Investigation on Living Comfort of Traditional Chinese Dwellings in the South Yangtze River region

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Abstract :

Environment and development are the major issues that the international community pays close attention to today. As the development strategy of contemporary human society, "sustainable development" has been recognized by all countries worldwide and has become humanity's common choice.[1] Experts estimate that if the quality of the living environment is improved, the work efficiency will increase by 15% ~ 20%.[2] As China's most representative traditional buildings, traditional dwellings in the South Yangtze River region must also achieve sustainable development. Improving residents' living comfort is the premise of sustainable development. Therefore, this paper obtains data from field measurement and questionnaire surveys and analyzes the correlation between objective measurement data and subjective evaluation data. The comfort of traditional folk houses' indoor and outdoor living environment in the south Yangtze River region is evaluated by AHP. Summarize the living comfort index that needs to be improved, and put forward the idea of sustainable development.

Keywords: Living Comfort;Traditional Chinese Dwellings;Sustainable

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1.Introduction

As a region with a long history, there are still many ancient towns and villages in the south Yangtze River of China, and the traditional houses in these areas are still inhabited. The core content to be studied is how to make these dwellings meet the living needs and realize sustainable development. We need to update and transform the current living comfort level to achieve long-term sustainable development.

The conditions of construction sustainability make it clear that every building is closely connected with its environment.[3]

As far as traditional dwellings in the south Yangtze River of China are concerned, the evaluation of their living comfort can be analyzed from two aspects: indoor environment and outdoor environment. Indoor living environment comfort refers to an indoor thermal environment (suitable temperature and humidity) suitable for human habitation, non-interfering acoustic environment, light environment under different use conditions, and relaxed and comfortable sense of space. [4] Outdoor living environment comfort comprises landscape, artificial environment, public security environment, transportation, social and cultural conditions, and other factors. It is the living comfort corresponding to the indoor living environment, which together constitutes the living comfort of the building.

At present, foreign and domestic experts and scholars have conducted in-depth research on different aspects of architectural living comfort. However, most are aimed at a single index or aspect. For example, in 1989 and 2005, based on Murry's research results, ISO put forward a standard system of comfort evaluation and put forward corresponding limits for different types of buildings.[5][6]

In 1970, Fanger fitted the curve with the heat balance equation of the human body and the thermal sensation data obtained from the experiment of MCNEILL. He obtained the thermal comfort evaluation indexes: the predicted average number of votes (PMV) and the predicted percentage of dissatisfaction (PPD), which are comprehensive indexes of thermal environment comfort. [7]

At the same time, China's current standards also cover all aspects of indoor and outdoor living comfort, such as "Architectural Lighting Design Standard"(GB 50034-2013)[8], "Energy-saving Design Standard for Public Buildings"(GB 50189-2015)[9], Indoor Air Quality Standard, and Scientific Evaluation Index System for Livable Communities(GB/T 18883-2002)[10]. These standards have given standard methods for the design, measurement, and evaluation of indoor and outdoor environment indicators of modern buildings but lack comprehensive evaluation methods or indicators for traditional dwellings.

By studying the objective measurable or valuable living environment index data, this study will comprehensively evaluate the indoor and outdoor living environment comfort of traditional dwellings in the South Yangtze River region.

Combined with the evaluation results, the ideas and suggestions for the sustainable development of traditional dwellings in the south Yangtze River region of China are put forward.

2.Materials and Methods

2.1 Construction of evaluation index of indoor living comfort

The indoor environment of residential users is composed of many physical environment factors. A large number of research works of literature and national norms and standards focus on the adjustment of the leading environmental factors, including air quality, thermal environment, light environment, and sound environment. There are several specific indicators under each environmental factor, and the correlation between indicators shown in Table 1. According to the actual needs and common indicators, objective indicators selected to evaluate the comfort of the indoor living environment of traditional houses. The relationship with the corresponding subjective response evaluation index shown in Figure 1.

Table 1. Hierarchical structure model of indoor environment living comfort evaluation system.

Index layer c	Indicator description
The comfort level of air quality	Carbon dioxide (CO2) concentration Formaldehyde（HCHO）concentration Total Volatile Organic Compounds（TVOC） Benzene（C6H6） concentration
The comfort level of thermal environment	Temperature Humidity Air speed Average Thermal Metabolic rate PMV（Predicted Mean Vote）
The comfort level of lighting environment	Average illumination
The comfort level of acoustic environment	Sound intensity

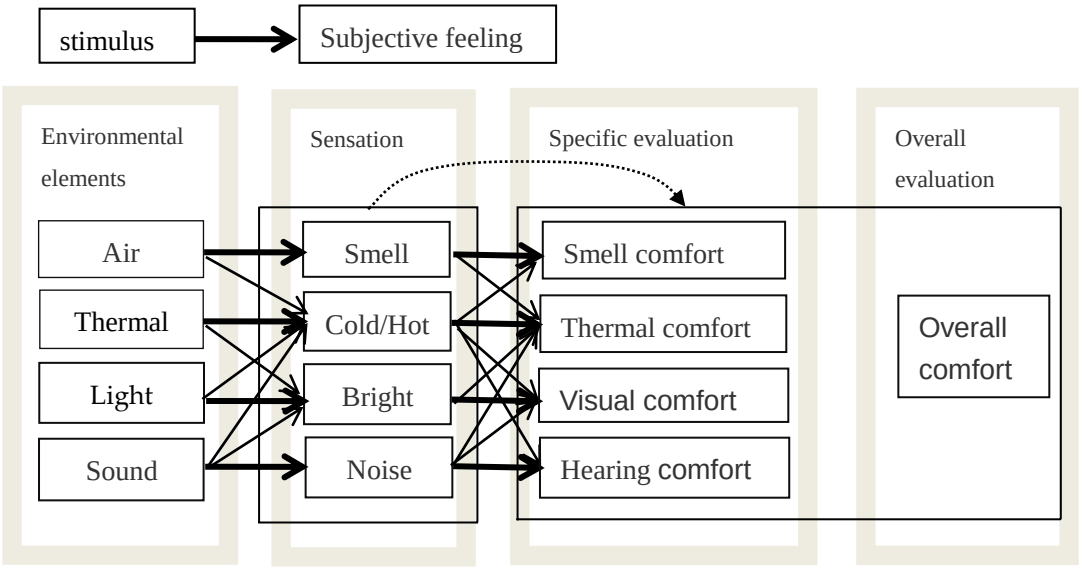

Figure 1. Interaction diagram of indoor environmental factors on overall comfort.[11]

Different linetypes represent different action strengths, and the linetypes deepen with the increase of action strengths.）

2.1.1 The comfort level of air quality

According to the WHO, as many as 30% of the population of developing countries suffered from the so-called sick building syndrome, and this figure rose to an alarming 60% in 2002[12]. It turns out that life in buildings from traditional materials (concrete, plasterboard, etc.) does not have a favorable effect on the persons exposed to them, as they release harmful substances into the air.

The definition of indoor air quality has undergone many changes. At first, indoor air quality was almost equivalent to a series of pollutant concentration indicators. Later, people realized that this purely objective definition could not cover the content of indoor air quality. At the 1989 International Indoor Air Quality Symposium, Professor Fanger of Denmark put forward a subjective air quality standard: air quality reflects people's satisfaction[13]. If people are satisfied with the air, it is high quality; On the contrary, it is low quality. ASHRAE's standard ASHRAE62.1——2004 "Ventilation Satisfying Acceptable Indoor Air Quality" considers both subjective and objective indoor air quality evaluations. It defined good indoor air quality as "no known pollutants in the air have reached the harmful substance concentration index determined by recognized authorities, and the vast majority of people (≥80%) in this air have not expressed dissatisfaction with this".[14]

"China's Ambient Air Quality Standards" (GB3095-2012)[15] defines air quality from carbon dioxide (co2) concentration, formaldehyde concentration, benzene concentration, TVOC, and other indicators. People use these four indicators most commonly, and their standards are carbon dioxide (co2) concentration below 0.1%, formaldehyde concentration below 0.1 mg/m^3, TVOC below 0.6 mg/m^3, and benzene concentration below 0.11 mg/m^3, respectively.

2.1.2 The comfort level of the thermal environment

The comfort level of the thermal environment is a subjective feeling that people are satisfied with the surrounding thermal environment. It is the result of a variety of factors, and it is a mental and subjective psychological reflection. The most common one is the PMV index.

PMV(Predicted Mean Vote) index is a comprehensive evaluation index based on the fundamental equation of human thermal balance

and the grade of subjective thermal sensation in psychophysiology and considering many related factors of human thermal comfort. Researchers can calculate the PMV value according to the heat balance of human body. [16]

When the heat generated in the human body is equal to the heat lost in the environment, people are in a state of heat balance. The following environmental parameters are also required in the calculation: air temperature, average radiation temperature, relative air velocity, and air humidity. Researchers can obtain PMV index by measuring data. The recommended value of PMV in ISO7730 is between -0.5 and+0.5.

2.1.3 The comfort level of the lighting environment

According to Weber-Fischer's law, researchers choose the average illuminance index to represent soft comfort. The average illuminance unit is lx (lux).

"Architectural Lighting Design Standard" GB 50034-2013 stipulates the general illuminance standard values of newly built, rebuilt, and expanded residential, public and industrial buildings. The slightest change of illuminance is the grading standard of illuminance value. The illuminance difference is about 1.5 times. This classification is consistent with the classification of standard S008/E-2001 of the CIE International Luminous Lighting Committee "Indoor Workplace Lighting."According to "Architectural Lighting Design Standard" GB 50034-2013, the living room of residential buildings (general activities) should be 100lx, and the living room of residential buildings (writing and reading) should be 300lx mixed lighting; Residential restaurants, 150lx.

2.1.4 The comfort level of the acoustic environment

As far as the comfort level of the acoustic environment is concerned, different people have different degrees of tolerance to noise, and the difference in building sound insulation effect will also impact living comfort in sound. According to the noise standard in the Law of the People's Republic of China on the Prevention and Control of Environmental Noise Pollution, the traditional residential buildings in the south Yangtze River region of China belong to the first class of building noise standard, and the noise is required to be between 55 and 45 decibels. Under the condition of meeting the national standards, this study will take residents' subjective feelings as the primary evaluation basis of acoustic comfort.

2.2 Outdoor living environment index of traditional dwellings in the south Yangtze River region of China

In 2011, "Valletta Principle" introduced a new dimension of dynamic maintenance and management. It encourages the improvement of people's livelihood and residents' participation in conservation and renewal activities and advocates taking historical towns as an organic part of the urban ecosystem. In this way, We can realize the overall sustainable protection and harmonious development.

It was completed in January 2016 according to the Scientific Evaluation Index System of Livable Communities of China's Ministry of Construction. It is a commonly used evaluation index system of livable communities in China. The evaluation index is formulated with the actual situation of the traditional ancient town and village protection and the survey of residents. Compared with ordinary residential communities, traditional dwellings should also consider the protection and inheritance of traditional culture, which significantly impacts the living environment. Such as the table 2:

Table 2.Residential Comfort Index of Outdoor Environment of Traditional Dwellings

Index layer c	Indicator description
Safety situation of residential area	Public security situation.
Infrastructure situation	Water and electricity supply. Drainage and sewage facilities. Network and communication facilities. Sanitation facilities.
Public service level	Educational facilities. Basic medical facilities. Commercial service facilities. Cultural and sports facilities.
Public environment	Environmental sanitation. Landscape greening.
Protection of original appearance of traditional buildings	Preservation of traditional architectural appearance. Protection of cultural heritage.
Inheritance of intangible cultural heritage	Protection and inheritance of intangible cultural heritage.

2.3 Construct the judgment matrix and calculate the weight of each index.

2.3.1 Conduct an expert questionnaire survey.

Many evaluation index factors evaluate the living comfort of Chinese Dwellings in the South Yangtze River region. Therefore, it is necessary to consider the research field of experts when asking and selecting experts. For the distribution of questionnaires, experts with specific authority in the industry can be selected [93]. Through consulting experts in traditional dwellings, the evaluation index factors are scored so that the obtained weight data is more objective, comprehensive, and accurate.

2.3.2 expert questionnaire processing

In order to reduce the amount of calculation in filling out the expert questionnaire, the experts graded the importance of the evaluation index of living comfort of traditional dwellings between 0 and 10. Because each expert has different research directions and backgrounds and considering the differences in experts' research angles, the familiarity coefficient is added to the score calculation to revise the evaluation results of each expert. In the operation process, experts give the familiarity of each value classification at the index level and introduce the familiarity coefficient simultaneously as score calculation. The calculation formula is:

$$QI = \left(\sum^{n} \mathrm{Qi} * \mathrm{Si} \right) / \sum^{n} Si \quad (1)$$

In the calculation formula[17]：

QI—the average score of the i-th evaluation index factor;

Qi— the score of the i-th evaluation index factor;

Si—— the familiarity coefficient of experts to the ith evaluation index factor;

K—— number of experts

Experts themselves determine familiarity, and generally can be divided into four levels: familiarity (corresponding value is 1), familiarity (corresponding value is 0.75), average (corresponding value is 0.5), and unfamiliarity (corresponding value is 0.25).

The weight of the evaluation index of living comfort is determined through the combination of questionnaire survey and analytic hierarchy process (AHP). A questionnaire survey was done, and ten experts related to traditional architecture were surveyed. Get the scores of each index after calculation in table 3.

Table 3. Scores of each index

Index layer （C）	Score（Q）
C1 The comfort level of air quality	7.741
C2 The comfort level of thermal environment	8.556
C3 The comfort level of lighting environment	6.889
C4 The comfort level of acoustic environment	7.111
C5 Safety situation of residential area	8.926
C6 Infrastructure situation	7.852
C7 Public service level	7.185
C8 Public environment	8.037
C9 Protection of original appearance of traditional buildings	7.926
C10 Inheritance of intangible cultural heritage	6.481

2.3.3 fraction conversion and establishment of a judgment matrix.

After obtaining the weight consultation value of the evaluation index through the expert consultation method, the obtained weight is further adjusted by AHP.

The first step: data conversion

In the design of the questionnaire, in order to facilitate the experts to fill it out, the importance of comparing index factors is not set. Therefore, when determining the weight, it is necessary first to convert the obtained data into the importance scale value. This study processes the data of each layer in the above table. We divide the difference between the highest score and the lowest score of each layer equally into eight intervals. Corresponding to the eight intervals, we convert the original scores into Saaty1-9 scale values. The calculation formula is as follows:

In the calculation formula[18]：

$$C_{\mathrm{i}} = (Q_{\max} - Q_{\min})/9 * i \qquad (2)$$

CI - maximum value of the i-th scale;

Qmax - the maximum value of the evaluation index factor weight;

Qmin - the minimum value in the weight of evaluation index factors;

i- Scale range.

According to the obtained calculation, the Saaty1-9 scale value table (Table 4) is constructed.

Table 4.Index importance score difference transformation(Post-conversion score)

Index layer （C）	**Saaty1-9 scale**
C1 The comfort level of air quality	5
C2 The comfort level of thermal environment	8
C3 The comfort level of lighting environment	2
C4 The comfort level of acoustic environment	3
C5 Safety situation of residential area	9
C6 Infrastructure situation	6
C7 Public service level	3
C8 Public environment	6
C9 Protection of original appearance of traditional buildings	6
C10 Inheritance of intangible cultural heritage	1

The second step: Establishment of judgment matrix

The importance of the indicators in the evaluation system is compared pairwise, and the judgment matrix is constructed. Set the indexes as (W1, W2, …Wn), and compare each evaluation index in pairs according to the Saaty1-9 scale value.

Table 5. Comparison of evaluation index factors

Index layer	W1	W2	…	Wn
W1	W1/W1	W1/W2	W1/…	W1/Wn
W2	W2/W1	W2/W2	W2/…	W2/Wn
…	…/W1	…/W2	…/ …	…/Wn
Wn	Wn/W1	Wn/W2	Wn/…	Wn/Wn

According to the index hierarchy of the evaluation system determined in section 2.1, it is necessary to determine the judgment matrix of the index layer. The calculation results are shown in Table 6.

Table 6.Calculation result of matrix

Index layer （C）	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1 The comfort level of air quality	1	0.625	2.500	1.667	0.556	0.833	1.667	0.833	0.833	5.000
C2 The comfort level of thermal environment	1.6	1.000	4.000	2.667	0.889	1.333	2.667	1.333	1.333	8.000
C3 The comfort level of lighting environment	0.4	0.250	1.000	0.667	0.222	0.333	0.667	0.333	0.333	2.000
C4 The comfort level of acoustic environment	0.6	0.375	1.500	1.000	0.333	0.500	1.000	0.500	0.500	3.000
C5 Safety situation of residential area	1.8	1.125	4.500	3.000	1.000	1.500	3.000	1.500	1.500	9.000
C6 Infrastructure situation	1.2	0.750	3.000	2.000	0.667	1.000	2.000	1.000	1.000	6.000
C7 Public service level	0.6	0.375	1.500	1.000	0.333	0.500	1.000	0.500	0.500	3.000
C8 Public environment	1.2	0.750	3.000	2.000	0.667	1.000	2.000	1.000	1.000	6.000
C9 Protection of original appearance of traditional buildings	1.2	0.750	3.000	2.000	0.667	1.000	2.000	1.000	1.000	6.000
C10 Inheritance of intangible cultural heritage	0.2	0.125	0.500	0.333	0.111	0.167	0.333	0.167	0.167	1.000

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The third step: Calculate the weight

After the pairwise comparison matrix is constructed, the weight of each index can be calculated. When calculating the weight, it is necessary to use a consistency test to judge whether the constructed judgment matrix has logical errors. If it fails, it is necessary to rebuild the judgment matrix.

The vectors in each matrix row are geometrically averaged (square root method) and then normalized to get the weights and eigenvectors. The formula is:

$$W_i = \overline{W}_i / \sum_{i=1}^{n} \overline{W}_i \quad (3)$$

Calculate the maximum characteristic root λmax[19]:

$$\lambda_{\max} = \frac{1}{n} \sum_{i=1}^{n} \frac{(AW)_i}{W_i} \quad (4)$$

Table 7.AHP result

Index	Eigenvectors	Weight value	maximum characteristic root	CI value
C1 The comfort level of air quality	1.2144	0.102		
C2 The comfort level of thermal environment	1.9431	0.1633		
C3 The comfort level of lighting environment	0.4858	0.0408		
C4 The comfort level of acoustic environment	0.7287	0.0612		
C5 Safety situation of residential area	2.1861	0.1837		
C6 Infrastructure situation	1.4571	0.1224	10	0
C7 Public service level	0.7286	0.0612		
C8 Public environment	1.4571	0.1224		
C9 Protection of original appearance of traditional buildings	1.4571	0.1224		
C10 Inheritance of intangible cultural heritage	0.243	0.0204		

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Table 8. Consistency check result

maximum characteristic root	CI value	RI value	CR value	result
10	0	1.486	0	Pass

The calculation result of AHP (AHP result)shows that the maximum characteristic root is 10.0, and the corresponding RI value is 1.486 according to the table 8, so CR=CI/RI=0.0<0.1, which passes the one-time test.

The table shows the weight calculation results of AHP. The weight calculation results of the analytic hierarchy process (square root method) show that the weight score of C1 is 0.102, C2 is 0.1633, C3 is 0.0408, C4 is 0.0612, and C5 is 0.1837, and C6 is 0.1224. The weighted score of C7 is 0.0612, C8 is 0.1224, C9 0.1224, and C10 is 0.0204.

Determine the final questionnaire according to the evaluation indexes formulated in the last part and the factors that may affect the indexes.In the questionnaire, we also need to consider the differences of thermal comfort in different seasons, whether the traditional dwellings have been transformed, whether air purification and air conditioning equipment have been added, and other factors. Through the questionnaire, we can understand the impact of these renovations on living comfort, which is helpful to think about the ideas of the subsequent sustainable development and renovation. On this basis, a field test and questionnaire survey for the current occupants is made. Through the field test, among the objective indicators, air quality, thermal comfort,

lightweight comfort, and sound comfort pass the field survey, and a questionnaire survey is conducted at the same time.

3.Results

3.1 Basic information of questionnaire distribution

In quantitative research, probability sampling is used in order to obtain objective results by using statistical methods. In qualitative research, "purposeful sampling" in non-probabilistic sampling is often used. According to the research purpose, the research object that can provide the maximum amount of information for the research problem is selected. As qualitative research focuses on obtaining a more in-depth and detailed explanatory understanding of the research objects, the number of research objects is generally not too large, and it is not possible (or necessary) to adopt the method of probability sampling. As the ultimate purpose of this study is to describe the artistic characteristics and influencing factors of traditional doors and windows in the south Yangtze River regions of China, which is a qualitative study, it is necessary to investigate the participants to have more understanding of the purpose of the study. Therefore, we can choose the purposive sampling method and first set some conditions for participants, such as being engaged in the related work of traditional Chinese architecture or having learned relevant knowledge and continuing to engage in related work. The purpose sampling is adopted in this study, which belongs to non-probability sampling. The non-probabilistic sampling method of recruiting or obtaining a sample for analysis, in which a random process does not determine the contents contained in the sample. Therefore, there is no fixed requirement for the sample size.

250 questionnaires were distributed this time, and 200 valid questionnaires were collected. In the questionnaires, the Likert 5-level scale was adopted for the comfort of each index, with one being the lowest comfort level and five being the highest. Yes (1) and no (2) are used for the house renovation, installation of air purification facilities, and installation of air conditioning equipment.

3.2 Analysis of the relationship between objective index data and subjective evaluation index data

The data collected in this study include objective data obtained by measurement and subjective evaluation data obtained by questionnaire survey. Firstly, Spearman correlation analysis is made on the subjective and objective data to understand the reflection of objective data on the living comfort of traditional folk houses south of the Yangtze River.

3.2.1 Correlation analysis of air quality and comfort

Table 9. Correlation analysis of air quality and comfort

		Carbon dioxide (CO2) concentration (%)	Total Volatile Organic Compounds (TVOC) (mg/m³)	Benzene (C6H6) concentration (mg/m³)	Formaldehyde (HCHO) concentration (mg/m³)	In the past 2 years, have you carried out the transformation of circuit and energy saving?	Are air purification systems installed in residential buildings?
Evaluation of indoor air comfort	**correlation coefficient**	0.096	-0.028	0.051	-0.089	0.117	0.101
	Saliency (two tails)	0.176	0.697	0.012	0.212	0.100	0.153

****. At the level of 0.01 (two tails), the correlation is significant.**

Through data analysis by SPSS software, we found that there was no apparent correlation between indoor air comfort and carbon dioxide (co2) concentration, formaldehyde concentration, and benzene concentration. It also has no apparent correlation with whether the house has an electric circuit, energy-saving renovation, and whether the house has an installed air purification system. Therefore, we should consider subjective evaluation data when evaluating air quality comfort.

3.2.2 Correlation analysis between PMV and subjective thermal comfort

According to the average temperature, the South Yangtze River region can be roughly divided into spring and autumn, summer and winter, and three seasons with noticeable temperature differences. When measuring objective indicators such as temperature and humidity and investigating subjective thermal comfort, we choose to divide it into three seasons for investigation and comparison. The objective evaluation index of thermal comfort is the PMV value obtained by calculation. We use SPSS software to analyze the relevant data and get the table 10.

Table 10. Correlation analysis between PMV and subjective thermal comfort

			PMV value (summer)	PMV value (winter)	PMV value (spring and autumn)	In the past 2 years, have you carried out the transformation of circuit and energy saving?	Are air conditioners installed in traditional dwellings?
Indoor thermal comfort	**What do you think of the comfort of indoor temperature? (Summer)**	**correlation coefficient**	0.510**	0.167	-.021	0.305**	-0.572**
		Saliency (two tails)	0.003	0.000	0.000	0.000	0.000
	What do you think of the comfort of indoor temperature? (Winter)	**correlation coefficient**	-0.111	-0.354**	-0.177	-0.014	-0.351**
		Saliency (two tails)	0.116	0.018	0.012	0.839	0.000
	What do you think of the comfort of indoor temperature? (Spring and Autumn)	**correlation coefficient**	0.164	-0.210	0.338**	0.002	0.130
		Saliency (two tails)	0.020	0.003	0.769	0.977	0.001

**. At the level of 0.01 (two tails), the correlation is significant.

The data shows that there is a significant correlation between PMV values in each season and subjective evaluation values. From the measured and calculated PMV values in each season, we can find that the PMV values in spring and autumn are primarily above 0, with a

concentration of 0-0.5, which accords with the recommended value of ISO7730 PMV and is the most comfortable.PMV values in summer are all above 0, but some values exceed 0.5. There is a positive correlation between PMV values in summer, spring, and autumn and subjective evaluation values. The higher the PMV value, the higher the subjective evaluation value and the higher the comfort level. Because of the low temperature in winter, its PMV value is mostly below 0, so it has a negative correlation with the value of subjective evaluation; that is, the higher the comfort level, the lower the PMV value. In addition, there is a close relationship between energy-saving renovation and thermal comfort in summer. There is a close correlation between the installation of air-conditioning equipment and thermal comfort in summer and winter. These correlation analysis results show that subjective evaluation is consistent with objective measurement data, and it is feasible to use subjective evaluation results as evaluation data.

3.2.3 Correlation analysis between lighting data and light comfort

Table 10. Correlation analysis between lighting data and light comfort

		In the past 2 years, have you carried out the transformation of circuit and energy saving?	average illuminatio n
What do you think of the comfort of Indoor light comfort?	**correlation coefficient**	-0.313**	0.316**
	Saliency (two tails)	0.276	0.116

**. At the level of 0.01 (two tails), the correlation is significant.

Data analysis shows a significant correlation between average illuminance and indoor light comfort. Specifically, there is a negative correlation between indoor light comfort, energy saving, and circuit transformation; that is, soft comfort without transformation (marked data is 2). Indoor light comfort is positively correlated with average illuminance. The higher the illumination, the higher the indoor light comfort.

3.2.4 Correlation analysis between noise data and acoustic comfort

Table 11. Correlation analysis between noise data and acoustic comfort

		In the past 2 years, have you carried out the transformation of circuit and energy saving?	Noise level
What do you think of indoor sound comfort?	**correlation coefficient**	0.009	-0.020
	Saliency (two tails)	0.896	0.781

**. At the level of 0.01 (two tails), the correlation is significant.

The correlation between the measured average noise data and subjective evaluation is not apparent, which means that the noise has little influence on subjective indoor acoustic comfort, and the subjective judgment is related to the individual's feelings. There is no apparent correlation between objective and subjective. Therefore, it is more accurate to take subjective feelings into account in acoustic comfort.

3.3 Overall evaluation results of living comfort of Traditional dwellings in the south Yangtze River region of China

Through the correlation analysis between subjective indicators and objective indicators, we can find that some subjective evaluation data are consistent with objective measurement data, and some objective data have no apparent influence on subjective data. Therefore, on the premise that the objective data measurement meets the requirements of relevant national laws and regulations, the subjective evaluation can better reflect the comfort of traditional dwellings south of the Yangtze River. Through calculation, we can get the final evaluation result of living comfort after weight calculation, as shown in the table 12.

Table 12. Evaluation results

Index	Weight value	Average evaluation score
C1 The comfort level of air quality	0.102	4.2
C2 The comfort level of thermal environment	0.1633	2.982
C3 The comfort level of lighting environment	0.0408	3.89
C4 The comfort level of acoustic environment	0.0612	2.88
C5 Safety situation of residential area	0.1837	4.64
C6 Infrastructure situation	0.1224	3.865
C7 Public service level	0.0612	3.94
C8 Public environment	0.1224	3.92
C9 Protection of original appearance of traditional buildings	0.1224	3.11
C10 Inheritance of intangible cultural heritage	0.0204	3.72
Evaluation results		3.75

By multiplying the final average value by the weight, the calculated comfort value of traditional dwellings in the south Yangtze River region of China is 3.75. According to the comfort level 1-5, the overall comfort level should be in a comfortable range, but there are significant differences among different indicators. Among them, the scores of thermal comfort, acoustic comfort, and preservation of scenic spots and relics are low, which should be paid more attention to in the follow-up sustainable development update.

4. Discussion and Conclusions

Through investigation, calculation, and comparison, it is found that the overall living comfort of traditional dwellings in the south Yangtze River region is in a comfortable range, which is closely related to the energy-saving and air-conditioning equipment renovation of many dwellings in the survey. However, there are still some shortcomings. The data shows that the thermal comfort in winter is low, whether objective PMV value or subjective evaluation.Although the measured indoor noise is in line with the national standard, the indoor acoustic comfort is still low. In addition, the historical features of traditional houses in the south Yangtze River region are poorly maintained. These are the areas that need to be focused on in the follow-up sustainability update. Thoughts on the renewal and sustainable development of traditional dwellings in the south Yangtze River region of China based on the improvement of living comfort：

4.1 *Ideas of sustainable development improvement based on thermal comfort in winter.*

Traditional folk houses in the south Yangtze River region use wood as the primary building material, especially in the application of doors and windows, which makes them different from other houses in thermal insulation performance. The survey results show that even if the Installation of air-conditioning equipment in traditional dwellings, the living comfort in winter is still low, so it is necessary to increase the energy saving of houses and the renovation and renewal of heating facilities. We can add an insulation layer to the house specifically; Renovation of doors and windows to increase the sunshine area; Install solar panels on the roof, and make full use of solar energy heating.

4.2 Ideas for sustainable development and improvement based on acoustic comfort.

The measured data and residents' feeling evaluation show that the sound insulation effect of traditional houses in the south Yangtze River region is poor, which leads to the evaluation score of acoustic comfort in an uncomfortable range.The reason may be that the internal partition walls of traditional wooden houses in the south Yangtze River region are all single-board lightweight partition walls with low sound insulation. The low-frequency or high-frequency sound emitted by people in daily activities such as talking, watching TV, and entertaining in the room will be transmitted to other rooms through the vibration of the wall panels and the gaps between the wall panels. On the one hand, the privacy of the rooms is poor, and on the other hand, it will cause trouble to people in other rooms. Therefore, we can try to achieve a better sound insulation effect by improving the structure of interior walls, such as making single-layer walls into double-layer walls and adding sound insulation materials in the middle of the walls. In this way, it can enhance their living comfort, make the traditional dwellings more vital, and achieve better sustainable development.

4.3 Thoughts on Sustainable Development and Improvement Based on Preserving the Original Appearance of Traditional Houses

The survey results on living comfort show that the original features of traditional dwellings have not been well protected. This may be because the housing renovation in recent years has not followed the original style. Traditional folk houses in the south Yangtze River region are mainly wood. Therefore, when considering the transformation of the original architectural features, wood is mainly used for restoration and maintenance to better retain the features. It is also possible to make better sustainable use and improvement while maintaining the original appearance. Using wood for maintenance has many advantages and is more environmentally friendly.

People living in houses built from natural materials claim they have a pleasant, happy, and

healthy life .[20]The use of ecological material solutions such as wood and materials based on wood is increasingly favored in connection with the sustainability trend. The use of wood in all areas of life is almost as old as humanity itself. Wood, being one of the oldest construction materials, is by no means obsolete for use in construction [21].The advantage of this construction material is its easy processing, high degree of rigidity relative to its weight, relatively good insulation properties, and high durability (only with the right choice of wood species and a correct design and maintenance[22].Wood can be used in residential and commercial buildings as construction or aesthetic material [23].

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