Evaluation Model of Ancient Building Conservation in Gulangyu Island Based on Factor Analysis

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Abstract. Protecting ancient buildings and cultural relics means preserving the history and cultural context of the city. When dealing with ancient buildings, old houses, and old neighborhoods, we should treat them with a sense of cherishment and reverence [1]. Through the protection and inheritance of ancient buildings, traditional Chinese culture can be better maintained and developed, so that it can play a greater role and influence in modern society. This paper collects a total of 1,052 valid questionnaire data on the views and evaluation of ancient architecture protection from five subjects, namely, merchants, residents, tourists, government and society, and uses the factor analysis method to select 25 protection indexes, constructs the evaluation system of ancient architecture protection, calculates the comprehensive proportion of the protection evaluation of the ancient architecture of Gulangyu Island to be 86.599%, and provides the relevant suggestions for the protection of the ancient architecture.

Keywords: Gulangyu Island; Factor analysis; Conservation of ancient buildings; Entropy right method

1 Introduction

Xi Jinping emphasized at the Twentieth National Congress the need to promote cultural self-confidence and self-improvement, and to forge a new glory of socialist culture! Ancient buildings are witnesses and carriers of history. Through the protection of ancient buildings, they can enable people to better understand and experience past cultures and lifestyles, and can inspire a sense of cultural pride and identity and deepen their love and cherish of national traditions. Xi Jinping's assessment of the value of Gulangyu: "In China's urban construction and scenic area construction, there are not many places that can combine natural and humanistic landscapes in a very harmonious way, and Gulangyu Island is one of them, so it is very necessary to make it a national treasure."

At present, the main contradiction facing the current situation of ancient building protection is that there are many hidden dangers inside some ancient buildings, and their repair work was suspended during the Coronavirus Epidemic, and a large number of ancient buildings need to be repaired after normalization, but there is a shortage of manpower. Additionally, urbanization construction represents a conflict between reinforced concrete and the preservation of old quarters. The protection of ancient buildings in urban construction has always been a major concern of the architectural design industry and urban planning [2]. The evaluation of ancient building protection can help us understand the protection status of ancient buildings and the potential

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problems that exist, and carry out the protection work in a more scientific way.It helps the government and relevant departments to allocate and manage resources more scientifically, and to rationally plan the priorities and focuses of the conservation of ancient buildings; it can obtain the conservation status and characteristics of ancient buildings, and understand their existing historical value and the integrity of their cultural heritage; and it can point out the directions and paths for the managers, and provide specific conservation suggestions.

With the starting point of how to better carry out the protection and inheritance of ancient buildings in the context of the new era, this paper takes the famous world cultural heritage - Gulangyu Island as the research object, and further explores the factors affecting the protection of ancient buildings by constructing the Factor Analysis Model and scores the ancient buildings in each group, so as to provide a reference and reference value for the sustainable protection and inheritance of ancient buildings in the future.

2 Status of Conservation of Ancient Buildings

In 2009, Gulangyu introduced the "National Key Cultural Relics Protection Unit - Gulangyu Modern Architectural Complex Protection Plan", which implements graded protection and maintenance for 11 national key cultural relics protection units and 308 historical buildings. 2022, the "Xiamen Gulangyu Cultural Heritage Core Elements Protection and Management Measures" was introduced, which explicitly points out to ensure the integrity and authenticity of the ancient buildings and to bring out the cultural value. As one of the early open foreign trade ports in Fujian, Gulangyu Island mixed different architectural styles such as traditional Minnan style, Western classical revival and veranda style, making it a place where architecture of all nations comes together.

On the basis of the above policy and literature research, we launched a field research from October 2022 and found that there are big problems in the protection of ancient buildings, such as scattered layout planning of ancient buildings on the island, the scope of protection involves the whole island, and it is difficult to centralize the management of repair; Asia’s rapid urbanisation subjects cultural heritage to tensions that threaten its preservation and poses dilemmas for decision-makers [3]. with the opening up of the tourism industry, most of the ancient buildings on the island have become buildings with commercial or public welfare properties; the conflicting contradictions of the principle of conflict of the principle of the original appearance of the ancient buildings and the modern needs of the residents' lives. Neglecting the protection and restoration of cultural relics and ancient buildings in actual development planning will exacerbate the conflict between the development of modern civilization and the preservation and inheritance of cultural relics and ancient buildings [4].

3 Comprehensive Evaluation of the Protection of Ancient Buildings Based on Factor Analysis

3.1 Design of the indicator system

In order to study the rationality and accuracy of the results, with reference to the relevant thesis scholars research, this paper from the government, society, residents, businesses, tourists, five

dimensions to start to select 30 fully reflect the protection of ancient architecture indicators, the construction of ancient architectural protection evaluation system, the specific protection of evaluation indexes selected as shown in Table 1.

Table 1 Relevant indicators for the evaluation of ancient building conservation

form	Indicator name	Number
Government factors	Government economic support for ancient buildings	X_{11}
	Government regulations for the protection of ancient buildings	X_{12}
	Government's diversified development and utilization of ancient buildings	X_{13}
	Professionals regularly inspect the condition of ancient buildings	X_{14}
	Daily dynamic monitoring of government departments	X_{15}
Social factor	Mass media	X_{21}
	Physical offline publicity and promotion	X_{22}
	Spontaneous conservation actions by civil society organizations	X_{23}
	Professional practice related to ancient architecture	X_{24}
	Reserve professional talent echelon building	X_{25}
Merchant factors	Cooperation with the government	X_{31}
	Cultural and creative IP co-branding	X_{32}
	Routine repairs to old buildings	X_{33}
	Consciously regulate business	X_{34}
	Cultural promotion of ancient architecture	X_{35}
Population factor	Creating an atmosphere for the preservation of ancient buildings	X_{41}
	Cooperation with the government	X_{42}
	Residents' living habits	X_{43}
	Publicize and warn	X_{44}
	Daily inspections	X_{45}
Visitor factors	Ancient architecture knowledge base	X_{51}
	Cooperate with local excursion regulations	X_{52}
	Conservation awareness and behavior of ancient buildings	X_{53}
	Awareness and behavior in the promotion of ancient architecture	X_{54}
	Participate in on-site interactions related to ancient architecture	X_{55}

3.2 Factor analysis calculations

Factor analysis is a multivariate statistical analysis method that effectively reduces the dimensionality of variables without causing significant loss of information [5]. This is a factor analysis calculation based on SPSS25.0 to study the influence of five subjects on the conservation of ancient buildings, which is a revelation for evaluating the conservation of the same type of ancient buildings. Through the combination of online and offline methods of multi-level random

sampling of the five identity groups proportionally, 1052 valid questionnaires were finally collected. Firstly, the data were de-measured normalization and applicability test, according to the results of KMO and Bartlett's spherical test, the sample KMO value is 0.892, higher than 0.5, P value is 0.0001, Bartlett's test significance level is less than 1%, and the questionnaire data is highly significant, so the dataset is suitable for factor analysis modeling.

Factor extraction. The variance of the common factor indicates the part of the variance of the variable that can be explained by the common factor, and the results of the common factor test show that the variance of the common factor extracted from the 25 selected protection indicators is greater than 0.6, which responds that the common factor extracted from each variable can effectively represent the variance of the variable, and further proves that the 25 selected protection indicators are suitable for factor analysis.

Extracting the principal factors. In this paper, principal component analysis is used to determine the number of public factors, and the total number of public factors with eigenvalues of the factor loading matrix greater than 1 is 5, and the cumulative contribution rate of variance is 65.892%, which indicates that the 5 factors reflect more than 65% of the information of the original data, and the percentage of the information accounted for is not high probably because this project is an exploratory study. In addition, combined with the gravel plot, it can be seen that the eigenvalue is between 5-6 when the number of factors in the horizontal coordinate is 1-2, indicating that the contribution of explaining the original variables is the largest, showing that when the factors reach 6, the eigenvalue is already less than 1, and the contribution to the explanation of the original variables is small, so the choice of 5 factors is the most appropriate.

Table 2 Explanatory table for total variance*

Ingredient	Initial eigenvalue			Extract the sum of the squares of the loads			Rotational load sum of squares		
	total	Variance percentage	Accumulated%	total	Variance percentage	Accumulated%	total	Variance percentage	Accumulated%
1	5.883	23.534	23.534	5.883	23.534	23.534	3.347	13.388	13.388
2	3.258	13.032	36.566	3.258	13.032	36.566	3.329	13.316	26.704
3	3.076	12.305	48.871	3.076	12.305	48.871	3.286	13.144	39.849
4	2.302	9.208	58.079	2.302	9.208	58.079	3.274	13.095	52.943
5	1.953	7.813	65.892	1.953	7.813	65.892	3.237	12.948	65.892
6	.581	2.325	68.217						
...	...	...	...						
25	.292	1.169	100.000						

*Extraction method: Principal component analysis.

Factor rotation and naming. Based on the above results the five selected principal component factors are named as followsF_1 Government factor factor,F_2 Social factor factor,F_3 Business factor factor,F_4 Resident factor,F_5 Tourist factor. In order to name the interpretability of the

factors, this paper adopts the method of great variance to carry out orthogonal rotation of the factor loading matrix, and the results of the rotation indicate that the government factor with the greatest influence is the "daily dynamic monitoring of government departments". X_{15} The protection indicator is as high as 0.807; the social factor is X_{24} = 0.802; the business factor factor is X_{32} = 0.799; the residents factor isX_{42} = 0.809; the factor for tourists is X_{51} =0.812.

Calculation of public factor scores. The table of coefficients of the factor indicators can be derived from the table of coefficients of the rotated component matrix, which is substituted into the formula for calculating the factor scores:

$$\mathrm{F_n} = n_1\mathrm{X_{11}} + n_2\mathrm{X_{12}} + n_3\mathrm{X_{13}} + n_4\mathrm{X_{14}} + n_5\mathrm{X_{15}} \ldots + n_{25}\mathrm{X_{55}} \quad (1)$$

The specific calculations are:

$$\begin{aligned}\mathrm{F_1} = &-0.008\mathrm{X_{11}} - 0.011\mathrm{X_{12}} - 0.036\mathrm{X_{13}} - 0.039\mathrm{X_{14}} - 0.039\mathrm{X_{15}}\\ &+0.253\mathrm{X_{21}} + 0.263\mathrm{X_{22}} + 0.278\mathrm{X_{23}} + 0.274\mathrm{X_{24}} + 0.271\mathrm{X_{25}}\\ &-0.030\mathrm{X_{31}} - 0.036\mathrm{X_{32}} - 0.031\mathrm{X_{33}} - 0.033\mathrm{X_{34}} - 0.030\mathrm{X_{35}}\\ &-0.029\mathrm{X_{41}} - 0.034\mathrm{X_{42}} - 0.022\mathrm{X_{43}} - 0.037\mathrm{X_{44}} - 0.024\mathrm{X_{45}}\\ &-0.043\mathrm{X_{51}} - 0.027\mathrm{X_{52}} - 0.046\mathrm{X_{53}} - 0.045\mathrm{X_{54}} - 0.024\mathrm{X_{55}}\end{aligned} \quad (2)$$

$$\begin{aligned}\mathrm{F_2} = &-0.006\mathrm{X_{11}} - 0.020\mathrm{X_{12}} - 0.016\mathrm{X_{13}} - 0.016\mathrm{X_{15}}\\ &-0.024\mathrm{X_{21}} - 0.035\mathrm{X_{22}} - 0.032\mathrm{X_{23}} - 0.033\mathrm{X_{24}} - 0.030\mathrm{X_{25}}\\ &+0.266\mathrm{X_{31}} + 0.262\mathrm{X_{32}} + 0.260\mathrm{X_{33}} + 0.267\mathrm{X_{34}} + 0.258\mathrm{X_{35}}\\ &-0.032\mathrm{X_{41}} - 0.019\mathrm{X_{42}} - 0.011\mathrm{X_{43}} - 0.017\mathrm{X_{44}} - 0.021\mathrm{X_{45}}\\ &-0.027\mathrm{X_{51}} - 0.040\mathrm{X_{52}} - 0.024\mathrm{X_{53}} - 0.025\mathrm{X_{54}} - 0.038\mathrm{X_{55}}\end{aligned} \quad (3)$$

$$\begin{aligned}\mathrm{F_3} = &-0.012\mathrm{X_{11}} - 0.005\mathrm{X_{12}} + 0.007\mathrm{X_{14}} + 0.001\mathrm{X_{15}}\\ &-0.023\mathrm{X_{21}} - 0.020\mathrm{X_{22}} - 0.034\mathrm{X_{23}} - 0.034\mathrm{X_{24}} - 0.023\mathrm{X_{25}}\\ &-0.024\mathrm{X_{31}} - 0.013\mathrm{X_{32}} - 0.014\mathrm{X_{33}} - 0.036\mathrm{X_{34}} - 0.009\mathrm{X_{35}}\\ &+0.249\mathrm{X_{41}} + 0.259\mathrm{X_{42}} + 0.252\mathrm{X_{43}} + 0.256\mathrm{X_{44}} + 0.256\mathrm{X_{45}}\\ &+0.010\mathrm{X_{51}} + 0.002\mathrm{X_{52}} - 0.008\mathrm{X_{53}} + 0.010\mathrm{X_{54}} + 0.013\mathrm{X_{55}}\end{aligned} \quad (4)$$

$$\begin{aligned}\mathrm{F_4} = &-0.005\mathrm{X_{11}} + 0.010\mathrm{X_{12}} - 0.011\mathrm{X_{14}} + 0.015\mathrm{X_{15}}\\ &+0.004\mathrm{X_{21}} - 0.036\mathrm{X_{22}} - 0.056\mathrm{X_{23}} - 0.035\mathrm{X_{24}} - 0.042\mathrm{X_{25}}\\ &-0.042\mathrm{X_{31}} - 0.024\mathrm{X_{32}} - 0.027\mathrm{X_{33}} - 0.033\mathrm{X_{34}} - 0.027\mathrm{X_{35}}\\ &+0.011\mathrm{X_{41}} + 0.011\mathrm{X_{42}} + 0.008\mathrm{X_{43}} + 0.015\mathrm{X_{44}} - 0.003\mathrm{X_{45}}\\ &+0.267\mathrm{X_{51}} + 0.261\mathrm{X_{52}} + 0.259\mathrm{X_{53}} + 0.268\mathrm{X_{54}} + 0.249\mathrm{X_{55}}\end{aligned} \quad (5)$$

$$\begin{aligned}\mathrm{F_5} = &\ 0.249\mathrm{X_{11}} + 0.246\mathrm{X_{12}} + 0.255\mathrm{X_{13}} + 0.249\mathrm{X_{14}} + 0.259\mathrm{X_{15}}\\ &-0.031\mathrm{X_{21}} - 0.023\mathrm{X_{22}} - 0.022\mathrm{X_{23}} - 0.025\mathrm{X_{24}} - 0.025\mathrm{X_{25}}\\ &-0.007\mathrm{X_{31}} - 0.007\mathrm{X_{32}} - 0.011\mathrm{X_{33}} - 0.017\mathrm{X_{34}} - 0.014\mathrm{X_{35}}\\ &+0.052\mathrm{X_{41}} - 0.009\mathrm{X_{42}} - 0.023\mathrm{X_{43}} - 0.015\mathrm{X_{44}} - 0.006\mathrm{X_{45}}\\ &+0.046\mathrm{X_{51}} - 0.016\mathrm{X_{52}} + 0.004\mathrm{X_{53}} - 0.006\mathrm{X_{54}} - 0.012\mathrm{X_{55}}\end{aligned} \quad (6)$$

Modeling of protection evaluation. Firstly, the average score of each index in the original data is calculated, and substituted into the formula of Fn factor calculation to get the weighted total

score of each factor, and the variance contribution rate of the five factors in Table 2 is used as the weights, on the basis of which the conservation evaluation model Z for the protection and inheritance of ancient architecture in Gulangyu Island is constructed.

The arithmetic average calculation of the collected statistical result data yields the values of 25 indicators of ancient architecture in Gulangyu Island:

$$X_{11} = 3.1787, X_{12} = 3.2690, X_{13} = 3.2300, X_{14} = 3.0922, X_{15} = 3.2975;$$

$$X_{21} = 3.8280, X_{22} = 3.5466, X_{23} = 3.6568, X_{24} = 3.4943, X_{25} = 3.4401;$$

$$X_{31} = 3.2842, X_{32} = 3.6854, X_{33} = 3.5865, X_{34} = 3.3555, X_{35} = 3.4905;$$

$$X_{41} = 3.4164, X_{42} = 3.6112, X_{43} = 3.5418, X_{44} = 3.5418, X_{45} = 3.8717;$$

$$X_{51} = 3.4411, X_{52} = 3.6027, X_{53} = 3.6036, X_{54} = 3.4972, X_{55} = 3.1721$$

Substituting into the protection evaluation model can get the calculation results of each public factor of the protection evaluation of ancient buildings:

$$F_1 = 2.6546, F_2 = 2.9378, F_3 = 3.8831, F_4 = 3.5867, F_5 = 3.4385$$

Taking the variance contribution rate of the five factors in Table 2 as the coefficient weights of each factor, and the denominator as the cumulative contribution rate, the conservation evaluation model Z for the conservation and inheritance of ancient architecture in Gulangyu Island is constructed on this basis:

$$\mathrm{Z} = \frac{13.388\%\mathrm{F}_1 + 13.316\%\mathrm{F}_2 + 13.144\%\mathrm{F}_3 + 13.095\%\mathrm{F}_4 + 12.948\%\mathrm{F}_5}{65.892\%} \tag{7}$$

3.3 Analysis of results

Finally, the limit evaluation interval [-2, 2] is substituted into the evaluation model of ancient architecture protection and inheritance, and the value of Z limit interval can be obtained as [0.9516, 4.7578], in which the evaluation model of Gulangyu ancient architecture protection and inheritance takes the value of 3. 2961 accounted for 86.599% of the total interval, and is located in the middle and upper reaches of the evaluation of the model, which can be seen that the protection and inheritance of the ancient architecture of Gulangyu is more successful, but there are still problems that need to be improved. There are problems that need to be improved, such as the relatively low score of the policy factor, the social awareness of the protection of ancient buildings, tourists and residents to cooperate with the government's work and other evaluation scores need to be improved, etc. The reason may be that Gulangyu Island is not a strong policy constraints on the ancient buildings, the social protection of the ancient buildings lack of publicity, the tourists are more difficult to control as well as the residents do not have a systematic training, the protection of the awareness of the weak.

4 Further Proposals to Conserve the Ancient Architecture of Gulangyu Island

Construction industry is a vital sector for the national and economic development of any country [6]. Ancient buildings are a reflection of a nation's culture and overall quality. Therefore, the

preservation of ancient buildings is particularly important. For the above ancient building protection evaluation factor model can be seen that the government, tourists, residents in the protection of ancient buildings play a greater role, so it is believed that the protection of ancient buildings should be:

4.1 Strengthening the implementation of policies for the protection of ancient buildings

It is vital to establish a clear hierarchical responsibility system for protecting historical buildings on Gulangyu Island. The current protection laws are general, lacking a well-defined delineation of responsibility. Relevant departments need to implement a grading system for historical buildings. Additionally, an effective monitoring system for preserving ancient architectural heritage is essential due to the decay and distortion of buildings made of timber, stone, and brick in the hot and humid climate. Lastly, there should be an improved decision-making mechanism for ancient building protection, involving government-led development and professional institution participation to manage Gulangyu's cultural heritage.

4.2 Opening up diversified funding channels while raising public awareness of protection

Organize various kinds of exhibitions, lectures and other activities on Gulangyu Island to attract outside investment, and put equal emphasis on government and private investment. Secondly, provide high-quality services for tourists on the island in terms of food, accommodation, transportation and tourism, increase the diversity of choices for tourists and minimize the outflow of tourist spending. Enhance its functions of leisure and vacation, cultural experience, etc., to lengthen the stagnation time of tourists and enrich the variety of consumption. Comprehensively improve the public's high degree of awareness of the traditional culture of ancient architecture, and enhance the public's awareness of the protection of ancient architecture. Major museums, historical exhibition halls, ancient architectural sites and other places can carry out interactive exhibitions, virtual scene experience and other activities. Communities, colleges and universities can set up ancient building protection groups and organizations, and regularly carry out volunteer services and other activities to promote the significance and value of ancient building protection.

4.3 Encourage community residents to participate in the protection of ancient buildings

The protection of ancient buildings on Gulangyu Island involves, in addition to traditional listed protection and repair, the protection of relevant supporting facilities and the protection of the ecological and humanistic landscape clusters in the vicinity of ancient dwellings. The basic needs of people's lives should be taken into account as a whole, such as living facilities, fire safety, reinforcement of houses and other practical issues. The government can carry out multi-sectoral negotiations and cooperation, actively listen to the feedback of residents, and effectively solve the problems of local residents' lives, improve people's sense of well-being and satisfaction with life, and preserve the fireworks atmosphere.

5 Conclusion

Historic sites and structures are tangible representations of the cultural heritage of a certain group of people that have withstood the tests of time [7]. The preservation and inheritance of ancient buildings can better promote cultural heritage, enhance pride, and stimulate tourism and economic prosperity. This paper collected a total of 1052 valid questionnaire data from five main stakeholders, including businesses, residents, tourists, government, and society, regarding their views and evaluations of the protection of ancient buildings. The study utilized factor analysis to select 25 protection indicators, construct an evaluation system for the protection of ancient buildings, and calculated the comprehensive protection evaluation ratio of Gulangyu's ancient buildings to be 86.599%. Additionally, the paper provides relevant suggestions for the protection of ancient buildings from the perspectives of policy, society, and residents.

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