



A Mini Review of Soundscape Research in Urban Public Spaces in Mainland China

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Abstract. Soundscape is a new inter-professional discipline that studies the mutual influence and relationship between sound, environment and listener. Since the concept of soundscape was put forward in the late 1960s, the research related to it has been continuously developed and deepened, and has now formed a more stable research system. In the past ten years, the research practice related to soundscape in mainland China has made a breakthrough development. This paper analyses and reviews the research status of urban public space soundscape in mainland China from six aspects: cities, classical gardens, urban parks, historic districts, university campuses, and tourist scenic areas, and takes part of the urban public space soundscape as the main object of research, introduces the significance of the research on public space soundscape and its importance, and summarizes and looks forward to the main research methods and future development trends at this stage.

Keywords: soundscape, urban public space, soundscape research methodology, development trend

1 Introduction

In the past ten years, the research practice related to soundscape in mainland China has made a breakthrough development. This paper analyses and reviews the research status of urban public space soundscape in mainland China from six aspects: cities, classical gardens, urban parks, historic districts, university campuses, and tourist scenic areas, and takes part of the urban public space soundscape as the main object of research, introduces the significance of the research on public space soundscape and its importance, and summarizes and looks forward to the main research methods and future development trends at this stage.

2 Research Significance and Importance of Soundscape in Urban Public Space

The soundscape is defined as the sound environment as perceived and understood by an

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individual or society, depending on the relationship between the person and the sound environment. Soundscape focuses on the balance between sounds, the harmony between sound and environment and people, and the interaction between sound sources in the environment. Soundscape has a significant impact on the quality of life in cities, neighbourhoods and built environments. Soundscape research originated from the study of environmental noise, but unlike environmental noise, which focuses on the physical characteristics of noise, soundscape advocates from the subjective perception of people, focusing on the study of social, cultural, environmental and other relevant contextual factors on the impact of the sound environment.

Soundscape is an indispensable part of the environment of urban public space such as historic district blocks, city parks and tourist attractions. As an important part of the city, urban public space not only carries rich historical and cultural information, but is also a concentrated manifestation of the city's charm. In these urban public spaces, in addition to buildings, streets and other physical visual landscape, soundscape also plays a significant role. For example, the sound of street and alley conversations, vendors, vehicles, as well as distant bells, drums and so on. These sounds are intertwined together to form a vivid picture of the city, so that people seem to be able to travel through time and feel the humanistic atmosphere and cultural heritage of the city. In addition, soundscape has a unique advantage in shaping regional cultural personality. Different cities, different public areas, their soundscape also has its own characteristics. These characteristic sounds not only represent the local cultural characteristics, but also the iconic symbols of the city. Through scientific evaluation, moderate design, reasonable protection and effective inheritance of these sounds, regional culture can be better promoted and the cohesion and centripetal force of the city can be enhanced.

Therefore, paying attention to the soundscape of urban public space is of great significance in enhancing multidimensional urban cognition. With the acceleration of urbanisation and the pursuit of people's quality of life, the development and protection of urban public space has received more and more attention. In this process, soundscape, as an important part of urban public space environment, has also received more attention and research. Through the in-depth study of soundscape, we can understand the history and culture of the city more comprehensively, and improve the quality and charm of the city. At the same time, it can also provide useful references and lessons for urban planning and tourism development.

3 Current Status of Research on Soundscape in Urban Public Space in Mainland China

Soundscape research in mainland China started relatively late, and in 2005, Li Guoqi's doctoral thesis "Soundscape Research and Soundscape Design"[1] formally established the disciplinary status of soundscape studies in China. In recent years, domestic soundscape research has developed steadily. In 2014, the international document "Soundscape: definition and conceptual framework" helped the soundscape concept to spread rapidly in China. Figure 1 shows the distribution of soundscape research publications in mainland China from 2002 to 2023[2], which shows that sound-

scape-related research has shown a more obvious growth trend in the past five years.

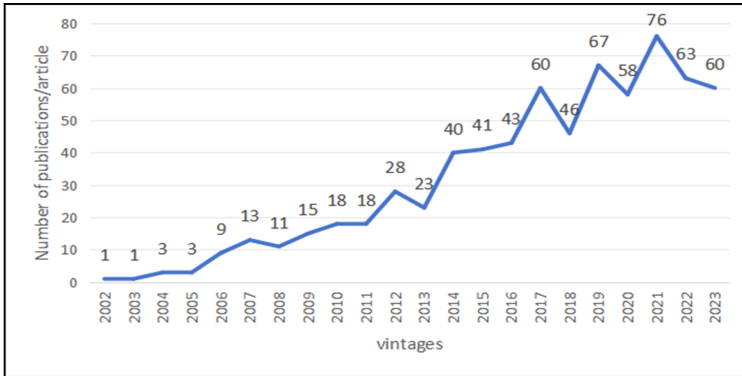


Fig. 1. Distribution of the number of articles issued, 2002-2023(Author drawing).

With the deepening of domestic soundscape research, the research method tends to be mature, the research system tends to be perfect, and its research carrier gradually extends from small public spaces such as urban parks to large-scale physical spaces such as colleges and universities, historic districts, traditional settlements, scenic areas, etc., and the focus of the research focuses more on the humanistic value of sound.

3.1 At the Urban Level:

The research team of Harbin Institute of Technology headed by Kang Jian proposed in the article "Soundscape in Urban Public Open Space"[3] that it should be researched from the three aspects of sound, listener, and spatial environment, which provides a theoretical basis for the description, evaluation, and design of the soundscape in urban public space. The soundscape in urban public space mainly involves three aspects: people, sound and space, and the evaluation of its soundscape is very complicated. In "Cross-cultural Research on Semantic Segmentation Approach Analysis of Soundscape in Urban Public Open Spaces"[4], a study comparing two public spaces in each of Sheffield (UK) and Beijing (Beijing) was conducted by using the semantic analysis approach and four main determinants of the soundscape in urban public open spaces were found: relaxation, communication, spatiality and dynamism.

In "Research on the Characteristics of Soundscape Worth Protecting and the Importance of Protection in Cities"[5], Jia Yihong takes Tianjin as a blueprint, and finds that the soundscape characteristic factors worth protecting by using the method of soundwalking are: sense of relaxation, vitality, representativeness, intensity, and richness, respectively. Based on the above theories, in "Research on Urban Acoustic Landscape Protection Model and Protection Methods"[6], it summarises 13 acoustic landscape quality indexes and constructs a CART decision tree model based on these indexes to evaluate and monitor acoustic landscape quality.

3.2 In Classical Chinese Gardens:

With the deepening of research in recent years, the localisation of soundscape has taken classical Chinese gardens as the main carrier. The research team from South China University of Technology, headed by Yuan Xiaomei, elaborates on the unique cultural characteristics of the soundscape in classical Chinese gardens through the idea of the unity of man and nature, combined with the philosophical backgrounds of Confucianism, Taoism, and Buddhism. and technological logic [7]. In "The Three Realms of Soundscape in Chinese Classical Gardens", Yuan Xiaomei further explains the unique soundscape realm of Chinese classical gardens through the three aspects of natural scenery, poetic and pictorial mood, and the realm of life. Wu Shuoxian, in "The Integration of Three Landscapes and the Composition of Multiple Landscapes in Chinese Classical Gardens"[8], explains the importance of soundscape in three landscapes, and puts forward the idea of creating multiple landscapes by combining the soundscape, the aromascape and the lightscape. In "The Sound Beauty of Traditional Chinese Garden Plant Landscaping"[9], Yuan Xiaomei and Wu Shuoxian systematically summarise the experience and techniques of soundscape design in traditional Chinese gardens with regard to the sound beauty embedded in traditional Chinese garden plant landscaping. The soundscape research team of South China University of Technology has established the first complete system of typical soundscape resources in Chinese gardens, unified the standards of garden sound data collection and archiving, and provided a historical basis for the conservation of soundscape resources in Chinese traditional gardens [10].

3.3 In terms of Historical and Cultural Neighbourhood:

In historical and cultural neighbourhoods: Historical neighbourhoods are the most important historical heritage of a city, and soundscape has a great influence in historical neighbourhoods, and soundscape can directly and vividly present the unique charm of the city. Each sound represents a culture and a state of life, which together constitute the unique temperament of the city. By listening to these sounds, people can gain a deeper understanding of the city's history and culture, and feel the local human spirit and customs.

Liu Jiang et al. took the historic district of Sanfangqixiang in Fuzhou City as the research object, and provided a more comprehensive means for the renewal and development of historic districts by examining the impact of soundscape perception on the landscape evaluation of historic districts under the business model [11]. Based on the perspective of human geography, Deng Zhiyong et al. analysed the quantitative relationship between objective acoustic parameters and subjective semantic evaluation using the field soundscapes of six historic and cultural districts as examples [12]. Xie Hui et al. selected traditional cultural and historical neighbourhoods with mountainous characteristics as research objects in Chongqing Municipality, and put forward the principles and methods of soundscape design in mountainous cities, and the improvement strategies of introducing the concept of soundscape design into the mountainous urban habitat environment [13]. Historic districts, where most of the partici-

pants are tourists and local residents, are important tourist destinations reflecting local characteristics. Liu Jiang et al. take Chengdu Jinli Ancient Street as an example to explore the attachment characteristics of the soundscape of historic districts to tourists' venues and the factors influencing them [14]. Huang Shan proposes to start from the current situation of the soundscape of traditional Hui settlements and its sound quality characterisation indexes, and take the evaluation of its soundscape value characteristics as the starting point to start the research on the soundscape protection strategy of traditional Hui settlements [15].

3.4 In Urban Parks:

Liu Jiang, Hong Yanchen et al. in the study of soundscape in urban parks, explored the characteristics of the differences in visitors' perception of soundscape in different types of plantscape spaces and the main factors affecting the overall perception of soundscape, and established an evaluation model of soundscape preference in forest parks, which provides a basis for the construction and development of forest parks [16-18]. Zhu Yujie et al. in "The Impact of Forest Park Soundscape on Psychological Recovery Benefits--Taking Fuzhou National Forest Park as an Example"[19] take Fuzhou National Forest Park as an example, and study the positive impact of forest park soundscape on psychological recovery benefits through soundscape exploration evaluation. Shi et al. in "Progress of Soundscape Research in Modern Parks in China"[20] summarised the soundscapes of forest, water and human-oriented parks and compared the soundscape characteristics of different types of parks.

3.5 In the University Campus:

University campus is the main place for teachers and students of colleges and universities to carry out teaching, scientific research, work, recreation, leisure and other activities, usually the university campus provides teaching, self-study, office, sports, accommodation and recreation and other rich social functions, the different functions of the acoustic environment of the There are obvious differences in the requirements for the acoustic environment for different functions. Each area naturally forms different soundscapes due to different functional requirements and users, and the whole university campus presents a soundscape that is different from other social public places, so the quality of campus soundscape is crucial. Tan Jun et al. used the matrix evaluation comprehensive evaluation method to comprehensively evaluate the quality of campus acoustic environment [21]. Li Jialing analysed the variability of soundscape in different areas of a university campus under different influencing factors [22]. Xinhui Fei et al. established a soundscape evaluation model by researching and experimenting the soundscape on campus, which was then used to guide the design and improvement of the soundscape on campus [23]. Yan Fang et al. proposed a visual soundscape research method, soundscape map, to address the lack of visual representation of soundscape research [24]. Kou Xinyuan put forward the protection of natural sound and the weakening of noise to create a comfortable acoustic environment on campus in the "Three Scenic Designs of Colleges and Universities". [25]

3.6 In the Aspect of Tourism and Cultural Attractions:

The pleasant and unique soundscape is an important aspect of tourist attractions to attract tourists. Liu Aili et al. analysed the differences between domestic and international research on tourism soundscape in "Progress of Research on Tourism Soundscape at Home and Abroad"[26], pointing out that domestic scholars are mainly concerned with the identification and development of soundscape resources and the evaluation of soundscape of tourist places, while foreign scholars are more concerned with the quietness of soundscape and the management of tourism noise. Cui Zhihua and Yang Xiaoyu [27] take the core area of Zhongshan Mausoleum Scenic Spot in Nanjing as the object, construct a scenic soundscape comfort evaluation model by combining the measurement of the objective elements of sound and the subjective evaluation of tourists, and analyse and evaluate it by using the GIS software, and put forward a reference method for the design of the soundscape in the scenic area. Yue Miao [28] By researching the soundscape of humanistic attractions in West Lake Scenic Area, he understands the characteristics and subjective evaluation of the soundscape of such attractions and puts forward improvement opinions. In addition, Hu Jun [29] from Zhejiang University drew the soundscape map of the West Lake Scenic Area through the GIS platform, which is the first time to introduce the method of geoinformatics platform and database in the study of soundscape, and lays the foundation for in-depth research and analysis of the soundscape of the scenic area. Hao Zezhou [30] Taking Shenzhen Garden Mountain Scenic Area as the research object, we collected statistics on the types of soundscape in the area, and used it as the basis to study the temporal and spatial change law and subjective evaluation characteristics of forest soundscape, and experimentally explored the recreational effect of forest soundscape for people.

To sum up, soundscape research in mainland China continues to characterise and diversify on the basis of foreign soundscape research, initially forming a research trend characterised by overall dispersion and local concentration, relying on interdisciplinary concepts and adopting a variety of emerging technologies.

4 Main Research Methods of Soundscape in Urban Public Space in Mainland China

4.1 Objective Measurement

Acoustic Measurements.

The most commonly used objective measurements in the field of acoustics, used to collect physical data at the measurement site. Acoustic measurements need to be carried out at selected measurement points over different time periods. For indoor places, the indoor sound field is often analysed by measuring its sound pressure level, equivalent A-weighted sound pressure level (LAeq), reverberation time, speech transmission index and other parameters; for outdoor space, fixed-point noise detection, the measurement results are generally expressed in A-weighted sound pressure level, and sometimes it is necessary to carry out a spectrum analysis of the noise. Meng Fanlin et al. in "Research on Evaluation of Soundscape and Influencing Factors of Urban Parks -

Taking Kunming Cuihu Park as an Example"[31] take Kunming Cuihu Park as an example, and collect data related to the soundscape of the park through acoustic measurements to analyse the factors influencing the soundscape of the park. Wang Yaping et al. in "Experimental Study on Soundscape and Audiovisual Perception in Urban Historic Streets"[32] investigated the influence of the ambient sound pressure level of urban pedestrian streets on the comfort of urban spatial acoustic landscapes through acoustic measurements. In "Analysis of Influencing Factors on Outdoor Soundscape Evaluation of Large General Hospitals - Taking Changsha Central Hospital as an Example"[33], Qi Yue et al. measured the equivalent sound pressure levels at 28 measurement points in three different functional areas of the hospital to obtain the soundscape data of the hospital environment, and then analysed the influencing factors.

Soundwalk.

"Soundwalk" is a method of real-time recording of sounds during a path walk and real-time evaluation of the soundscape along the way, so as to realise the elaboration and evaluation of the soundscape under study from multiple perspectives. The application of acoustic walking method is collectively embodied in the acoustic environment research of public space. Zhang Yuan used the acoustic walking method to conduct urban and regional acoustic survey and determine the characteristics of high-density urban acoustic landscape in the study of the restorative effect of the acoustic landscape of urban public open space at [34]. Zhou Jing et al. in "Research on the Optimisation of University Campus Soundscape Based on Soundwalking Method--Taking Xiamen University Haiyun Student Residence Area as an Example"[35] used the soundwalking method to evaluate quantitatively and qualitatively the soundscape elements such as the types of sound sources and the preference of sound sources in the campus, and analysed the problems existing in the soundscape of the campus.

Laboratory Evaluation Method.

An artificial neural network is built in the laboratory to predict an individual's evaluation of a soundscape through a simplified simulation of the central nervous system of a human being; it consists of highly interconnected computational units that respond to input stimuli and have the ability to learn. Compared with field research, the laboratory research method can effectively avoid the interference of random factors in the environment, has better control of variables, and can obtain more scientific conclusions. In the study of the restorative effect of soundscape in urban public open spaces, Zhang Yuan carried out a restorative effect study on park spaces by comparing the field soundscape evaluation with laboratory simulation evaluation. In "Evaluation of Soundscape Preferences in Wetland Parks"[34], Ye Jing et al. fitted the data collected by the soundwalking method with soundscape preferences to construct a soundscape preference evaluation model for wetland parks. Dongxu Zhang used software to simulate the sound field and compared it with the data measured in the field to establish an acoustic model of the courtyard and indoor space of the monastery in "Research on the Soundscape of Han Buddhist Monasteries"[36]. Lian Yingqi et al. in "A Comparative Study of Soundscape Evaluation by Laboratory Simulation and Field

Survey"[37] conducted a laboratory simulation to evaluate the soundscape of a campus, and compared it with the results of the field research to simulate and analyse the optimal sound level conditions. Tingting Xia investigated the influence of soundscape on the mental stress relief effect of urban green space and its application in [38] by combining the collected sound samples and videos with each other, and playing them to the evaluators to get the subjective evaluation of the soundscape.

Soundscape Map Method.

Soundscape map is developed from the noise map, soundscape map refers to the response to a particular area of the Current situation of the soundscape map, through the soundscape map can be easily mastered in the map of each spatial location of the sound pressure level, the composition of the sound source, the soundscape of the perceived quality of the situation. Soundscape maps are usually constructed with Geographic Information System (GIS). He Yujie[39] When evaluating and planning the soundscape of parks, GIS software was used to simulate the current map of the soundscape from the data collected and processed, which provided more detailed suggestions for the optimal design of the soundscape of parks. Tian Fang [40] analysed the soundscape of Zijinshan National Forest Park using GIS. Hu Jun [41] Based on the soundscape map technology, the soundscape map of Hangzhou Liulang Wenying Park in four seasons was drawn based on the temporal and spatial change rules of the soundscape in Hangzhou Liulang Wenying Park. Cui Zhihua [42] Discussion on the method of soundscape planning and design in landscape areas based on GIS using remote sensing data, and construction of a comprehensive evaluation model of soundscape comfort.

4.2 Subjective Evaluation

Questionnaire Survey Method.

It is a survey method in which the investigator uses a uniformly designed questionnaire to obtain information from the selected respondents. In soundscape research, it is often used to understand the subjective data of the respondents about the sound environment of a certain place. It is suitable for larger scale surveys, and the survey data can be easily quantified and processed.

Yang Lingling takes Lijiang Dayan Ancient Town as an example [43], and explores the differences in the subjective evaluation of tourists on the soundscape of the ancient town through questionnaire surveys. Xueqin Liu et al. take Hangzhou Canal Asian Games Park as an example [44], collect the subjective evaluation data of tourists' acoustic and visual landscapes through a questionnaire survey to analyse the coupling relationship between acoustic and visual landscapes in the park.

Likert Scale Method.

Improved by the American Social Psychologist Likert in 1932 on the Basis of the Original Total Plus Scale. The scale consists of a set of statements, each of which has five kinds of responses, namely, strongly agree, agree, not necessarily, disagree, and strongly disagree, which are recorded as 5, 4, 3, 2, and 1 respectively, and the total

score of each respondent's attitude is the sum of the scores obtained from his responses to each question, and this total score can indicate the strength or weakness of his attitude or the different status of him on this scale. Liu Jiaca et al. used a five-level Likert scale method to assess the perception of the acoustic environment of the pedestrian street in the Study on the Relationship between Acoustic Environment Perception and Visibility of the Pedestrian Street on the Pro-Arterial Road. [45]

Factor analysis method.

A statistical method that synthesises multiple variables into a few factors to reproduce the correlation between indicators and factors, using the factor analysis function of SPSS software to analyse the evaluation factors, the public factor extraction adopts the principal component method, and the covariance matrix of variables is used for the factor extraction to achieve the purpose of simplification and dimensionality reduction. Chen Qing, in her research on the optimisation strategy of soundscape in sightseeing space of industrial parks [46], used questionnaire survey and SD method to collect people's subjective evaluation data of soundscape in industrial parks, and in data processing, used factor analysis method to quantitatively analyse the collected data, extracted the main factors affecting the soundscape in sightseeing space of industrial parks, and then summarised the soundscape characteristics of the sightseeing space of industrial parks. Chen Maichi et al, when studying the evaluation of rural tourism soundscape [47] by taking Hongcun in southern Anhui as an example, explored the evaluation factors of sound source in rural tourism soundscape as sound characteristics, information richness and infectiousness by factor analysis of the data from questionnaire survey.

4.3 Emerging Technologies

WeChat App.

Based on the research method of soundwalking, the VanXing app developed by Northwestern Polytechnical University uploads sound clips from various locations, allowing interviewees to independently select a space and experience the sound, and then fill out a questionnaire to collect subjective evaluation data on the current soundscape.

Big Data Learning.

With the development of science and technology, emerging technologies such as artificial intelligence and big data are also applied to acoustic landscape research. Meng Qi has successfully constructed a prediction model for the acoustic comfort evaluation degree of underground commercial street based on artificial neural network (ANN) algorithm of Matlab platform [48]. Lei Zhenyu et al. [49] developed various Python-based soundscape recognition systems, which have basically achieved the distinction between animal sounds and natural sounds. He Yi [50] researched the audio-visual environment of historic districts in China through the form of big data, and used the decision tree algorithm based on machine learning to construct a model to obtain a

more effective and accurate prediction model for the evaluation of the audiovisual environment of historic districts.

5 Summary and Outlook

5.1 More Mature Aspects

In the past two decades, soundscape research in mainland China has shown a steady development, and has now formed a stable research system with rich and diverse research tools. The theories of ecology, environmental psychology and other disciplines have been comprehensively applied with subjective and objective combination of research methods, which has an outstanding interdisciplinary nature. The research object is broad, covering urban parks, historic districts, university campuses, landscape gardens, etc. The research content is diversified, involving acoustic landscape evaluation, acoustic landscape design and protection. With the continuous development of research in the field of acoustic landscape, landscape design is no longer a single visual landscape design, but a multifaceted landscape design including auditory landscape.

At present, scholars collect sound data of each test point through the soundscape walking method in public spaces such as urban parks, historic districts, college campuses, tourist attractions, etc., and collect people's subjective evaluation data by combining questionnaires and semantic difference method; data analysis is carried out through SPSS software, and commonly used analytical methods include factor analysis, correlation analysis, linear regression method and so on. Some scholars apply GIS geographic information system in the research of soundscape, and establish a visual soundscape map through geoinformatics platform and database. The development and application of new technologies have promoted the application practice of soundscape research.

5.2 Relative Deficiencies

Although soundscape research has shown a trend of interdisciplinary research, there is still a gap between the real integration of disciplines, and although research teams have formed a complex cooperation network and realised cross-country and cross-region exchanges, the academic linkage is not strong, and there is still a need to strengthen disciplinary exchanges and collaborative research and to improve the depth of research.

With the in-depth development of the research, Chinese scholars have fully used GIS, VR technology, big data, machine learning and other emerging technology means to actively explore the wisdom of digital soundscape research, but the results of the research are relatively shallow, the use of technical means is relatively single, so more rich and applied soundscape information technology approach is still the focus of the current research.

Although scholars have constructed a more scientific mathematical evaluation model of soundscape, due to the soundscape is in a state of continuous dynamic change, subjective perception and objective evaluation of the contradictory situations occur from time to time, resulting in the model prediction results and the actual situation is

not the same, need to further improve the soundscape evaluation model.

5.3 Future Research Trends

The fundamental difference between acoustic landscape and traditional noise research lies in the fact that acoustic landscape attaches importance to the interaction between people and the environment, and to the exploration of various influencing elements in the process of people's perception and evaluation of the acoustic environment. The relationship between all these elements and the acoustic environment is multivariate and non-linear. In addition, the rapid development of big data and machine learning provides new possibilities for the study of multiple elements of acoustic landscape. Future research needs to select the universal evaluation factors applicable to the type of spatial soundscape for specific sound environments in order to improve the reliability of the soundscape model; based on the different types of soundscape, appropriate research methods are selected to construct a flexible, accurate and systematic evaluation system.

6 Conclusion

In the past two decades, soundscape research in mainland China has shown a steady development, and has now formed a stable research system with rich and diverse research tools.

Future research needs to select the universal evaluation factors applicable to the type of spatial soundscape for specific sound environments in order to improve the reliability of the soundscape model; based on the different types of soundscape, appropriate research methods are selected to construct a flexible, accurate and systematic evaluation system.

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