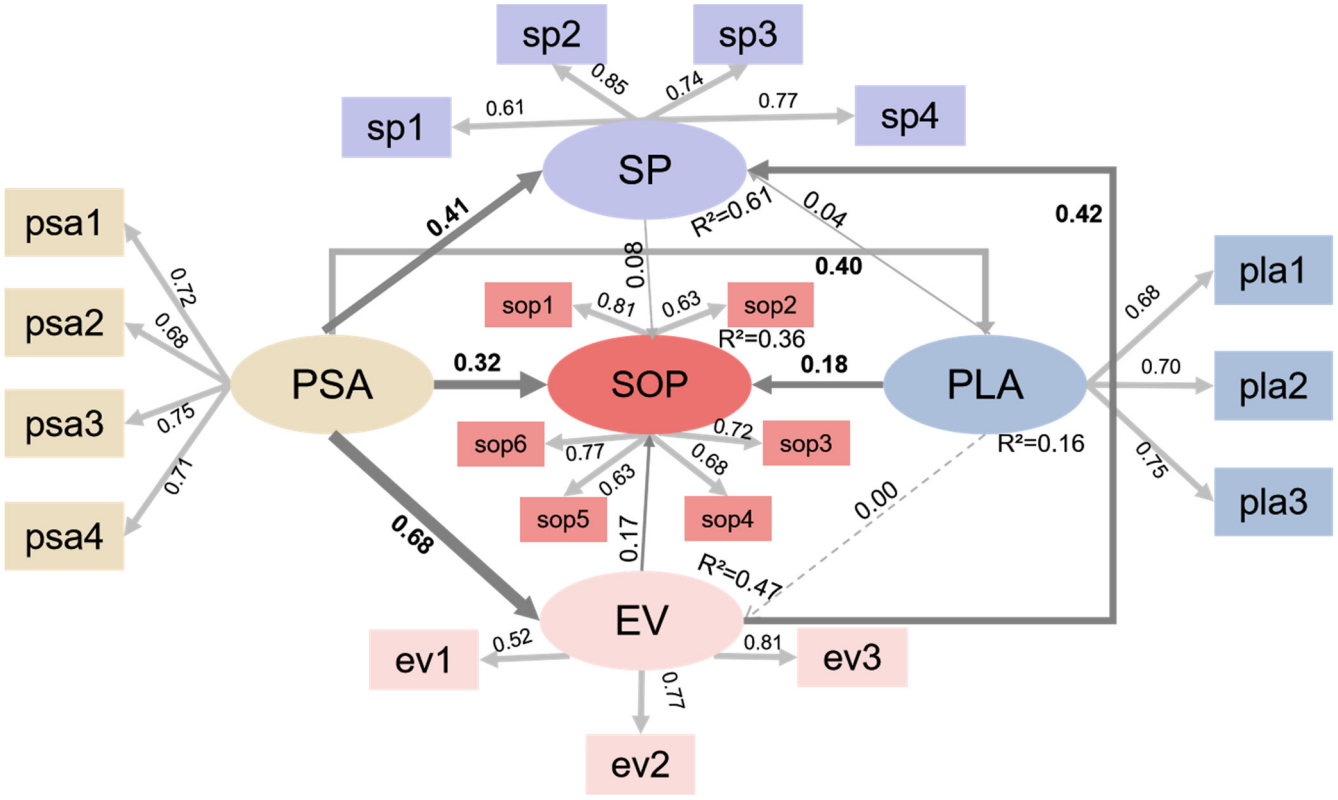


Figure 6. Structural equation model with standardized path coefficients.

4.4. Necessary Condition Analysis

Necessary condition analysis (NCA) determines whether an antecedent must be present for an outcome to reach a specified level. Necessity is evaluated using the effect size and its statistical significance, while bottleneck analysis identifies the minimum level of the antecedent required to achieve a given outcome level [54]. Structural equation modeling (SEM) and NCA therefore provide complementary perspectives: SEM estimates the relationships among constructs, whereas NCA identifies conditions that constrain outcome attainment. Based on the theoretical model and the statistically significant relationships identified through SEM, NCA was conducted for the two core outcome constructs, SP and SOP. Specifically, four relationships were examined: PSA → SOP, PLA → SOP, PSA → SP, and EV → SP. All analyses were performed in R 4.4.3.

NCA estimates necessity effects using ceiling techniques, including ceiling regression with a free disposal hull (CR-FDH) and ceiling envelopment with a free disposal hull (CE-FDH). Because the variables in this study were measured using five-point Likert scales, CR-FDH was adopted as the primary technique for interpreting the necessity effects. The results of both techniques are reported in Table 8. An antecedent was classified as a necessary condition when its effect size exceeded 0.10 and the permutation test was significant at $p < 0.01$. For SOP, PSA satisfied both criteria under CR-FDH (d = 0.226, $p < 0.001$), whereas PLA had a small effect size and was not statistically significant. PSA was therefore identified as a necessary condition for achieving SOP. For SP, PSA also met the necessity criteria (d = 0.233, $p < 0.001$) and was classified as a necessary condition. EV did not satisfy both the effect-size and significance criteria and was therefore not identified as necessary. These results indicate that PSA exerted medium-sized necessity effects on both SOP and SP.

Table 8. Results of Necessary Condition Analysis (NCA). Effect sizes (d) of $0 < d \leq 0.10$ indicate a small effect, whereas $0.10 < d \leq 0.30$ indicate a medium effect. The *p*-values were obtained through permutation tests with 10,000 resamples.

Causal Path	Ceiling Technique	Accuracy	Ceiling Zone	Scope	Effect Size (d)	*p*-Value
PSA → SOP	CR	95.8%	2.633	11.66	0.226	<0.001
	CE	100%	2.090	11.66	0.179	0.036
PLA → SOP	CR	99.1%	0.492	8.89	0.055	0.692
	CE	100%	0.728	8.89	0.082	0.656
PSA → SP	CR	96.7%	2.433	10.5	0.233	<0.001
	CE	100%	2.812	10.5	0.268	<0.001
EV → SP	CR	98.1%	0.595	9	0.066	0.112
	CE	100%	0.917	9	0.102	0.074

Bottleneck analysis identifies the minimum level of a condition, X, required for an outcome, Y, to reach a specified target level. The CR-FDH technique was used to estimate the bottleneck values presented in Table 9. PSA began to constrain SOP when the target level of SOP reached 60%. At this level, at least 16.9% PSA was required. Achieving the maximum target level of SOP required a PSA level of 92.3%. For SP, the necessity constraint emerged at a target level of 40%, for which at least 6.1% PSA was required. Achieving the maximum target level of SP required a PSA level of 70.8%.

Table 9. Bottleneck levels for achieving target outcomes. The bottleneck analysis was performed using the ceiling regression with free disposal hull (CR-FDH) method. NN indicates that no necessary condition exists at the corresponding outcome level.

SOP (%)	PSA (%)	PLA (%)	SP (%)	PSA (%)	EV (%)
0	NN	NN	0	NN	NN
10	NN	NN	10	NN	NN
20	NN	NN	20	NN	NN
30	NN	NN	30	NN	NN
40	NN	NN	40	6.1	NN
50	NN	NN	50	16.9	NN
60	16.9	NN	60	27.7	NN
70	35.7	6.7	70	38.5	6.8
80	54.6	13.8	80	49.3	16.4
90	73.4	21.0	90	60.1	26.1
100	92.3	28.2	100	70.8	35.7

The bottleneck analysis extends the SEM results by demonstrating that PSA is not only positively related to SOP and SP but also places a necessary constraint on their attainment. According to the estimated ceiling line, high levels of SOP and SP cannot be achieved when PSA remains below the corresponding bottleneck thresholds. This pattern indicates that sense of place in traditional villages is strongly dependent on perceived authenticity. Visitors are more likely to develop a strong relationship with a place when its soundscape is perceived as conveying local culture, historical continuity, and contextual appropriateness. Soundscape planning in traditional village heritage sites should therefore extend beyond physical acoustic indicators and immediate pleasantness. It should also preserve and strengthen the authentic sound sources and cultural meanings that support PSA.

4.5. Associations Between Sound Sources and Perceived Authenticity

Mantel tests were used to assess the strength of associations between matrices. For each of the 12 sound-source categories, the Sound-source Dominance Degree (SDD) was calculated from the Perceived Occurrences of Sound (POS) and Perceived Loudness of Sound (PLS), using the equation SDD = POS × PLS [55]. The indicators corresponding to the five perceptual constructs were converted into five separate matrices, and Mantel tests were conducted in R. The results are presented in Figure 7a. The sound-source matrix was significantly associated with PSA. However, the association pattern was not uniform across sound-source categories, indicating that PSA responds selectively to sound-source information. This finding suggests that visitors do not incorporate all perceived sounds equally into their authenticity judgments. Instead, they appear to rely more strongly on auditory cues that reflect the village's natural environmental characteristics and traditional ways of life.

To examine the overall association structure between sound-source types and soundscape perception, Pearson bivariate correlations were calculated between the 12 sound-source categories and the 20 subjective perceptual indicators across the five constructs. The results are presented in Figure 7b. Clear directional differences were observed among the sound sources. Birdsong, water sounds, children's play sounds, instrumental sounds, and productive activities were positively correlated with most subjective perceptual indicators. Water sounds showed the most consistent and statistically significant positive associations. By contrast, human conversation, electronic device sounds, construction noise, and road-traffic noise were negatively correlated with most indicators. The negative associations were particularly pronounced for human conversation, construction noise, and road-traffic noise. These results indicate that different sound-source types occupy distinct positions within the overall perceptual structure. Sounds with natural ecological characteristics or associations with traditional everyday life were more strongly related to positive soundscape assessments, whereas modern intrusive sounds were associated with less favorable perceptual evaluations. Birdsong, water sounds, children's play sounds, instrumental sounds, and productive activities therefore showed the strongest positive associations, while human conversation, construction noise, and road-traffic noise showed the strongest negative associations.

Pearson bivariate correlations were further calculated between the 12 sound-source categories and the four PSA indicators: Local distinctiveness, Cultural significance, Naturalness, and Freedom from external influence. As shown in Figure 7c, water sounds were positively associated with all four PSA indicators, while birdsong was positively associated with three. These two sound sources therefore showed the most consistent positive associations with PSA in Xixinan Village. Human conversation, electronic device sounds, construction noise, and road-traffic noise were significantly negatively associated with the PSA indicators. These negative relationships may reflect the limited congruence of these sounds with the local cultural context and their potential to weaken visitors' judgments of soundscape authenticity.

When considered together with the SEM and NCA results, the sound-source analyses demonstrate that PSA has both a perceptual pathway and a specific environmental basis. Particular sound-source compositions were consistently associated with PSA, while PSA was identified as a necessary condition for attaining higher levels of SOP. Authentic sound sources that are congruent with the local cultural context provide important environmental cues for PSA, whereas modern intrusive sounds may weaken this perceptual process. The conservation of traditional village soundscapes should therefore extend beyond the general control of acoustic environmental quality. Greater attention should be given to preserving

and strengthening authentic sound sources and sound-source compositions that convey place-specific cultural meanings.

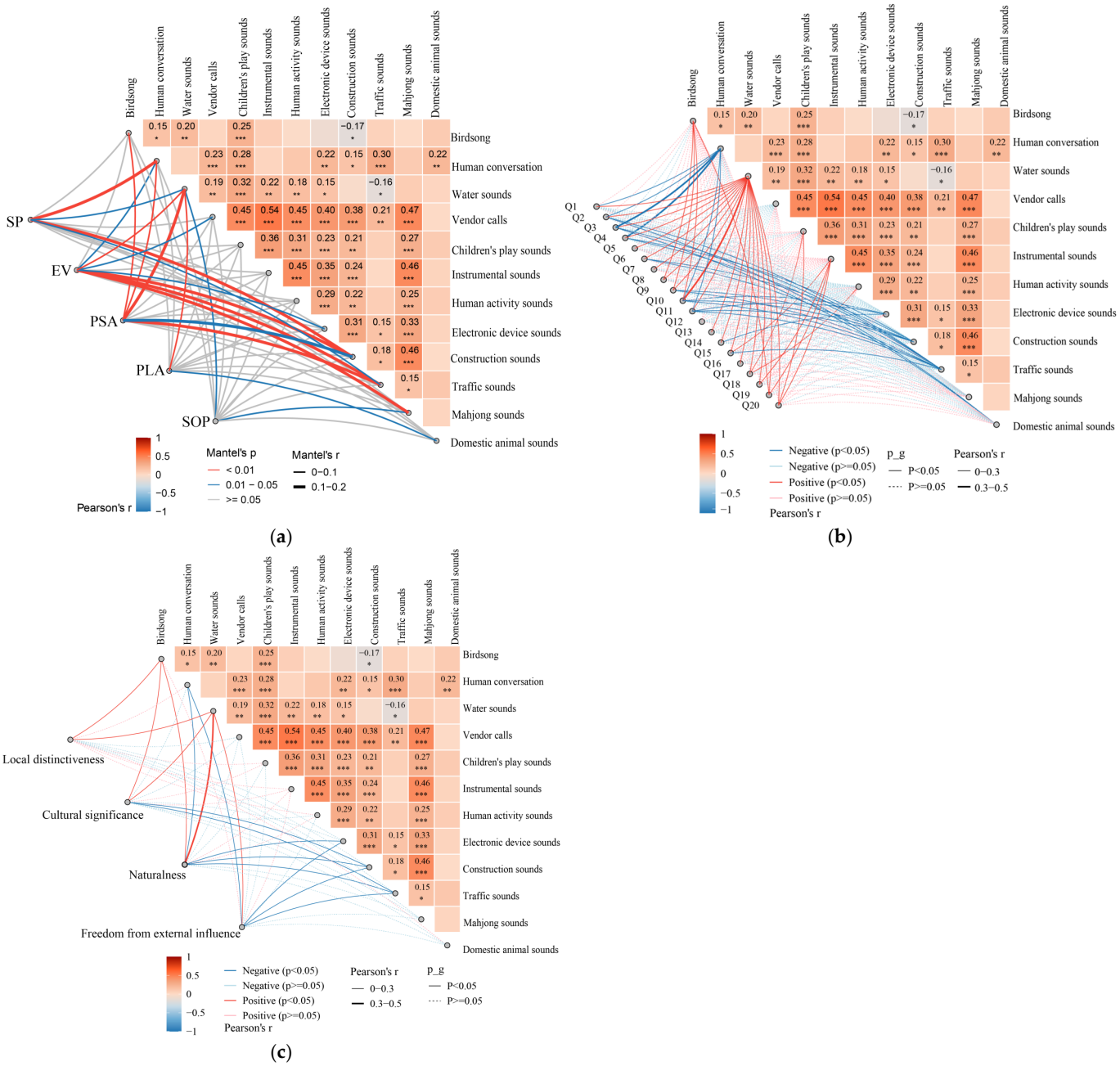


Figure 7. Associations between sound sources and soundscape perception dimensions based on Mantel tests (**a**). Correlation network between sound sources and subjective perceptual indicators (**b**). Associations between sound sources and PSA dimensions (**c**). Correlations between different sound sources: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

5. Discussion

5.1. Perceived Soundscape Authenticity: From Soundscape Quality to Heritage Meaning

One important shift from conventional noise control to soundscape research is the need to understand sound within its social, cultural, and spatial context [56]. Across soundscape studies, numerous descriptors have converged on a two-dimensional structure centered on pleasantness and eventfulness. However, the appropriateness of sound to a place may provide an additional dimension beyond affective quality [22]. In this study, PSA showed

good discriminant validity from SP and EV. This indicates that authenticity is not a repeated measure of general soundscape quality, but a related yet distinct perceptual dimension. PSA was also significantly associated with EV (β = 0.682) and SP (β = 0.412), while retaining an independent effect on SOP (β = 0.317). Together with the PSA indicators of local distinctiveness and cultural significance, and the selective associations between specific sound sources and PSA, these results suggest that PSA extends the idea of appropriateness in historic environments. It reflects whether visitors perceive the current soundscape as congruent with the local cultural context, rather than simply whether the soundscape is pleasant or lively. This is consistent with the recent shift in heritage soundscape research from perceptual quality toward cultural meaning [14].

Recent work has also suggested that eventfulness may contribute more strongly than pleasantness to cultural perception [57]. This is consistent with the stronger effect of PSA on EV than on SP in the present study. An authentic heritage soundscape does not necessarily need to be quieter. Traditional everyday life, natural processes, and cultural activities may instead make the environment richer and more lively. A high-quality soundscape in a traditional village should therefore not be defined simply as "quiet" or "comfortable". It should also retain sufficient auditory information to convey local culture.

In this study, both PSA and PLA were significantly associated with SOP, whereas the direct effects of SP and EV on SOP were not significant. This finding is partly consistent with, but also differs from, previous studies. Research on Gulangyu Island found that overall soundscape evaluation was closely related to visitors' place attachment [8]. Other studies have shown that pleasantness and eventfulness can interact with visual landscape perception in shaping place attachment [58]. In the present study, however, SP and EV showed no independent direct effects on SOP, while PSA and PLA played more prominent roles. This suggests that, in heritage environments such as traditional villages, the development of person–place relationships may depend not only on the perceptual quality of the soundscape, but also on whether sensory information is understood as part of local history and culture.

This interpretation is consistent with recent studies emphasizing meaning-related pathways. Culturally symbolic sounds can contribute to cultural cognition and the formation of heritage meaning [59]. Positive soundscape perception may improve experience directly, but may also operate indirectly through cultural authenticity [60]. The present study further suggests that traditional village soundscapes may involve two related but distinct forms of evaluation: sensory–affective evaluation, represented by SP and EV, and cultural–meaning evaluation, represented by PSA. The former describes the perceived quality of the acoustic environment, whereas the latter concerns its historical and cultural significance.

The NCA results extend this discussion beyond general positive associations. PSA was identified as a necessary condition for both SOP (d = 0.226) and SP (d = 0.233), whereas PLA for SOP and EV for SP did not show the same necessity effects. This means that authenticity is not simply an additional quality that can be compensated for by other environmental advantages. A high level of PSA alone does not guarantee a strong sense of place. However, when PSA remains below a certain level, high levels of SOP and SP are constrained. PSA therefore does not replace pleasantness or eventfulness. Rather, it adds dimensions that are less represented in conventional soundscape assessment, including historical continuity, cultural congruence, and place meaning. The results also suggest that heritage soundscapes may have a minimum threshold of perceived authenticity. Soundscape conservation should therefore extend from the acoustic environment itself to the heritage meanings carried by sound.

5.2. Environmental Basis of Perceived Soundscape Authenticity

PSA is not an abstract perception independent of the acoustic environment. The relationships between the 12 sound-source categories and PSA were clearly selective. Water sounds and birdsong showed the most consistent positive associations, whereas road traffic, construction, and electronic-device sounds were mainly negatively associated with PSA. This pattern is consistent with the definition of acoustical heritage proposed by Zhu et al. [9], which places heritage value at the intersection of sound/acoustics, culture, and history rather than in acoustic properties alone. The role of specific sound sources in PSA therefore reflects how visitors select auditory cues with local meaning from the contemporary acoustic environment.

Water sounds provide a particularly clear example. Previous studies have shown that natural sounds are generally highly preferred [8]. However, explaining the water sounds of Xixinan solely in terms of preference for natural sounds would overlook their stronger place-specific meaning. Historical materials in this study show that water sounds have long been associated with the Fengle River, the traditional water system, and historic weirs. Water sounds in Xixinan therefore combine the perceptual advantages of natural sounds with the cultural continuity of a historical sound source. Their positive association with PSA may arise from both. This interpretation is also consistent with Mediastika [61], who showed that judgments of "iconic sounds" in historically layered environments may depend more on local historical meaning than on present acoustic quality alone. In other words, a sound may become a heritage cue not only because it is pleasant, but also because it "has always been there".

Previous studies have often suggested that human activity and cultural activity sounds can strengthen emotional connection and perceived historical depth in everyday heritage environments [14,57]. In the present study, however, human conversation was negatively associated with several perceptual indicators and with PSA. This difference suggests that "human sound" is not inherently authentic. Residents' dialect conversations, traditional hawking, visitor conversations, and amplified tour-guide speech may all fall within a broad category of human activity sounds, although their cultural origins, loudness, modes of occurrence, and spatial contexts differ substantially. A more plausible interpretation is therefore that authenticity depends on contextual congruence among sound, activity, space, and culture. The effect of the same sound may also vary across spatial contexts [15].

Accordingly, the negative association observed for human conversation should not be interpreted as evidence that human voices are inherently inauthentic. Rather, some human sounds encountered during the survey may not have matched visitors' expectations of a traditional village environment. Future studies should therefore distinguish more clearly among residents' voices, visitor conversations, local dialects, hawking, and amplified tourism-related speech.

Finally, the comparison between historical and contemporary sound sources also shows that authenticity should not be understood as the fixed restoration of a past acoustic environment. Among the 16 place-specific sound sources identified from historical materials, some are no longer consistently perceptible, while new modern sounds have entered the current soundscape. Heritage soundscape conservation should therefore identify the key sounds and contexts that continue to represent local culture, rather than attempt to preserve the entire historical acoustic environment [61]. Traditional village soundscape authenticity is better understood as a form of dynamic cultural continuity. What needs to be sustained is not an isolated sound, but the relationship among sound source, activity, space, and historical-cultural context that gives the sound its local meaning. This understanding also provides a basis for moving from conventional noise management toward authenticity-oriented soundscape design.

5.3. Authenticity-Oriented Spatial Planning and Soundscape Design

Soundscape conservation in traditional villages should not be limited to reducing overall sound pressure levels. Spatial planning should instead respond to different sound-source types and their relationships with the local cultural context. In Xixinan Village, sound pressure levels were relatively high along the Fengle River, but the acoustic environment also contained water sounds, birdsong, and moderate human activity. By contrast, high sound levels near roads and construction areas were mainly produced by road traffic and construction noise. Sound pressure level alone is therefore insufficient for evaluating heritage soundscape quality.

The associations between sound-source types and PSA provide a basis for differentiated management. In water-related cultural landscape spaces, including the river, historic weirs, and wetlands, priority should be given to protecting the water system and its ecological environment while reducing the masking of place-specific water sounds by traffic and amplified sound. In traditional residential and everyday-life spaces, residents' actual productive and social activities should be maintained, while disturbance from tourist groups and externally amplified commercial sound should be limited. At village entrances, roads, and peripheral tourism-service areas, measures such as construction-time control, restrictions on commercial amplification, and vegetated buffers could reduce the transmission of traffic, construction, and electronic-device sounds into the historic core.

Authentic sound sources in historic environments vary across spatial types. Soundscape management should therefore not rely on a single list of "positive sounds" for the entire village. A more appropriate approach is to improve the congruence between sound sources and the functions and cultural contexts of specific spaces.

Authenticity-oriented soundscape design can further be developed through a multilevel spatial strategy. This includes protecting historically continuous sound sources and their physical settings, strengthening existing auditory cues that express local culture, controlling modern intrusive sounds that conflict with the heritage context, and creating acoustic buffers along tourism-development and traffic edges. Visitor routes could also be designed as soundscape sequences in which place-specific sounds gradually become more prominent and mechanical disturbance decreases from peripheral areas toward the historic core.

Such design should not rely on artificially playing traditional sounds to create a historical atmosphere. Priority should instead be given to maintaining the water systems, everyday activities, cultural practices, and spatial settings that continuously produce these sounds. The object of traditional village soundscape conservation should therefore extend from isolated sound sources to an integrated system of sound sources, activities, spaces, and culture. In this way, soundscape management can move beyond noise control toward the maintenance of local auditory continuity and cultural authenticity.

5.4. Limitations and Future Research

This study has several limitations. First, objective acoustic measurements were based on 10 min recordings at each location and were conducted mainly during mornings and afternoons in autumn. Although both weekdays and weekends were covered, these measurements cannot fully capture diurnal and seasonal variations in the village soundscape. In addition, LAeq,10 min represents an energy-averaged sound level over the measurement period and cannot adequately describe short-term peaks, temporal fluctuations, or spectral characteristics. The acoustic measurements in this study were mainly used to characterize the general acoustic environment during the survey period. Percentile sound levels, spectral indicators, and psychoacoustic parameters were not included.

Second, future studies should adopt age-stratified or quota sampling and use multi-group analysis to examine age-related differences. This would provide a more robust assessment of whether the identified relationships are consistent across different age groups. Third, this study intentionally focused on visitors and did not include residents or other long-term users. The present findings therefore mainly reflect soundscape authenticity and place experience from the visitor perspective.

Future research should move beyond asking whether soundscape authenticity exists to examine how it is formed, how it changes, and how it can be applied. First, the formation mechanisms of PSA require further investigation. Social sound sources could be classified in greater detail, including residents' voices, visitor conversations, traditional activity sounds, and modern intrusive sounds. Audiovisual experiments or contextual simulations could then be used to test how the congruence among sound, space, and culture shapes authenticity judgments.

Research could move from point-based perceptual evaluation toward dynamic processes. This would allow changes in authenticity perception to be examined along visitor routes and spatial sequences, as well as across different cultural backgrounds and traditional villages. Historical sound-source evidence, spatial functions, objective acoustic characteristics, and PSA could also be integrated into a spatially explicit framework for soundscape authenticity assessment. Such a framework could support heritage soundscape zoning, long-term monitoring, and planning decisions. Soundscape authenticity research could therefore develop from static perceptual evaluation toward a more mechanistic, dynamic, and spatial understanding.

6. Conclusions

The main contribution of this study is to extend traditional village soundscape research beyond evaluations centered on pleasantness, eventfulness, and acoustic quality toward the assessment of heritage meaning and authenticity. By linking historical sound-source evidence, contemporary sound-source perception, and visitors' authenticity judgments, the results show that PSA is not a repeated measure of general soundscape quality. Instead, it represents a distinct judgment of how well the soundscape corresponds to the local cultural context. This provides a new perspective for understanding how environmental sounds become heritage cues with place-specific meaning.

The study further shows that soundscape authenticity is not determined by a single category of sound. Rather, it emerges from the contextual relationship among sound source, activity, space, and culture. This extends current understandings of acoustical heritage and authenticity by emphasizing dynamic cultural continuity. In practical terms, the findings support a shift in traditional village soundscape conservation from noise reduction and comfort improvement toward authenticity-oriented conservation based on historical continuity, cultural congruence, and spatially differentiated management. This provides a theoretical basis for the sustainable planning and design of soundscape heritage.

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Institutional Review Board Statement: The study was non-interventional and minimal-risk and used anonymized questionnaire and interview data without collecting directly identifiable or sensitive personal information. In accordance with Article 32 of the Measures for Ethical Review of Life Science and Medical Research Involving Humans (National Health Commission Order No. 4, 2023), research using anonymized information or data that causes no harm to human participants and does not involve sensitive personal information or commercial interests may be exempted from ethics review. The study was conducted in accordance with applicable ethical principles for research involving human participants, including the Declaration of Helsinki.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

The screening process used to derive the 12 sound-source categories for the field survey, including retention, merging, exclusion, and addition, is presented in Table A1.

Table A1. Historical Evidence, Present-Day Occurrence, and Classification of Sound Sources in Xixinan Village.

Sound Source	Evidence Source	Sound-Producing Basis	Present-Day Occurrence	Treatment	Final Sound-Source Category
Water sounds from the four weirs	Fengnan Gazetteer, Vol. 9, "Record of the Repair of Two Weirs"	Four historic weirs	Consistently present	Merged	Water sounds
Rushing water sounds	Wu Qi, Yixiang Cichao, Vol. 1, "Miscellaneous Verses on Xinan: Gaoyu Pavilion"	Fengle River	Consistently present	Merged	Water sounds
Stream sounds	Zhu Yunming, Eight Views of Xinan: "Meixi Thatched Cottage"	Village streams	Consistently present	Merged	Water sounds
Wind-instrument sounds	Zhu Yunming, "Zhuwu Fengming"	Wind instruments	Infrequently present	Merged	Instrumental sounds
Wind through cypress trees	Zhu Yunming, "Ancient Trees at the Ancestral Hall"	Cypress trees	Not consistently identifiable	Excluded	Not included
Wind through bamboo leaves	Zhu Yunming, "Zhuwu Fengming"	Bamboo groves	Not consistently identifiable	Excluded	Not included
Drum music	Feng Mengzhen, Kuaixuetang Diary	Drums and percussion instruments	Not consistently identifiable	Excluded	Not included
Nuo opera sounds	Fengnan Gazetteer	Nuo opera performers	Not consistently identifiable	Excluded	Not included
Work-related activity sounds	Zhu Yunming, "Greenery Encircling the Eastern Fields"	Agricultural tools and farming activities	Infrequently present	Merged	Human activity sounds
Human conversation	Feng Mengzhen, Kuaixuetang Diary	Local residents	Consistently present	Retained	Human conversation
Wind through pine trees	Wu Qi, "Miscellaneous Verses on Xinan: Songyun Pavilion"	Pine forests	Not consistently identifiable	Excluded	Not included

Table A1. *Cont.*

Sound Source	Evidence Source	Sound-Producing Basis	Present-Day Occurrence	Treatment	Final Sound-Source Category
Children's play sounds	Everyday activities of children	Visitors and local residents	Infrequently present	Added	Children's play sounds
Rain sounds	"Spring Flood at Shanyuan"	Raindrops	Weather-dependent	Excluded	Not included
Birdsong	Wu Qi, "Miscellaneous Verses on Xinan: New Bridge"	Birds	Consistently present	Retained	Birdsong
Poultry sounds	Fengnan Gazetteer	Domestic poultry	Infrequently present	Merged	Domestic animal sounds
Reading and recitation sounds	Zhu Yunming, "Meixi Thatched Cottage"	Traditional school activities	Not consistently identifiable	Excluded	Not included
Firecracker sounds	Fengnan Gazetteer, Dragon Boat Festival festivities	Firecrackers	Not consistently identifiable	Excluded	Not included
Electronic device sounds	On-site field survey	Electronic playback devices	Consistently present	Added	Electronic device sounds
Construction sounds	On-site field survey	Building and construction activities	Infrequently present	Added	Construction sounds
Traffic sounds	On-site field survey	Motorized and non-motorized traffic	Consistently present	Added	Traffic sounds
Mahjong and card-game sounds	On-site field survey	Residents' recreational activities	Infrequently present	Added	Mahjong sounds
Vendor calls	On-site field survey	Tourism-related commercial activities	Infrequently present	Added	Vendor calls

Appendix B

The total variance explained in the common method bias assessment is presented in Table A2.

Table A2. Total Variance Explained. Extraction Method: Principal Component Analysis.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.883	34.413	34.413	6.883	34.413	34.413
2	2.202	11.008	45.420	2.202	11.008	45.420
3	1.702	8.512	53.932	1.702	8.512	53.932
4	1.278	6.389	60.321	1.278	6.389	60.321
5	1.102	5.508	65.829	1.102	5.508	65.829
6	0.787	3.933	69.763	—	—	—
7	0.699	3.495	73.257	—	—	—
8	0.661	3.304	76.562	—	—	—
9	0.554	2.769	79.330	—	—	—
10	0.541	2.705	82.036	—	—	—
11	0.510	2.549	84.584	—	—	—

Table A2. *Cont.*

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
12	0.490	2.452	87.036	—	—	—
13	0.392	1.962	88.998	—	—	—
14	0.370	1.850	90.848	—	—	—
15	0.353	1.763	92.611	—	—	—
16	0.343	1.717	94.329	—	—	—
17	0.333	1.666	95.995	—	—	—
18	0.307	1.537	97.532	—	—	—
19	0.275	1.377	98.909	—	—	—
20	0.218	1.091	100.000	—	—	—

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