Soundscape and Influencing Audio-Visual Factors of Tourism Villages in Northern China

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With the continuous development of rural tourism, the sound environment of public spaces in tourism villages has been receiving increasing attention. To optimize the soundscape of public spaces in these villages, this paper studies five typical tourism villages in the Beijing-Tianjin-Hebei urban agglomeration, the largest urban agglomeration in northern China. Through fields surveys on the audio-visual landscape factors and Virtual Reality (VR) experiments, the soundscape and visual landscape of the typical public spaces in these villages are evaluated. Correlation analysis and Structural Equation Model (SEM) are employed to analyse the influence of visual landscape factors on soundscape evaluation. The results indicate that, among the three types of public spaces surveyed (i.e., squares, parks, and pavements), human sounds and natural sounds are the primary sound sources in squares, whereas natural sounds prevail in parks and pavements. Moreover, the sound pressure level in parks is relatively high. The pleasantness results in squares, parks and public spaces along the streets are positive, and the eventfulness results in squares and parks are mostly, positive, whereas the pleasantness results in the public spaces along the streets are mostly negative. Furthermore, the results indicate that greenery satisfaction, architectural aesthetics and space openness are significantly positively correlated with soundscape pleasantness, however greenery satisfaction, environmental cleanliness, sky visibility and space openness are significantly negatively correlated with soundscape eventfulness. Using SEM, we found that architectural aesthetics and space openness had positive effects on soundscape pleasantness, with standardised path coefficients of 0.196 and 0.152, respectively ($p < 0.05$), whereas environmental cleanliness and architectural aesthetics had significant effects on soundscape eventfulness, with standardised path coefficients of -0.242 and 0.151, respectively ($p < 0.05$). This study provides a scientific basis for improving the public space environment in tourism villages.

1. INTRODUCTION

The rural tourism industry in China is experiencing a surge because of the implementation of the national rural revitalisation strategy. According to statistics from the Ministry of Agriculture and Rural Affairs of the People's Republic of China, as of the end of 2019, there were over 2.9 million business units engaged in leisure agriculture and rural tourism in China, generating revenue of RMB850 billion.[1] The tranquil and picturesque environment of villages is a defining characteristic that distinguishes them from urban built-up areas,[2] and it is also a major draw for urban residents to visit for tourism.[3] The picturesque natural landscape and tranquil sound environment of the village provide a respite from the hustle and bustle and stress of urban life, thereby making it an idyllic destination for promoting a healthy environment.[4–8] However, disharmonious situations related to sound have been observed in certain tourism villages, including conflicts between traffic noise, commercial noise, and natural sounds. These situations may have a negative effect on tourists' experiences and undermine their original expectations and perceptions of the peaceful atmosphere in villages.[9] Therefore, conducting thorough research is essential to optimize the soundscape of tourism villages.

Unlike conventional noise control methods, the concept of soundscape emphasizes perception and views the sound environment as a resource.[10] Therefore, soundscape evaluation focuses not only on the physical measurement of sound but also on people's subjective experiences to the sound environment.[11,12] Soundscape evaluation involves various factors, including auditory and visual features and respondent characteristics. With respect to auditory factors, sound characteristics are important aspects affecting soundscape evaluation.[13] Sound characteristics include primarily the sound pressure level and frequency. In urban public spaces, there is a correlation between sound pressure levels and sound environment evaluations. Specifically, as the sound pressure level increases, people tend to perceive the sound environment as noisy.[14] Specific sound frequencies, such as pitch changes in

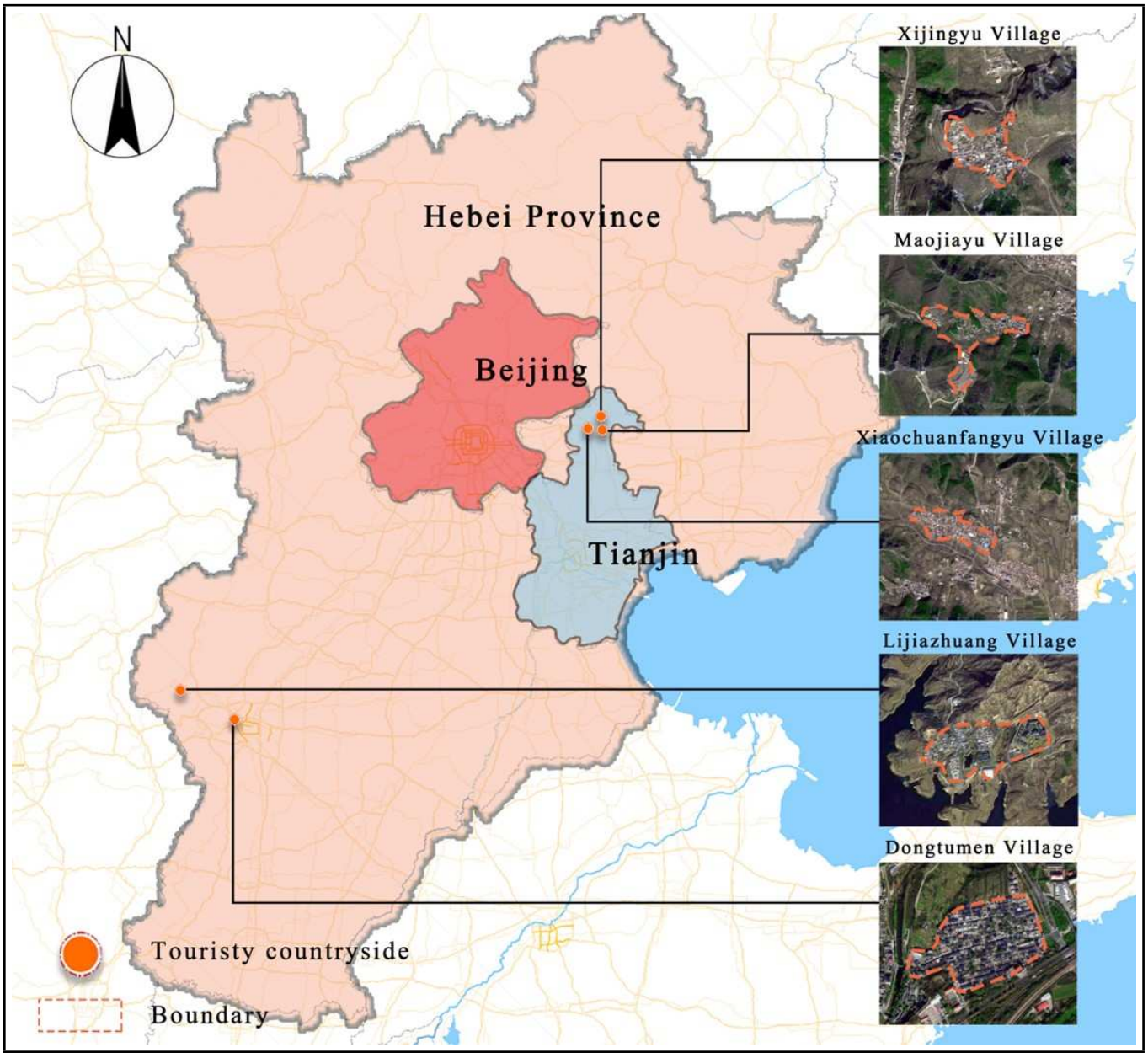

Figure 1. Locations of tourism-oriented villages.

birdsong, catch people's attention, whereas continuous white noise or pink noise helps people relieve stress and anxiety.[15] Furthermore, individuals' sound source preferences have a direct effect on soundscape evaluation. Typically, natural sounds such as birdsong and water sounds are preferred, whereas artificial sources such as traffic noise are viewed negatively.[16–18] In terms of visual factors, the goodness-of-fit between visual stimulation and a soundscape can significantly affect respondents' acoustic comfort and acoustic preference.[19–21] With respect to respondent characteristics, an individual's social background and behavioural factors have a significant effect on soundscape perception. For example, gender, age and behavioural patterns, such as walking alone or with a companion, influence individuals' sensitivity and preferences for sound environments.[22–25]

Unlike urban soundscape, rural audio-visual landscape and tourist experiences have distinct features. For example, village public spaces boast a high green coverage rate, with natural sounds like rustling of leaves and birdsong, as well as human sounds such as tourist chatter and traditional music, being the primary sources of sound.[26] These sounds can evoke positive emotions and local attachment, thus influencing people's evaluations of the visual quality and quietness of rural landscape.[27,28]

To conduct an in-depth analysis of the rural soundscape characteristics and the influence of visual landscape factors on soundscape evaluation, this study focused on five typical tourism villages located within the Beijing-Tianjin-Hebei urban agglomeration. The main objectives were to: (1) evaluate the soundscape characteristics of public spaces in tourism villages, (2) analyse the effect of visual landscape factors on the soundscape evaluation of tourism villages, and (3) explore the influence path of visual factors on the soundscape evaluation of public spaces in tourism villages.

This study evaluated the soundscape characteristics of public spaces in tourism villages through virtual scene recreation and questionnaires. Correlation analysis was conducted to explore the relationship between visual landscape factors and

Table 1. Profile of tourism-oriented villages.

The Name of Village	Types of Villages	Village Characteristics	Scene Photos
Xijingyu Village	Villages Dominated by Characteristic Industries	Xijingyu Village, located on a stone mountain, covers an area of 276.53 hectares. Two-thirds of the buildings are constructed from stone and well preserved in a concentrated area. The village has a thriving homestay industry, offering a total of almost 500 beds, as well as a cafe and a tavern. In 2023, it attracted 40,000 tourists and generated tourism revenue exceeding RMB10 million.	
Maojiayu Village	Villages for Suburban Leisure and Recreation	Maojiayu village, located in Jizhou District, Tianjin, covers an area of 518.46 hectares. It is home to picturesque natural landscapes, including the billion-year stone and million square -metre forest. In recent years, it has been developed into a longevity resort, mainly attracting tourists from Beijing and Tianjin during the holidays.	
Xiaochuanfangyu Village	Villages Relying on Scenic Spots and Tourist Attractions	Xiaochuanfangyu village is also located in Jizhou District, Tianjin, and spans an area of 50.78 hectares. Boasting a beautiful environment and favourable topographic conditions and owing to its proximity to scenic spots, it has become a unique tourism village renowned for its perfect blend of natural beauty and village life.	
Lijiazhuang Village	Villages for Characteristic Resource Development	Lijiazhuang village, covering an area of 133.33 hectares, is the former site of the United Front Work Department of the CPC Central Committee. This area has deeply explored the red cultural resources and has become a red tourism village by implementing environmental improvements, residential renovations and other qualities.	
Dongtumen Village	Villages for Cultural and Folk Custom Tourism	Dongtumen village spans an area of 93.33 hectares. Its primary thoroughfare is the Qinhuang Ancient Road, which runs from east to west and features the Tumen Pass as its main entrance. In view of its historical and cultural background, the village attaches importance to the preservation, development and utilisation of cultural relics and promotes the integration of culture and tourism.	

soundscape evaluation factors. Furthermore, SEM was utilized to analyse the influence paths of visual factors on soundscape evaluation.

2. METHODS

2.1. Study Areas

The Beijing-Tianjin-Hebei region is one of China's three major urban agglomerations, covering an area of $218,000$ km^2 with a population of 110 million. As a strategically important area for the country, rural tourism has been integrated into the overall layout of the rural revitalization strategy. According to relevant research,[29] tourism villages can be classified into five main categories: specialty industry villages, suburban leisure villages, scenic spot-based villages, special resource villages, and cultural and folk villages. As presented in Fig. 1, this paper analyzes five national key tourism villages, namely, Xijingyu village, Maojiayu village, Xiaochuanfangyu village, Lijiazhuang village and Dongtumen village in Beijing–Tianjin–Hebei urban agglomeration. These five villages boast abundant natural landscape resources and unique regional cultural characteristics, enjoying high popularity within the Beijing-Tianjin-Hebei urban agglomeration. Among them, Lijiazhuang village and Dongtumen village are in Shijiazhuang city, Hebei Province, and the other three villages are in Jizhou District, Tianjin.

As shown in Table 1, Xijingyu village boasts a history of over a century and was designated a traditional Chinese village in 2012. As a traditional national village with well-preserved historical features, it emphasises tourism development and serves as a model for specialty industry villages. Maojiayu village, which is surrounded by mountains and boasts a high forest coverage rate, attracts tourists primarily from Beijing and Tianjin during the holidays. Accordingly, it represents a sub-

Table 2. Locations and panorama of public spaces in tourism villages.

Squares		Parks		The public spaces along the streets	
Site	Panorama	Site	Panorama	Site	Panorama
					
Xijingyu Village (S1)		Xijingyu Village (P1)		Xijingyu Village (AS1)	
					
Lijiazhuang Village (S2)		Maojiayu Village (P2)		Xijingyu Village (AS2)	
					
Lijiazhuang Village (S3)		Xiaochuanfangyu Village (P3)		Maojiayu Village (AS3)	
					
Dongtumen Village (S4)		Lijiazhuang Village (P4)		Xiaochuanfangyu Village (AS4)	

urban leisure village. Xiaochuanfangyu village is surrounded by many scenic spots, such as Panshan Mountain Scenic Area and Jiulongshan National Forest Park. With its beautiful natural scenery, Xiaochuanfangyu village represents a scenic spot-based village. As the former site of the United Front Work Department of the CPC Central Committee, Lijiazhuang village boasts rich cultural landscape resources, thus representing a special resource village. Dongtumen village, situated along the Qinhuang Ancient Road, places great emphasis on the preservation of cultural relics and the integration of culture and tourism, making it a prime example of a cultural and folk village.

2.2. Auditory–Visual Information Collection

Based on relevant research and field surveys, the public spaces of the village include the central square, park and pavement along the streets. As shown in Table 2, this study analyses 12 typical public spaces in the tourism villages, in which S1–S4 are squares, P1–P4 are parks, and AS1–AS4 are the public spaces along the streets.

In August 2023, 5 min panoramic videos were recorded with a camera (GoPro Max) during peak crowd activity hours (9:00−12:00 and 14:00−17:00). The sound was recorded using a BHS II 3322 binaural microphone and a SQobold3302 4-channel recording and playback device (HEAD acoustics GmbH, Herzogenrath, Germany). An HS5671B sound level metre was used to measure the sound pressure level. Each measurement lasted 5 min. The sound level metre sensor was 1.2−1.5 metres away from the ground and more than 1 metre away from the building façade. The ICP binaural microphone and sound level metre were calibrated with an HS6020 calibrator (frequency: 1000 Hz, SPL: 94 dB). The sound recorded by the BHS II binaural headphones was imported into SQobold SQP 01 FFT for online analysis, and the psychoacoustic parameters were calculated using the ISO 532–1 method. To prevent the effects of equipment on/off and other noise, the clips of the first and last 1 minute of the recorded audio were removed.

2.3. Soundscape and Visual Landscape Perception Experiments

2.3.1. Experimental procedure

Before the start of the experiment, we used an GoPro Player to screen the recorded panoramic videos and edited the videos and audios to ensure correspondence and continuity. The edited videos were decoded with a GoPro Max Exporter for watching via VR.

To better reproduce the actual scenes, the respondents wore VR headsets (Type VIVE-VR) and HEAD acoustics 2019 binaural headphones to immerse themselves in the acoustic and visual scenes of public spaces in the tourism villages. The HMD environment has a monocular resolution of 1080×1200 pixels, i.e., a combined resolution of 2160×1200 pixels, a dual AMOLED 3.6 in. screen with a 90 Hz refresh rate and a 110° angle of view.

During the experiment, the respondents were required to watch 3 scenes, with each scene being displayed continuously for 3 min, and the respondents were allowed to rotate their heads or walk in a small area while watching the scenes (Fig. 2).[30] There was a 90-second interval between each scene, during which the respondents were asked to score the visual landscape and soundscape of the previous scene. To avoid individual adaptation differences and vertigo arising from prolonged use of VR headsets, the respondents' experimental time was controlled within a 15 min window. At the end of the experience, the respondents completed the Environmental Perception Questionnaire.

Figure 2. Photographs of the experimental process.

2.3.2. Questionnaire

As shown in Fig. 3, the Environmental Perception Questionnaire included 3 parts individual characteristics of the respondent, visual landscape evaluation, and soundscape evaluation.

Part 1 recorded the respondents' basic information, such as gender, age and major. Part 2 collected information on the visual landscape evaluations of the respondents. Based on conclusions from existing studies and the characteristics of public spaces,[31,32] five parameters, namely, greenery satisfaction, environmental cleanliness, architectural aesthetics, sky visibility and space openness, were selected to evaluate the visual landscape of public spaces in tourism villages. In rural public spaces, greenery satisfaction reflects the abundance of natural vegetation within the public space and the respondents' perception of greening; and environmental cleanliness embodies the overall appearance and sanitation conditions of the village. Architectural aesthetics highlight the architectural style and craftsmanship of the village's buildings. Sky visibility indicates the skyline and the ventilation and lighting conditions in the area. Space openness represents the openness of the public space. These factors collectively reflect the visual landscape characteristics of public spaces in tourism villages from different perspectives. Part 3 collected information on soundscape evaluation from the respondents. As shown in Table 3, each scene is evaluated according to eight soundscape attributes, namely, pleasant, chaotic, vibrant, uneventful, calm, annoying, eventful and monotonous, in accordance with ISO 12913-2.[12] A 5-point Likert scale (1—strongly disagree, 2—disagree, 3—neither disagree nor agree, 4—agree, 5—strongly agree) was used to evaluate each soundscape attribute.

A total of 123 college students majoring in urban and rural planning, architecture and others with a gender ratio of approximately 1:1 were recruited to participate in this experiment. The participants in this study shared similar lifestyles, as their daily routines revolved around schoolwork. They had not been subjected to recent pressures related to exams, social interactions, or economic factors. Additionally, all respondents had normal hearing and vision, including those who used corrective lenses. All the respondents were aware of the characteristics of the tourism villages, which ensured the accuracy of the respondents' evaluation of the tourism villages. Each respondent watched videos of three different types of spaces and filled out three questionnaires, leading to a total of 369 questionnaires collected for the experiment. Table 4 presents the statistics of the respondents' basic information. Figure 10 in the appendix presents the soundscape assessment results for 12 sample sites.

2.4. Perceived Emotional Quality of Soundscape

In accordance with the data analysis method of Method A in ISO 12913-3,[33] two soundscape dimensions, i.e., pleasantness and eventfulness, were calculated via the following equations. Equations (1) and (2) are as follows:

$$Pleasantness = \{(p-a)+\cos 45^\circ(ca-ch)+\cos 45^\circ(v-m)\}/(4+\sqrt{32}); \quad (1)$$

$$Eventfulness = \{(e-u)+\cos 45^\circ(ca-ch)+\cos 45^\circ(v-m)\}/(4+\sqrt{32}); \quad (2)$$

where p means pleasant, a means annoying, ca means calm, ch means chaotic, e means eventful, u means uneventful, v means vibrant, and m means monotonous.

2.5. Data Analysis

The experimental data was input into SPSS 23.0 for statistical analysis, and Spearman correlation analysis was conducted to analyse the relationships between the visual landscape factors and the soundscape evaluation of the tourism villages. The structural equation was built with IBM SPSS Amos 26 Graphics to analyse the influence path of visual landscape factors on soundscape evaluation. The reliability and validity of the results of the soundscape and visual landscape evaluations of the respondents were tested before the structural equation was constructed. Through reliability analysis and the Kaiser-Meyer-Olkin (KMO) test, a structural equation model of "visual landscape factors—soundscape evaluation" was established to explore the relationships between visual landscape factors and the soundscape evaluation of tourism villages.

3. RESULTS

3.1. Soundscape Characteristics of Public Spaces in Tourism Villages

3.1.1. Types of sound sources

Figure 4 presents a statistical chart depicting the frequencies of sound sources observed during the test of 12 sampled public

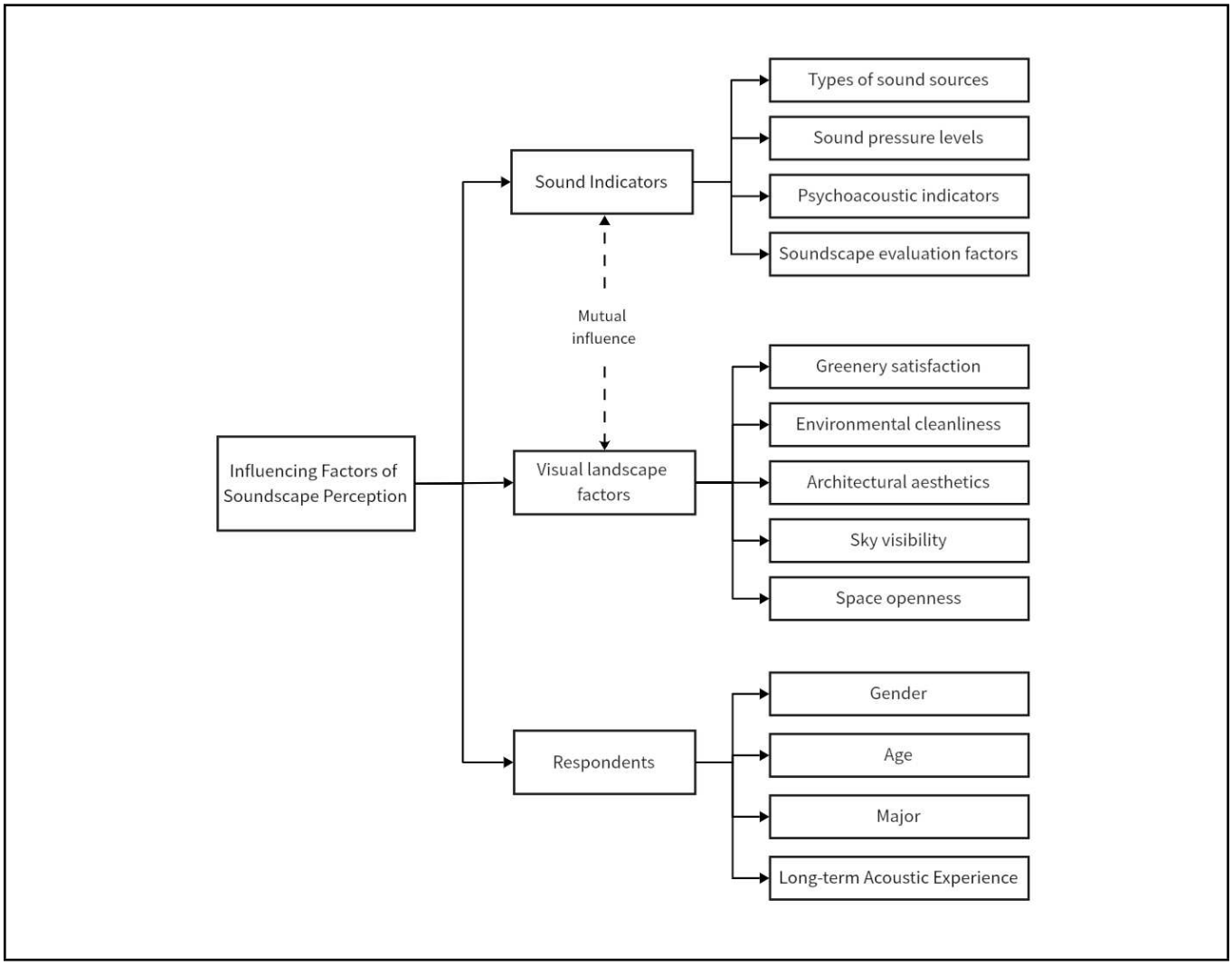

Figure 3. Influencing factors of soundscape perception.

Table 3. The visual and audio environment perception evaluation scale.

Type	Evaluation dimension		Strongly	Slightly	Neither	Slightly	Strongly	
Visual landscape factors	Greenery satisfaction	Poor	1	2	3	4	5	Good
	Environmental cleanliness	Poor	1	2	3	4	5	Good
	Architectural aesthetics	Poor	1	2	3	4	5	Good
	Sky visibility	Poor	1	2	3	4	5	Good
	Space openness	Poor	1	2	3	4	5	Good
Soundscape evaluation factors	Pleasant	Disagree	1	2	3	4	5	Agree
	Chaotic	Disagree	1	2	3	4	5	Agree
	Vibrant	Disagree	1	2	3	4	5	Agree
	Uneventful	Disagree	1	2	3	4	5	Agree
	Calm	Disagree	1	2	3	4	5	Agree
	Annoying	Disagree	1	2	3	4	5	Agree
	Eventful	Disagree	1	2	3	4	5	Agree
	Monotonous	Disagree	1	2	3	4	5	Agree

Table 4. Basic information of the respondents.

Indicators		Number	Percentage (%)	Cumulative Percentage (%)
Gender	Male	206	55.83	55.83
	Female	163	44.17	100
Age	≤ 20	180	48.78	48.78
	$21-30$	189	51.22	100
Highest Educational Qualification	Bachelor	256	69.38	69.38
	Master	113	30.62	100
Major	Urban and Rural Planning	179	48.51	48.51
	Architecture	187	50.68	99.19
	Mechanical Engineering	3	0.81	100

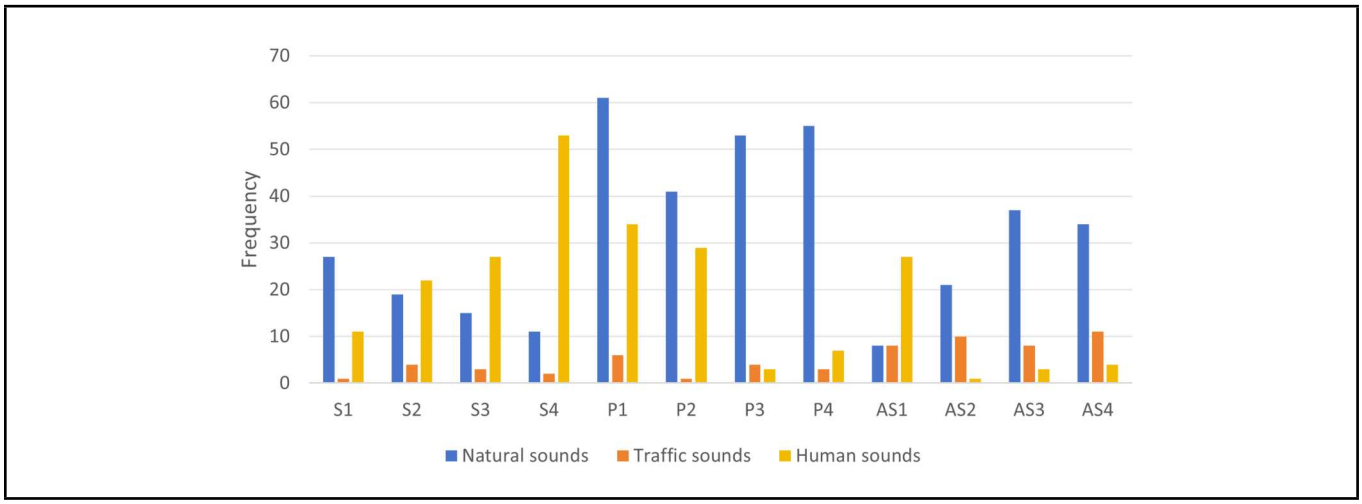

Figure 4. Sound sources in public spaces of tourism villages.

Table 5. Acoustic indicator statistics of public spaces in tourism villages (3 min).

Site		S1	S2	S3	S4	P1	P2	P3	P4	AS1	AS2	AS3	AS4
LAeq (dBA)	Left	57.4	44.3	50.2	65.3	66.4	71.3	63.4	48.3	59.2	63.6	55.0	59.9
	Right	57.4	43.6	52.0	64.6	68.0	71.8	63.4	48.2	59.3	63.6	54.9	58.5
LCeq (dBA)	Left	61.8	55.2	57.9	66.8	67.0	70.1	63.1	55.0	63.7	68.4	57.7	61.2
	Right	62.3	55.6	58.6	66.3	68.2	70.6	63.1	54.6	63.8	68.6	57.9	60.7
LAF5 (dBA)	Left	58.2	56.2	58.0	69.0	72.6	74.3	65.5	53.1	65.0	65.8	58.0	64.2
	Right	58.3	58.1	60.0	68.3	74.4	74.5	65.3	52.8	65.0	66.6	57.5	64.0
LAF95 (dBA)	Left	56.6	37.1	37.8	59.7	50.3	65.4	58.6	42.0	51.8	58.0	48.0	49.2
	Right	56.4	37.8	38.5	59.2	50.2	67.3	60.2	42.0	52.1	57.4	48.0	48.4
N5 (soneGF)	Left	12.3	10.0	10.9	19.8	22.0	30.0	18.8	8.5	15.1	20.2	11.6	17.3
	Right	12.0	11.5	12.6	19.4	25.1	30.9	18.6	8.4	15.5	21.0	11.7	16.2
N95 (soneGF)	Left	10.8	2.4	2.6	12.2	7.2	17.2	11.1	4.0	7.9	11.7	6.3	7.1
	Right	10.1	2.6	2.8	11.8	7.2	18.4	12.2	4.0	8.0	10.7	6.3	6.7
Nrmc (soneGF)	Left	11.5	4.4	6.3	15.9	14.6	24.8	15.0	6.1	11.2	15.9	9.3	11.7
	Right	10.9	4.2	7.1	15.4	16.1	26.0	15.3	6.1	11.3	15.7	9.3	11.0

spaces. As shown in the figure, the predominant sounds heard in squares (S1–S4) are human sounds and natural sounds, occurring 11–53 times and 11–27 times, respectively. The predominant sounds heard in parks (P1–P4) are natural sounds, which occur 41–61 times, followed by human sounds, which occur 3–34 times. In the public spaces along the streets (AS1–AS4), natural sounds are also predominant, occurring 8–37 times, followed by traffic sounds, which occur 8–11 times. After conducting a thorough analysis, we found that the primary sounds present in certain squares were human sounds. However, in all other spaces, natural sounds prevailed. This can be attributed to the fact that these villages are blessed with abundant natural landscape, with birds, cicadas, and wind being the primary sound sources in their public spaces.

3.1.2. Acoustic indicator

The acoustic and psychoacoustic indicators are presented in Table 5, with the equivalent continuous A-weighted sound pressure level (LAeq, 3 min) of the sampled public space ranging from 43.6 to 71.8 dBA and the equivalent continuous C-weighted sound pressure level (LCeq, 3 min) ranging from 55.0 to 70.6 dBC. LAF5, 3 min and LAF95, 3 min are in the ranges of $52.8-74.5$ dBA and $37.1-67.3$ dBA, respectively. With respect to loudness, the ranges of loudness exceed the limits in 5% of the time interval N5 and in 95% of the time interval N95 at $8.4-30.9$ soneGF and $2.4-18.4$ soneGF, respectively. Nrmc ranges from 4.2 to 26.0 soneGF.

Figure 5 shows the statistics of the sound pressure levels of the public spaces in the sampled villages. As shown in the figure, the equivalent sound pressure levels of the 3 types of spaces mostly range from 50 to 60 dBA, with only S4, P1, P2, and P3 being greater than 65 dBA. This may be caused by the high sound pressure level of natural sounds such as birdsong and cicadas chirping in the park. The distributions of L10 and Leq in each public space are similar, whereas the L90 of the public spaces along the streets is relatively low, indicating that this type of space is relatively quiet when there are no vehicles on the streets.

3.1.3. Soundscape evaluation

The positions of all the sampled points in the pleasantness-eventfulness two-dimensional model were calculated via the soundscape evaluation data using the equation according to Method A in ISO 12913-3.[33] As shown in Fig. 6, the results of all the soundscape pleasantness evaluations of squares, parks, and public spaces along the streets in tourism villages are positive, indicating that these three types of public spaces instil feelings of pleasantness in the tourists. The evaluation and analysis of eventfulness revealed that the results for squares and parks are mostly positive, whereas those for the public spaces along the streets are, for the most part, negative. This was likely because there were more crowd gatherings and activities in the spaces of squares and parks than in the public spaces along the streets. The analysis of the relationship between pleasantness and eventfulness revealed that with increasing eventfulness, pleasantness also tended to increase.

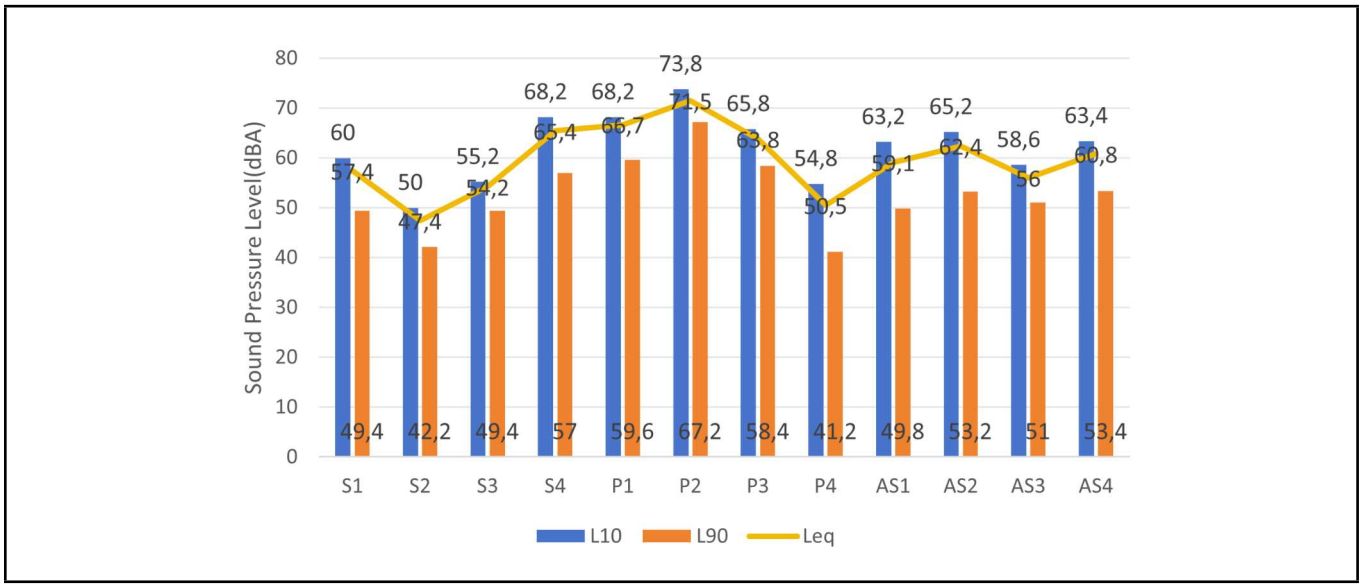

Figure 5. Sound pressure levels in public spaces of tourism villages.

These findings indicate that increasing the activities of public spaces in tourism villages improve the pleasantness of the soundscape.

The scene-by-scene analysis revealed that the pleasantness and eventfulness scores of S4, P1, and P2 were high because S4 is the commercial square space of the village, and thus has many tourists and vendors. Furthermore, P1 is the largest park in Xijingyu village, with pleasant scenery, a large flow of tourists, and children singing and playing. P2 is in the core park of Maojiayu village, and is located close to the scenic spot where elderly people and children sing and play. However, the eventfulness and pleasantness scores of P3 and P4, which are also parks, were low, possibly because P4 is an ordinary park with fewer people, and hence, fewer activities. A comprehensive analysis revealed that human sound was an important factor in the soundscape evaluation of tourism villages and that visitors expected to experience the local lifestyle and folk activities during a village tour.

3.1.4. Visual landscape evaluation

Figure 7 shows the visual landscape evaluation of 12 scenes. As shown in the figure, the respondents are highly satisfied with the visual landscape of the public spaces in tourism villages, with scores greater than 3 for all scenes except square S4. A factor-by-factor analysis revealed that most of the scores for the openness of the squares are greater than 4, except for square S4, and that the greenery satisfaction scores of the parks were all greater than 4. Moreover, all factors of the public spaces along the streets were relatively balanced, and most of the scores are greater than 3.5. Notably, all the visual landscape factor scores of S4, however, were low because the square is mainly a commercial square with a low visible green index and a paucity of special village characteristics.

3.2. Relationships Between Audio-Visual Factors and Soundscape Evaluation

3.2.1. Visual landscape

To analyse the relationships between visual landscape factors and soundscape evaluation, a correlation analysis was conducted, as shown in Table 6. The results revealed that greenery satisfaction, architectural aesthetics, sky visibility and space openness are significantly positively correlated with pleasantness, indicating that greater green coverage, excellent architecture and open spaces are conducive to improving the pleasantness of the soundscape of public spaces in villages. However, greenery satisfaction, environmental cleanliness, sky visibility, and space openness are significantly negatively correlated with the eventfulness evaluation, indicating that in the sampled public spaces, the results of the eventfulness evaluations of scenes with higher green coverage, a clean environment, and open space are relatively low.

3.2.2. Sound environment

Table 7 shows the correlation analysis between auditory factors and soundscape evaluation. As shown in the table, only LAF5 and LCeq are significantly positively correlated with eventfulness. LAF5 is significantly positively correlated with eventfulness evaluations, possibly because when the number of sound events in the environment increases, the type and number of sounds exceeding the LAF5 threshold also increase accordingly, thus improving the diversity of the soundscape. The reason why the sound pressure level (LCeq, equivalent continuous sound pressure level) is significantly positively correlated with eventfulness is that a higher sound pressure level is generally associated with richer human activities, and the sound sources produced by the activities increase the dynamics and richness of the sound environment, thereby increasing respondents' perception of eventfulness in the soundscape.

In addition, the correlation between other auditory data and soundscape perception evaluations is weak, which is consistent with Kang's conclusion,[14] i.e., people's subjective evaluation of a soundscape depends not only on the sound pressure level or other acoustic indicators but also on the type and perception of the quality of the sound.

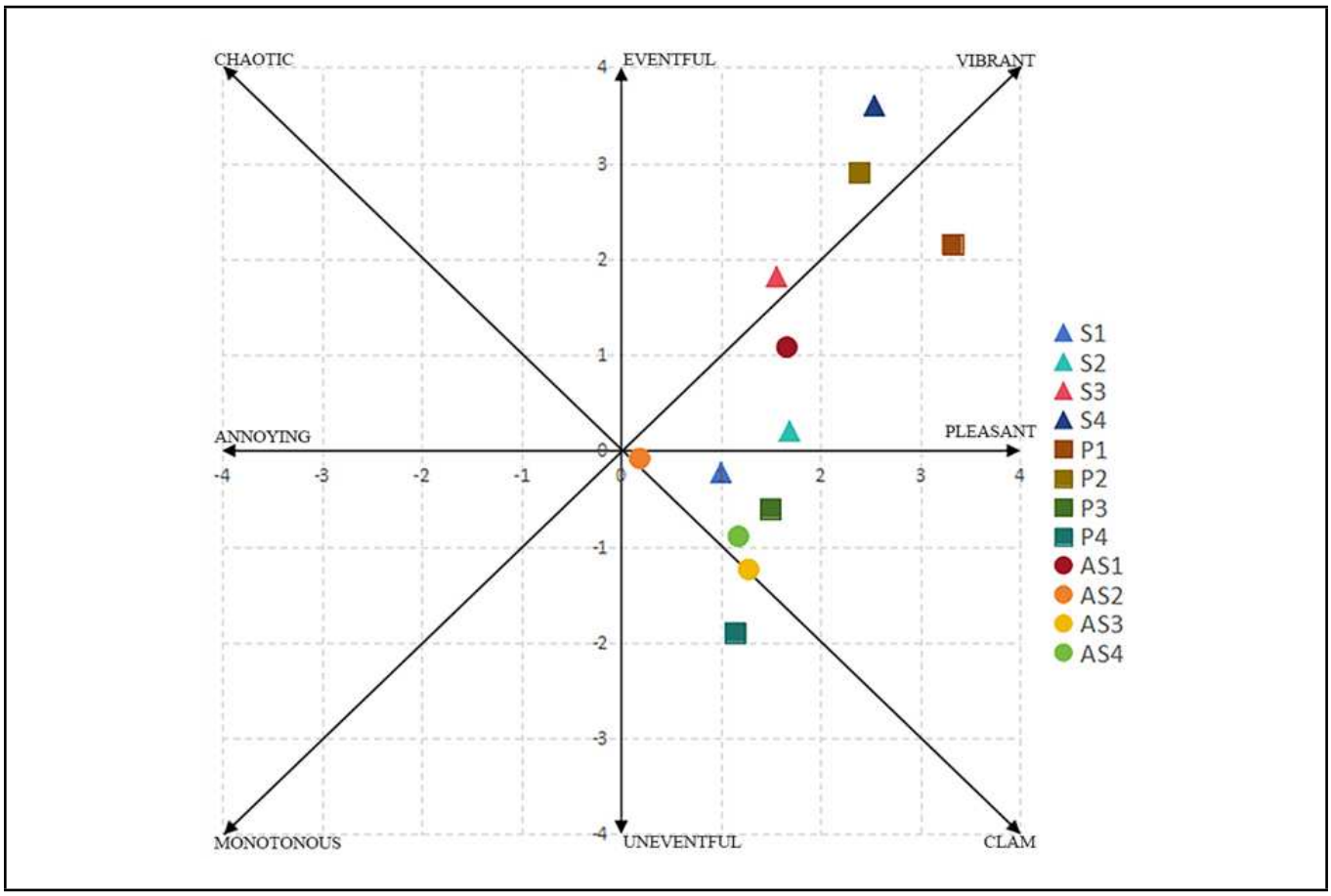

Figure 6. Pleasantness-eventfulness two-dimensional model.

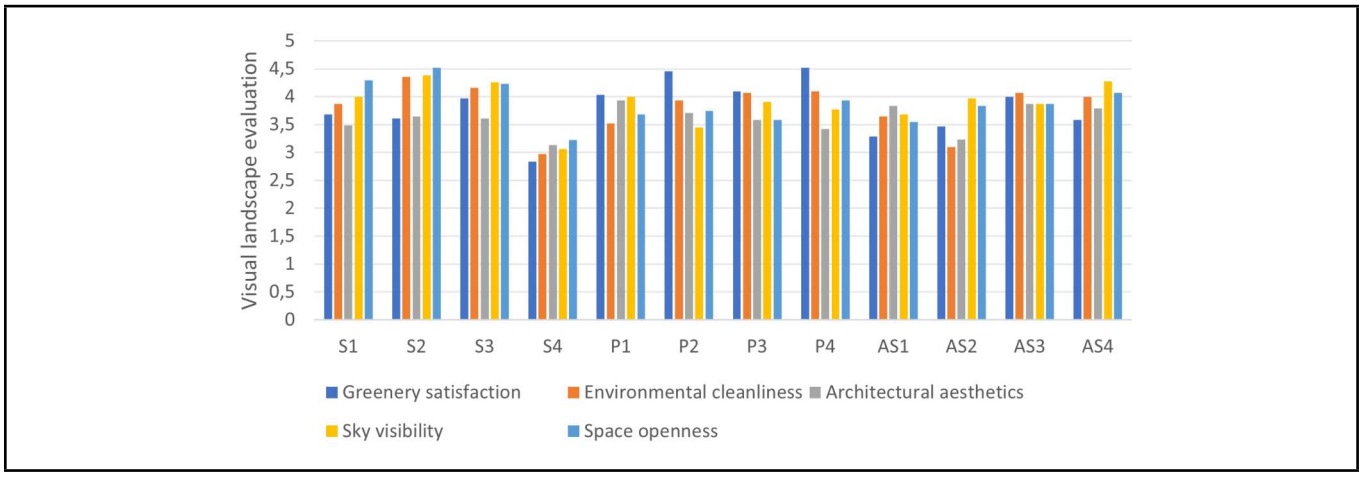

Figure 7. The evaluation of the visual landscape factors of the public space in tourism-oriented villages.

Table 6. Correlation between visual landscape factors and soundscape evaluation.

	Greenery satisfaction	Environmental cleanliness	Architectural aesthetics	Sky visibility	Space openness
Pleasantness	**0.125***	0.099	**0.196****	**0.105***	**0.180****
Eventfulness	**-0.143****	**-0.252****	-0.014	**-0.148****	**-0.142****

* Correlation is significant at the 0.05 level; ** Correlation is significant at the 0.01 level.

Table 7. Correlation between auditory factors and soundscape evaluation.

	LAF95	LAF5	Nrmc	Sound Pressure Level	LAeq	LCeq	N5	N95	Navg
Pleasantness	0.147	0.406	0.175	0.413	0.378	0.315	0.35	0.098	0.378
Eventfulness	0.392	**0.587***	0.455	0.538	0.552	**0.650***	0.552	0.42	0.552

* Correlation is significant at the 0.05 level; ** Correlation is significant at the 0.01 level.

Table 8. KMO value and Bartlett's Test of Sphericity.

KMO Value		0.825
Bartlett's Test of Sphericity	Approximate Chi-Square	1246.665
	Degrees of Freedom (df)	78
	p-value	0.000

Table 9. The values of fit indices for the models.

Model fit index	IFI	CFI	NFI	GFI
Statistical values	0.979	0.978	0.977	0.989
Recommended values	>0.900	>0.900	>0.900	>0.900

3.3. Building a Structural Equation Model for Visual Landscape Factor—Soundscape Evaluation

3.3.1. Reliability and validity tests

In this study, SPSS 23.0 was utilised to conduct reliability analysis, and the results revealed a Cronbach's alpha reliability coefficient of 0.938, indicating good internal consistency and high reliability of the data. The KMO value was 0.825, and the p value of Bartlett's sphericity test was less than 0.05, indicating that the validity of the questionnaire was good (Table 8).

3.3.2. Building a structural equation model for visual landscape factor—soundscape evaluation

According to relevant studies, visual landscape factors affect soundscape evaluation, and thus, there may be causal relationships between the variables. Therefore, this study used Amos Graphics 24.0 to construct the SEM of "visual landscape factor—soundscape evaluation" for public spaces in tourism villages. The initial model is shown in Fig. 8.

3.3.3. Test for goodness-of-fit of SEM

The fit indices of a model are the criteria for evaluating the goodness-of-fit between statistical models and actual data. As presented in Table 9, the statistical values of the IFI, CFI, NFI and GFI of the initial model are all greater than 0.9, indicating that the model fits well.

3.3.4. SEM analysis of "visual landscape factors—soundscape evaluation"

Figure 9 shows the SEM of "visual landscape factors—soundscape evaluation" for public spaces in villages. As shown in the figure, architectural aesthetics and space openness have a significant positive effect on pleasantness ($p < 0.05$), with standardised path coefficients of 0.196 and 0.152, respectively. Environmental cleanliness has a significant negative effect ($p < 0.05$) on eventfulness with a standardised path coefficient of -0.242, and architectural aesthetics has a significant positive effect ($p < 0.05$) on eventfulness with a standardised path coefficient of 0.151. These findings indicate that, in the public spaces of tourism villages, beautiful building facades and open spaces improve respondents' pleasantness with respect to soundscape, whereas a clean environment has a negative effect on the eventfulness evaluation of soundscape.

4. DISCUSSIONS

4.1. Evaluation of the Soundscape and Visual Influencing Factors in Tourism Villages

The public spaces of tourism villages are the primary places for outdoor activities for tourists and villagers and the main promoter of village characteristics. Visual landscape and soundscape evaluation can be used for exploring spatial characteristics and discovering problems. According to the results of the study, first, in tourism villages, natural sounds were the main sound source in most public spaces; with different spatial functions, these spaces had their own characteristic sound sources. For example, in the square, in addition to natural sounds, human activity sounds were important sound sources. In public spaces along streets, in addition to natural sound sources, traffic noise was an important sound source. The analysis of the sound pressure level of public spaces in tourism villages showed that, unlike in cities, the sound pressure level in parks was greater than that in the square and public spaces along the street. This is because the natural landscape in the tourist village park is rich, and natural sound sources such as wind, birdsong and chirping cicadas are louder, leading to an increase in the sound pressure level.

The soundscape evaluation showed that, first, all respondents' evaluations of pleasantness in the sampled public spaces were positive. This occurred because the sound sources of public spaces in villages were generally natural sounds that people liked, and the sound pressure level is not high. Therefore, the respondents' evaluations of these spaces are relatively positive. Second, in scenes with more human sounds, both the eventfulness evaluation and pleasantness evaluation values of the soundscape are greater because human sounds are closely related to local culture and life, such as villagers' communication, singing, and vendor hawking, which are considered cultural elements that enrich tourists' experiences in villages. Third, the evaluations of the public spaces along the streets were generally poor. Although the traffic noise level of the villages was not high, the vehicles and roads were important reasons for the negative effect on soundscape evaluation.[34] Therefore, reducing the traffic noise of roads and beautifying the landscaping of the streets will enhance the soundscape quality of the public spaces of tourism villages.[35]

4.2. Influence of Visual Landscape on Soundscape Evaluation in Public Spaces of Tourism Villages

This study showed that the greenery satisfaction, architectural aesthetics, and space openness of tourism villages are significantly positively correlated with soundscape pleasantness, a finding that was consistent with existing studies. Greenery satisfaction, environmental cleanliness, sky visibility, and space openness are significantly negatively correlated with soundscape eventfulness because, in the environment of a tourism village, respondents usually seek natural and cultural experiences that are different from those of cities. Therefore, excessive cleanliness and spaciousness may weaken such experiences and cause tourists to lose interest in public space openness.

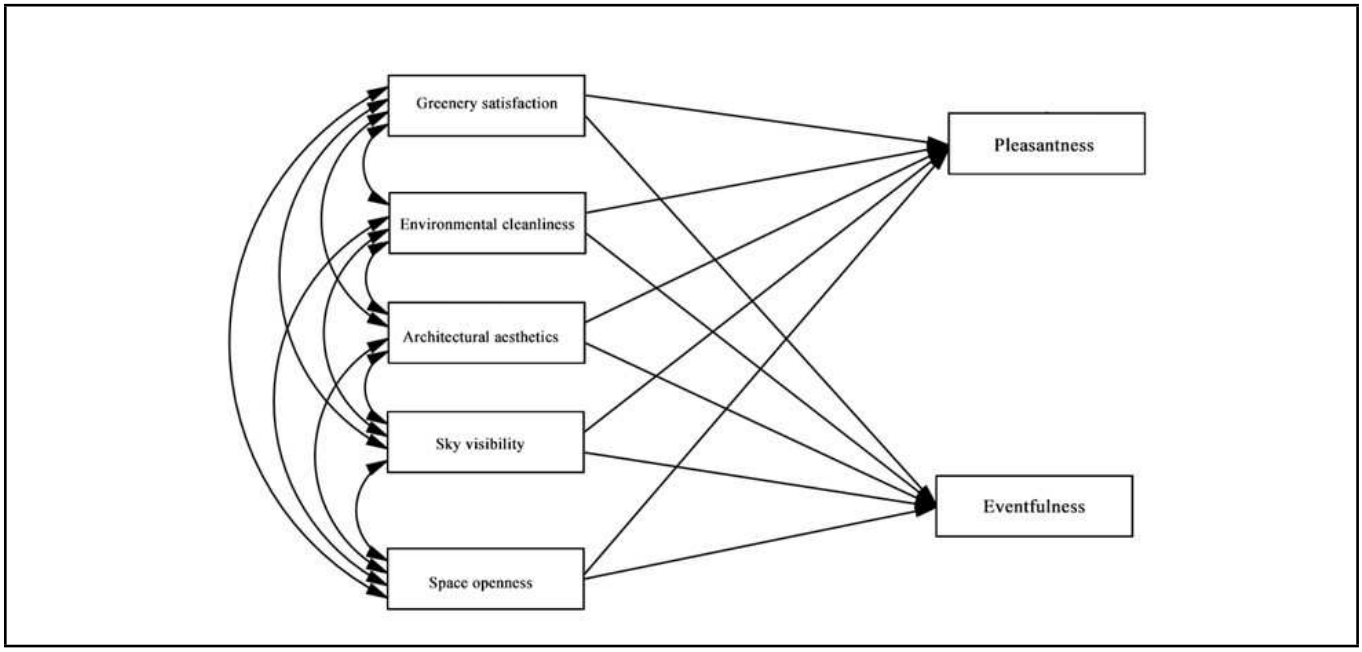

Figure 8. Initial structural equation model of "visual landscape factors—soundscape evaluation" for public spaces in tourism-oriented villages.

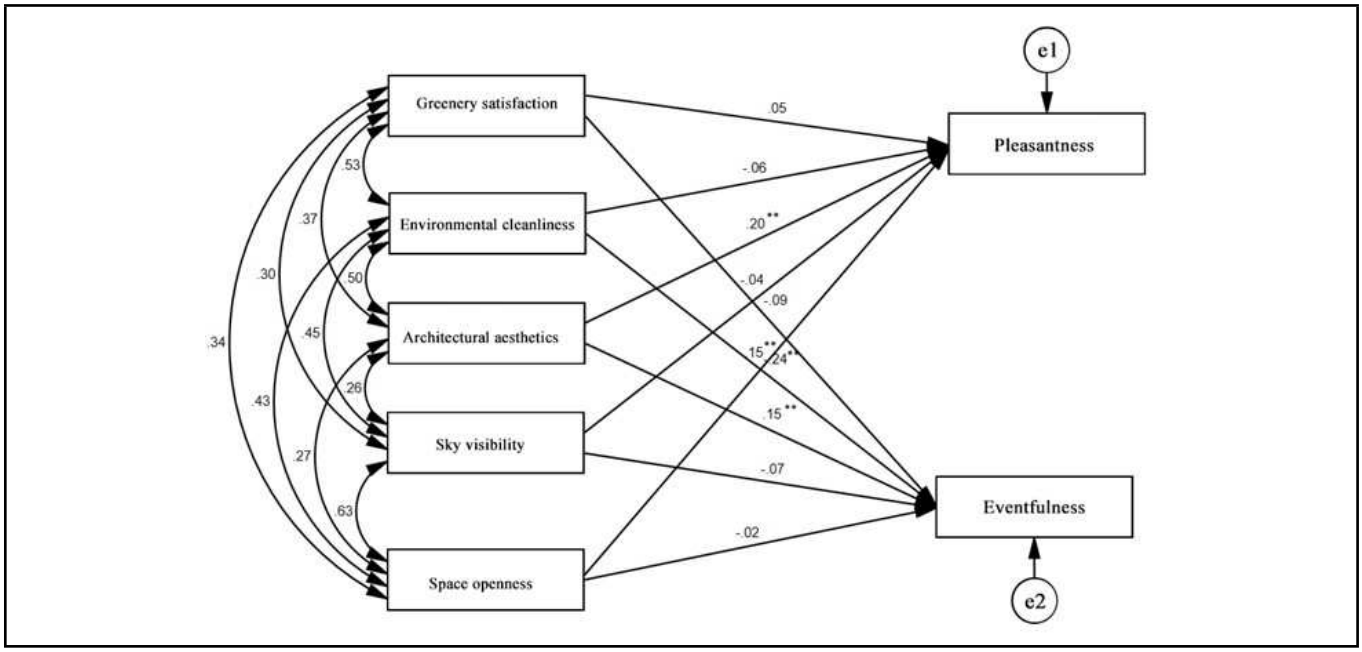

Figure 9. Structural equation model of "visual landscape factors—soundscape evaluation" for public spaces in tourism villages.

Table 10. Standardized path loadings for the model of the visual landscape and soundscape perception evaluation.

Path		Path Coefficient	Standardized Coefficient	C.R.	P
Pleasantness	Greenery satisfaction	0.054	0.014	0.884	0.377
Pleasantness	Environmental cleanliness	-0.059	0.016	-0.856	0.392
Pleasantness	**Architectural aesthetics**	**0.196**	**0.014**	**3.336**	**0.001**
Pleasantness	Sky visibility	-0.037	0.016	-0.547	0.585
Pleasantness	**Space openness**	**0.152**	**0.016**	**2.271**	**0.023**
Eventfulness	Greenery satisfaction	-0.087	0.021	-1.46	0.144
Eventfulness	**Environmental cleanliness**	**-0.242**	**0.024**	**-3.574**	**0.001**
Eventfulness	**Architectural aesthetics**	**0.151**	**0.021**	**2.601**	**0.009**
Eventfulness	Sky visibility	-0.069	0.024	-1.045	0.296
Eventfulness	Space openness	-0.023	0.024	-0.342	0.732

Through the SEM of "visual landscape factors—soundscape evaluation", this study showed that architectural aesthetics and space openness had a significant positive effect on soundscape pleasantness, indicating that in the public spaces of tourism villages, architecture and space perception had a direct effect on soundscape pleasantness. This occurred because this type of architecture and space were combined with local cultural elements that enhanced the respondents' cultural experiences and promoted emotional resonance.

4.3. Comparison of Soundscape Between Public Spaces in Tourism Villages and Those in Cities

After analysing the soundscape of the public spaces of tourism villages, this study shows that it was significantly different from the soundscape of the public spaces of cities.

4.3.1. Characteristics and functions of sound sources

The soundscape of public spaces in tourism villages consist primarily of natural sounds, which is in sharp contrast to urban public spaces where artificial sound sources, such as traffic noise and industrial noise, are more dominant.[36,37] In villages, natural sound sources such as wind, birdsong, and chirping cicadas not only enrich the soundscape but also increase the sound pressure level, providing tourists with an auditory experience quite different from that of the city. The study showed that the soundscape in villages consisted of more natural sound sources, whereas the urban soundscape are affected more by artificial sound sources.

In tourism villages, the sounds of human activities, such as villagers' communicating and singing, and vendors' hawking, are regarded as a part of the local culture and life that enhances tourists' perceptions of the experience. In cities, the sounds of similar human activities are generally regarded as noise, which has a negative effect on the pleasantness of the soundscape.[38]

4.3.2. Sound pressure level and soundscape evaluation

The sound pressure level of parks in tourism villages is higher than that of squares and public spaces along streets, unlike the situation in cities where the sound pressure level of parks is usually low.[39] The richness of the natural landscape within the village park is the main reason for the high sound pressure level. However, the sound pressure level of urban public spaces is affected by artificial sound sources such as traffic noise, and it is usually greater in squares and public spaces along streets. The respondents' evaluations of the soundscape of public spaces in tourism villages are generally positive, which is due mainly to the dominance of natural sound sources and the cultural value of sounds from human activities. In contrast, the results of soundscape evaluation of urban public spaces may be more complicated because of the possible effects of traffic noise and other factors.

4.3.3. Effects of visual landscape factors

In cities, natural environmental factors such as green plants make a more significant positive contribution to soundscape evaluation,[40,41] whereas in the public spaces of villages, architectural and space perceptions have a direct effect on soundscape pleasantness.

4.4. Soundscape Optimization for Tourism Villages

To optimize the soundscape evaluation of public spaces in tourism villages, this study proposes the following suggestions. In terms of sound environment: (1) Protect the natural sound sources in the public spaces of tourism villages, such as the sound of wind, birdsong, and cicadas chirping. (2) Strengthen the organization of cultural activities with distinctive features. Organize festive events and traditional activities in the public spaces of tourism villages that are rooted in local culture to enrich the cultural sound environment and provide tourists with a more immersive cultural experience. (3) Improve traffic organization and management in villages to minimize the negative impact of traffic noise on the soundscape of public spaces.

In relation to visual landscape: (1) Give priority to preserving the natural greenery of public spaces, avoiding excessive pruning and artificial manipulation of vegetation. (2) Optimize the design of buildings to maintain the openness of public spaces. (3) Promote the utilization of traditional craftsmanship and local materials to enrich the regional features and cultural significance of buildings.

4.5. Limitations and Further Research

All respondents in this study were college students whose ages ranged from 19 to 27 years. Therefore, the results do not reflect the soundscape preferences of other age groups or occupational groups. In future studies, interviews should be conducted with all age groups and multiple occupational groups to enrich the evaluation of the soundscape of public spaces in villages.

5. CONCLUSIONS

This study evaluated the soundscape characteristics of typical public spaces in tourism villages, analysed the influences of visual landscape factors on soundscape evaluation, and explored the influence paths of visual landscape factors on the soundscape evaluation of public spaces in tourism villages. The detailed conclusions are as follows.

First, the main sound source of public spaces in tourism villages is natural sound, whereas the secondary sound sources of different types of public spaces vary, including the human sounds in parks and squares and the traffic sounds in public spaces along the streets. The sound pressure level in parks is higher than that in public spaces along streets, whereas the sound pressure level in squares is relatively low. The results of the soundscape pleasantness evaluation of public spaces in tourism villages are positive, and those of the soundscape eventfulness evaluations of different parks and squares are quite different. In scenes where the result of the soundscape eventfulness evaluation is high, so is that of the soundscape pleasantness evaluation.

Furthermore, greenery satisfaction, architectural aesthetics, and space openness are significantly positively correlated with

soundscape pleasantness, whereas greenery satisfaction, environmental cleanliness, sky visibility, and space openness are significantly negatively correlated with soundscape eventfulness evaluations.

Finally, through the structural equation model of "visual landscape factors—soundscape evaluation", we find that architectural aesthetics and space openness have positive effects on soundscape pleasantness, with standardised path coefficients of 0.196 and 0.152, respectively ($p < 0.05$); environmental cleanliness has a significant negative effect on soundscape eventfulness, with a standardised path coefficient of -0.242 ($p < 0.05$); and architectural aesthetics have a significant positive effect on soundscape eventfulness evaluations, with a standardised path coefficient of 0.151 ($p < 0.05$).

This study showed that the soundscape and its influencing factors of public spaces in tourism villages were quite different from those of urban public spaces, thus broadening the scope of research on space types for soundscape evaluation and their influencing factors, and it provides support with respect to soundscape optimization for the renewal and transformation of public spaces in villages.

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APPENDIX

Data were gathered through quiestionnairs in which respondents assessed the sound environment across eight dimensions using the 1-to-5 Likert scale. The results are presented in Fig. 10.

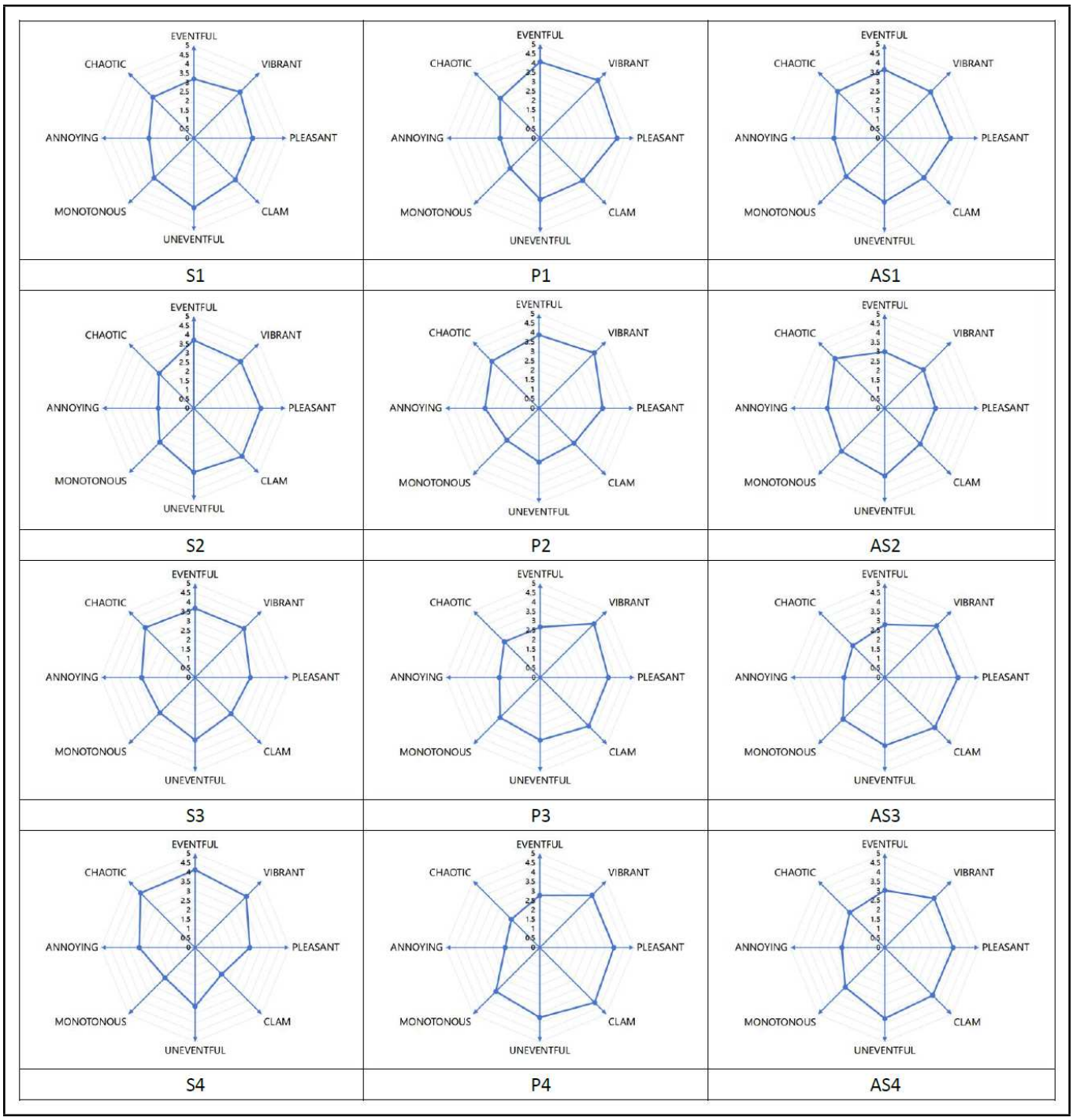

Figure 10. The evaluation of the soundscape factors of the public space in the tourism-oriented villages.