Study on the Usability of Residential Buildings in Traditional Villages in Southern China from the Perspective of Human Settlements

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Abstract. The paper explored the building renewal technology and the wisdom in the constructions of traditional villages in southern China through the quantitative analysis of the statistical data. The eco-environment deterioration has gradually become a serious and inneligible problem in China. The paper explored the ecological energy-saving technology and the wisdom in the constructions of traditional villages in southern China through the quantitative analysis of the statistical data. It revealed that modern technology has been integrated into traditional energy-saving technology for further development and it proposed to strengthen the systematic instruction and management for better development of ecological system and human settlement environment. It provides the usability of residential buildings in traditional villages in southern China from the perspective of human settlements.

Keywords: Traditional villages · Living environment · Ecological development

1 Introduction

Energy-saving, environmental protection and sustainable development have become the theme of the world. Traditional houses contain rich and simple green design concept, the overall design reflects the natural, energy saving and environmental protection design guiding ideology, covering the human and natural low consumption goals, advocate the use of renewable resources, pay attention to the use of geographical and local technology, Protect the ecological environment, to achieve the sustainable development of the building. Traditional residential construction technology focuses on technical suitability and nature, and seeks to update and develop the traditional architecture technology. It emphasizes the combination of construction technology and regional climate, natural resources and ecological environment, and explores the sustainable development of buildings in the natural ecological sense Technical design ideas. Thus, it is important to explore and understand the eco-energy-saving technologies and construction technologies in traditional villages, which may help us better to achieve sustainable development in traditional villages.

A. Marcus and W. Wang (Eds.): HCII 2019, LNCS 11585, pp. 14–28, 2019.
https://doi.org/10.1007/978-3-030-23538-3_2

The coupling research of ecosystem and practical life has become a hot topic in the fields of human settlements and been successively carried out by governments and scholars. In this paper, we analyzed the literatures published in the past 20 years in this field, and summarized the results. The research may help to provide instruction and reference for the development of ecosystem in traditional villages in Southern China. There are more than 1,600 related publications on the ecological development in domestic environment of human settlements from 1995 to 2016 through survey and statistics from the CNKI database. These researches involved in urban planning, landscape, ecology, geography, sociology and many other disciplines, which have been mainly distributed in 10 research directions (Fig. 1). Environmental Science and resources utilization is the most concentrated one.

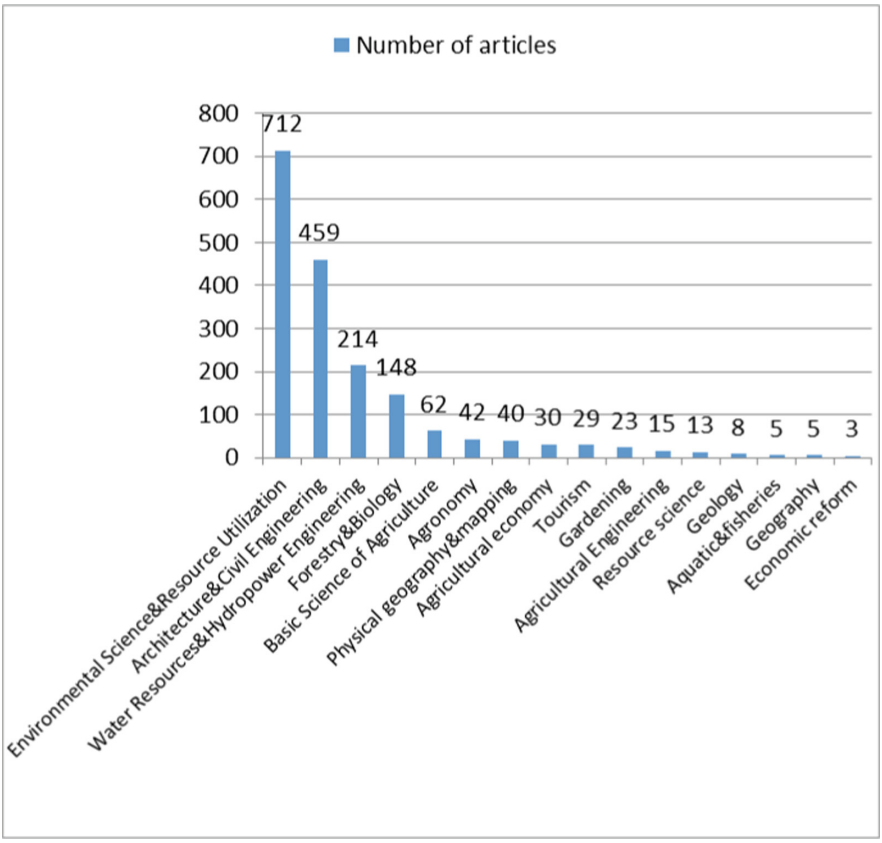

Fig. 1. The field of ecological coupling literature distribution in CNKI's view of human settlements.

From 1995 to 2017, more than 140 articles on ecological development in the context of human settlements have been collected in the Netherlands Science Direct Online database. The annual publications have kept increasing since 2003 as shown in Fig. 2.

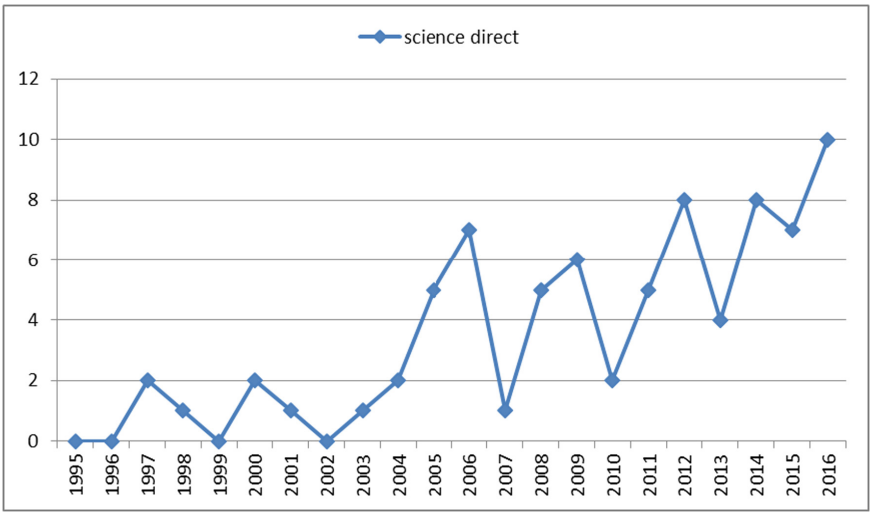

Fig. 2. The Netherlands Science Direct Online database contains the number of articles published in the context of human settlements.

2 Literature Review

The study on energy-saving technologies in traditional buildings can be traced back to 1894. In "Seven Lamps in Architecture", John [1] elaborated the natural attributes of technology and the concept of handicrafts. The philosophy in this book is similar to that of the sustainable development. Egyptian architects Hassna Fathy [2], Indian architect Charles Corrae [3] and Malaysia architect Ken [4], have fully considered the architectural economic conditions and technical conditions in their design practice. By using local materials and taking advantages of traditional technology, they have expanded the application of traditional technology to improve the environmental conditions. Zhang [5] said that a serious and inneligible problem in the construction of human settlements in China is the gradual eco-environment deterioration. He suggested that the construction of human settlements and better management system should be developed together. Yu, Wang and Lin [6] suggested that ecological development should be considered as an important way to solve the social and eco-environmental problems t caused by the process of modernization. Turnar et al. [7], ELD-Initiative [8] suggested that the causes of ecological degradation include the direct destructive activities of human beings and the underlying results under the influence of economic, political and cultural activities.

The wisdom for the adaptation of Chinese traditional houses to the climate could be seen everywhere. Wang [9] proposed and discussed the two main aspects in construction, including climatic factors and the adaptation to climate. Zhao [10] refined the climate regulation technology of the traditional buildings through the prototype analysis of the development of traditional building's architectural form. Bai and Liu [11] analyzed the mechanism of adapting to dry and heat, and the big temperature difference

between day and night as well as other climate characteristics of houses in Xinjiang province. The subtropical area of the Xia Linqi [12] systematically expressed the modern theory that the building heat protection should conform to the local climate in the subtropical area. Professor Tang [13] of Guangzhou university combined the method of classification summary, formula derivation and local measurement to quantitatively analyze the elements of Chinese traditional architecture in the south to adapt to the hot and humid climate. On the basis of the summary of the traditional ventilation wisdom, Zeng [14] has applied the effective ventilation experience of the traditional houses to the modern engineering design. Vitiello [15] proposed to integrate multidisciplinary (architecture, landscape science, natural environment, demography and anthropology) into the framework of the ecological research framework, emphasizing the need to develop the idea of ecological development in the View of Human Settlements within a broader framework of environmental compatibility. Vemuri et al. [16] emphasized that the study of the theory and method of ecological development in the context of human settlements must be a consideration of economic factors, social factors and ecological factors, dependent on population resources, building resources, natural resources and the co-ordination of social resources. Costanza [17] argued that the ecological service performance of human settlements ecosystem is the ability to derive benefits (social, economic, and human health) from human ecosystems; MEA [18] has identified ecosystems The ecological service performance can be qualitatively and quantitatively analyzed from multiple levels. Boumans [19] constructed the GUMBO model to quantitatively explore the ecological service performance of the ecosystem and provide a scientific and rational basis for the ecosystem assessment. Quantitative analysis means. Robert, Pastorok et al. [20] in their framework for the construction of ecological decision-making clearly put forward the ecological development project requires a professional, full planning and monitoring system, pointed out that the living environment should involve policy and institutional research. Matthias [21] emphasized that public management in ecological coupling should involve professionals with different subject backgrounds throughout.

3 Research Method

It is a typical hot and humid climate in Southern China. The summer is long and hot. The winter is cold and short. When people are in a certain environment will have a corresponding heat adaptation, then the hot and humid areas of rural residents how to adapt to heat, we conducted a thermal comfort-related survey and residential samples of the test analysis.

According to the types of rural residential areas in southern China, combined with their distribution characteristics and climatic conditions, the experimental subjects selected several typical farmers in Houtian Village, Heshan Village, Houxi Village and Army camp Village in southern China to carry out indoor thermal environment. Basic characteristics as shown in the following Table 1: Houtian village villagers to the traditional fishery, close to the beach life, the climate has typical coastal climate characteristics, residential use mainly to self-occupied, residential building structure is mainly mixed structure, reinforced concrete structure Combined with brick or mixed in

the bottom of the case for the stone houses in the case of the upper combination of mixed structure; against the village of the villagers to pay salaries and rental mainly to the traditional village homestead building form, its building density, climate and environment Similar to the characteristics of urban inland climate, residential building structure is mainly reinforced concrete structure combined brick-based; Houxi village villagers to pay the main, new village building density, climate similar to the characteristics of urban inland climate, residential The structure is mainly based on reinforced concrete structure combined brick-based; Army camp village living on the hillock above the highest elevation, the majority of the villagers to traditional agriculture for a living, residential self-occupied and production activities of the regional functions, new residential The building structure is mainly mixed structure, reinforced concrete structure combined with brick-based. Army camp village measured the object has two farm houses, but in order to better and lower altitude of the farm to compare, the main choice of which the highest elevation of 160 farm house for comparative analysis. It is shown in Fig. 3 that the test sample house layout and measurement control points.

Table 1. Samples of rural residential survey in southern China

Location of farmhouse	Altitude (m)	Building density	Building materials	Structure form	Test place
Houtian Village (Cui Heng Village) No. 467 (object 1)	20	High	Brick and reinforced concrete	Hybrid structure	Living room, bedroom
City Village No. 24 (object 2)	9.5	High	Brick, wood and stone	Hybrid structure	Living room
Pan Tu community No. 44 (object 3)	14	High	Stone and reinforced concrete	Hybrid structure	Living room, bedroom
Army camp village (Gu pai village) 160 (object 4)	300	High	Stone and brick	Hybrid structure	Living room

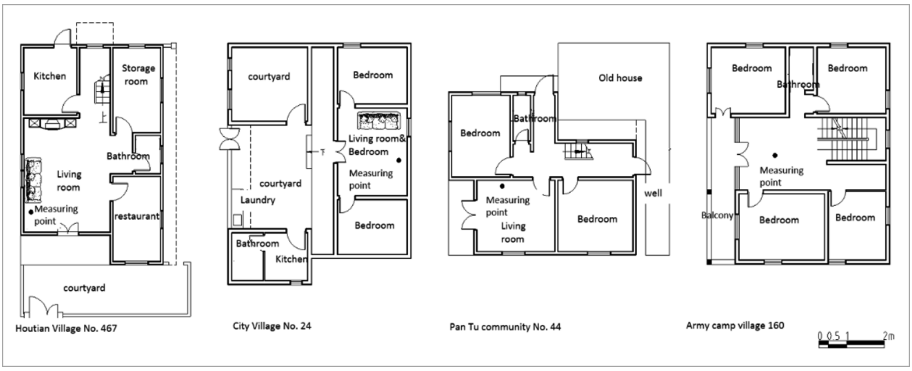

Fig. 3. Test sample house layout and measurement control points

4 Data Collection and Analysis

4.1 Basic Characteristics of Indoor Thermal Environment and Analysis of Air Temperature in South China

China's rural areas in southern China are widely distributed. In the context of the summer heat and warm (southern) climate of the large area, the local climate and environment are different due to the different geographical environment of the rural residential areas. The environment has obvious characteristics. Take the altitude of the different conditions for the classification, the altitude from low to high followed by the seaside village one after another Tamura, inland villages one by one against the village and after the village, mountain village one armor village. According to the finishing of the research data, the basic characteristics of the indoor thermal environment of rural residential areas in southern China are shown in following Fig. 4.

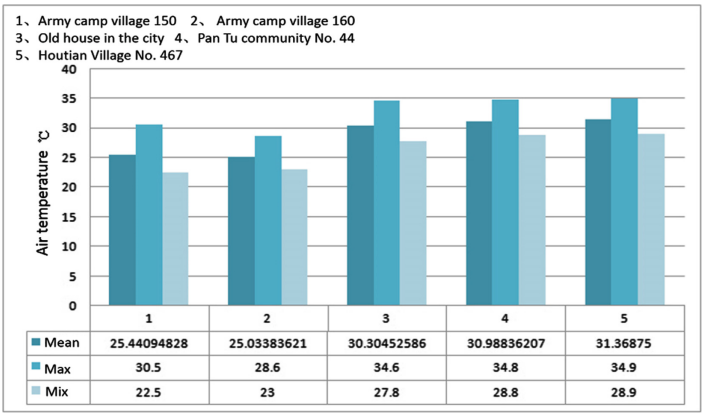

Fig. 4. Comparison of average temperature, maximum and minimum values of indoor temperature in summer in 2015

Comparison of the air temperature between the different measured objects The maximum, minimum, average and change trend of the air temperature of the measured objects 1, 2, 3 and 4 are shown in Fig. 4. The average temperature of the farmhouse in the barracks village is the lowest, and the temperature of the farmhouse in the city is the highest. The temperature change of the farmhouse and the barracks in the city is more intense. House temperature changes are more stable. Summer farmhouse indoor temperature in 2015 is shown in Fig. 5.

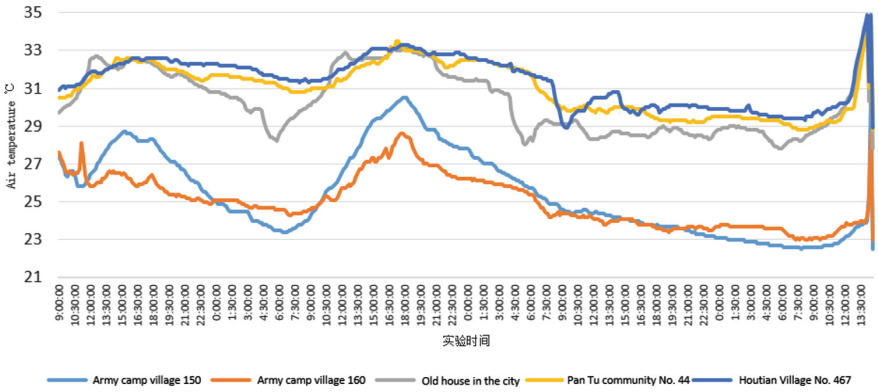

Fig. 5. Comparison of indoor temperature of rural households in 2015

4.2 Analysis of Measured PMV-PPD Data

PMV (Predicted Mean Vote) value was used as the mean thermal sensory voting index, and the effects of air temperature, relative humidity, wind speed and wall radiation on the indoor heat sensation were evaluated comprehensively. In 1984, PMV-PPD corresponds to the body's hot and cold feeling that as ISO-7730 standard has been internationally recognized, the current PMV is the most commonly used international thermal environmental evaluation indicators. It is generally believed that −0.15 PMV 0.15 is the expression of the human body to feel the hottest and comfortable thermal environment, PMV value to 1.6, indicating that the human body feels more discomfort to this thermal environment. PMV can be calculated by air temperature, air humidity, air flow rate, ambient radiation temperature, human activity and human clothing. Through the measured indoor thermal environment parameters, combined with the summer indoor human dress and activities, the indoor living room PMV value, the results shown in Fig. 6. The results showed that the PMV average was the most close to the thermal comfort interval, and the comfortable time period was longer than that of the rest of the experimental subjects. The experimental results were similar to those of the experimental subjects 1 and 3, and the measured data showed that the PMV of the experimental object 1. The PMV of the experimental object 2 was similar to that of the experimental object 4, and the PMV of object 2 was lower than that of the experimental subjects 1 and 3, but the thermal stability of the experimental subjects 2 and 4 were worse than that of other experimental subjects. It is shown in Fig. 6.

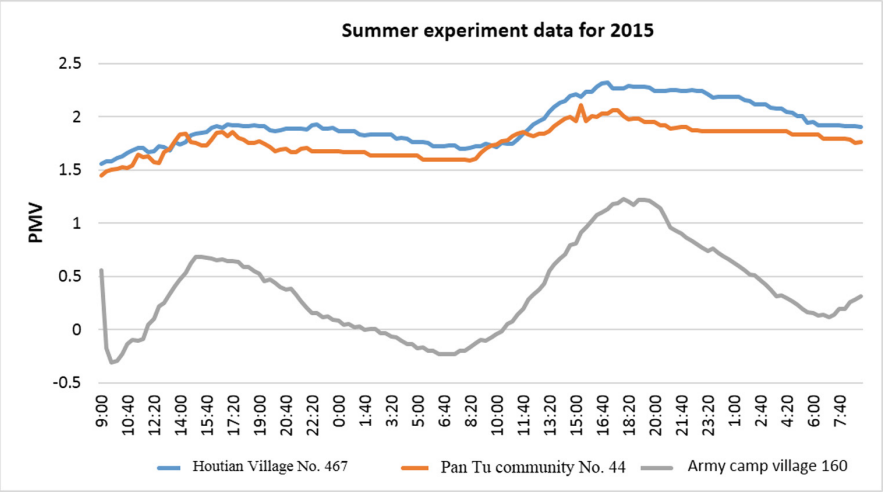

Fig. 6. Summer measured data PMV calculated value

5 Discussion

5.1 The Characteristics of Indoor Thermal Conditions in Traditional Villages in Southern China

(1) The change trend of the indoor temperature of the typical Chinese rural house is similar to that of the external environment, but the change of the terrain and the environment has the greatest influence on the thermal environment of the farmhouse. The highest temperature of the farmhouse has the highest temperature, the maximum change range, the indoor thermal environment The worst stability.

(2) For the buildings with similar orientation and material structure and similar structure, the indoor temperature convergence and the changing relationship are also convergent. The stability of the indoor thermal environment is similar to that of the modern concrete frame mixed structure. The use of the main building materials for the stone and red brick of the traditional rural house temperature is lower, but the magnitude of change.

(3) The layout of the village has a large influence on the thermal environment of the farmhouse, the high terrain height and the layout of the village are in line with the dominant temperature, and the thermal comfort is high, that is, the layout of the villages conforming to the climatic characteristics of the dominant wind direction is favorable The formation of a more comfortable indoor greenhouse thermal environment.

(4) The trend of the design of the experimental object is different, and the data show that the trend of temperature changes has nothing to do with the basic, the terrain is very close, different towards the temperature difference between the farm house is not large, we can see the building towards the rural areas of southern China's indoor heat The environment is a decisive factor.

5.2 The Design of Ecological Energy-Saving System for Traditional Villages in Southern China

Following the Law of Nature. The traditional villages in southern China have been planned reasonably by consideration of the site selection, layout, ventilation, sunshine, climate and other aspects. Traditional village living environment emphasizes the natural properties of houses, according to geographical conditions and terrain relations to organize the village environment. In the case of harmonious coexistence with the natural environment to adapt to the local life, the residence to follow here, rather than the other, and thus the formation of a unique humanities, geomorphology and the environment. China's Guangdong Province, Zhongshan Cui Heng Village is the Pearl River Delta alluvial plains into the sea typical of the traditional villages, the village on three sides around the mountains, east to the sea, just in the mountains of water holding the central. The vast majority of the village buildings are located in west, facing to east, leaning against the three sides of the Castle Peak, facing the Pearl River estuary blowing to the sea breeze. The village's location and layout reflects the traditional Chinese nature fully respect the concept, in line with possession of the wind together, yin and yang in the feng shui theory, and the surrounding terrain and landscape natural landscape to achieve harmony and unity. Its spatial pattern in the landscape shape, feng shui forest, feng shui tree, wind reservoir is formed under the sign of the pattern of settlement, and it is formed that the "mountain - farm - village - water - road" space corridor between the plow head of the mountain and the golden champagne hill. By emphasizing the traditional living environment combined with geographical conditions, relying on the mountain and river, homeopathic construction, a natural energy saving design idea is expressed. Figure 7 showing the settlement pattern of Zhongshan Cuiheng village which reflect law of nature "mountain - farm - village - water - road".

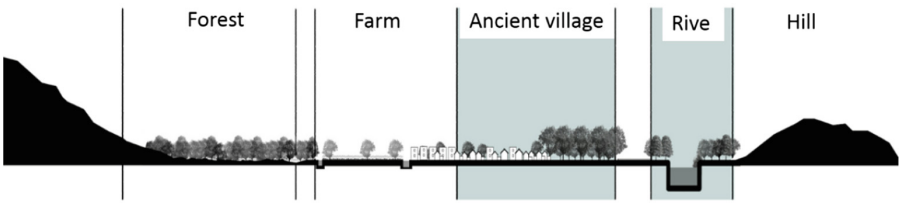

Fig. 7. Zhongshan Cuiheng Village "mountain - Farm - village - water - road" Road law natural settlement pattern

Adapting to Local Climate. The traditional living environment in southern China has been adapted to the regional ecological and climatic conditions and architectural functions, shape and space and other elements, through the appropriate architectural forms and appropriate technical measures, control of natural conditions and favorable climate resources to obtain the thermal environment of the building environment, Creating a low-energy and comfortable living environment. Residential sites to avoid

the wind speed of the top of the mountain and pass, as well as valleys and depression, and choose back to ying and facing to yang, back to mountain facing to water, screening winter cold at the same time to meet the summer cool breeze, settling near river to facilitate living water, to avoid flooding, while regulating the village micro-climate. Because of the design wisdom of the climate is also reflected in the traditional layout of the traditional residential space, to show the unique natural terrain and climate blend of group spatial characteristics. As shown in Fig. 8, the south of the village is designed to face the water. While in Fig. 9, the layout of the village is planned according to the shape of watery region.

Fig. 8. Planned design: the south of the village is facing to the water (Nanshe Village, Dongguan)

Fig. 9. Freestyle: the layout is according to the shape of watery region (Songtang Village, Foshan)

5.3 The Construction Technology for Ecological Energy-Saving in Traditional Villages in Southern China

The construction technology of traditional villages in southern China is a kind of construction method which is homogeneous with the local natural environment, and has simple ecological thoughts. It is based on local conditions for the characteristics of the technical system. This simple eco-technology is based on the analysis of the ecological environment and climate in the area where the building is located, and selects the most suitable type of building technology, including building type, tectonic technology, ventilation cooling and climate change.

Modeling Design. The traditional villages in southern China, which focus on the overall layout, are simple in size and have fewer bumps, so the building body size is smaller, thus reducing the heat transfer area. China's southern region has both warm and hot summer weather, and thus the traditional houses from the space layout, form of treatment and structural material design on the ground. Winter architectural space convergence closed in order to facilitate insulation, summer expansion and open to facilitate ventilation and cool air. The difference of thermal conductivity between the outer surface of the same volume under different volume is very different, so the pursuit of the same volume of the lower body surface area of the smallest residential building

space form is the preferred way of traditional Chinese houses in southern China, the building size coefficient is the smallest, Low, less energy consumption. Residential buildings are mostly regular rectangle or square form and its combination, bump changes are relatively small, to achieve ecological energy and economic principles. As shown in Fig. 10, the traditional design of the new houses in the traditional houses in southern China.

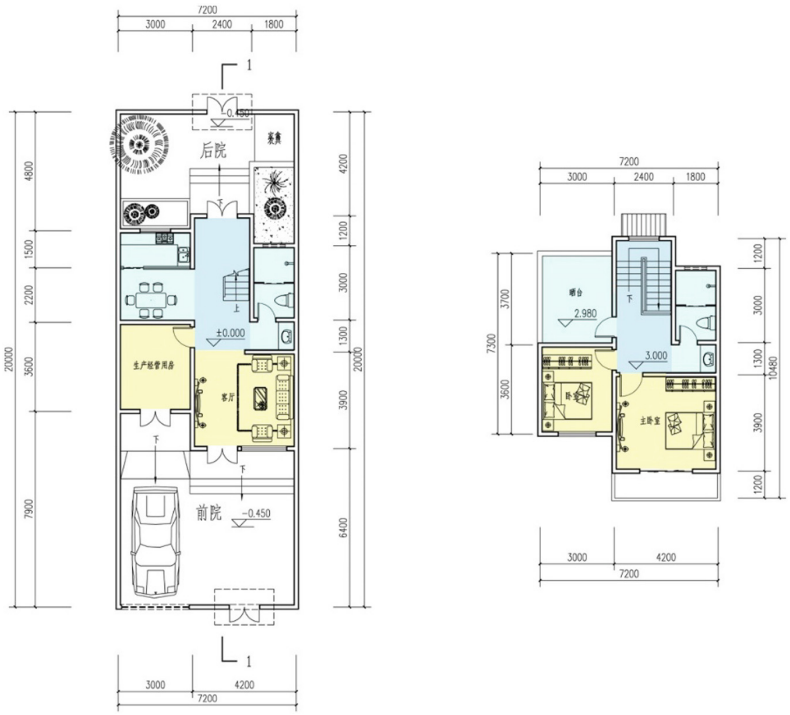

Fig. 10. The graphic design of the newly built residence in the traditional village homestead in South China

Adjusting the Ecological Environment Through Natural Ventilation Technology. China Southern residential building space natural ventilation technology using the patio, the atrium and the combination of the layout of the organization of ventilation. The interior of the building is open space, circulation, the room into the deep, hall wide and high, doors and windows, windows and windows formed to wear the wind, so that the air convection and heat. This patio is both an air outlet and an outlet. The wind in the summer, the patio in the sun exposure under the hot air transpiration, hot air rising, patio or side courtyard wind to form negative pressure area, cool breeze from the courtyard around the room into the courtyard, or both sides of the street cooling air Through the channel, to the patio continue to add the formation of hot and cold air temperature convection, hall, high windows and doors between the air flow, forming a

good wind, constitute a natural energy-saving natural ventilation system to achieve the purpose of summer natural cooling. Traditional houses in the many natural ventilation measures, adapt to the climate and automatically adjust. In addition, some houses in the courtyard set the water, because the water in the air there is the temperature difference, will form a wind cycle, take the indoor hot air, which play a role in indoor ventilation, lower room temperature, with cooling effect. China Southern traditional village houses through reasonable design, relying on the construction itself to form a wind cycle, which significantly adjust the indoor temperature, saving energy while regulating the environment microclimate. Figure 11 Ventilation design of the new houses in the traditional village house in southern China.

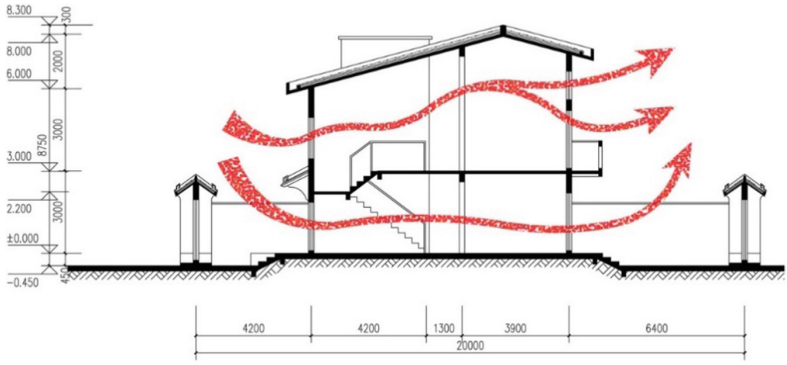

Fig. 11. Sectional ventilation design of new folk house in traditional Chinese village homes in South China

6 Conclusion

Traditional houses contain rich and simple green design concept, the overall design reflects the natural, energy saving and environmental protection design guiding ideology, covering the human and natural low consumption goals, advocate the use of renewable resources, pay attention to the use of geographical and local technology, Protect the ecological environment, to achieve the sustainable development of the building.

China's traditional ecological energy design in the south of the island is due to natural, mountain on the potential of the natural terrain to achieve the greatest degree of fit; the overall layout of the space to consider the winter wind and summer natural ventilation, and strive to the summer ventilation, winter wind unity; Reduce the building shape coefficient, increase the green planting surface and water to effectively solve the building in summer heat insulation and winter heating needs; in the residential space design in the use of courtyard, patio and stairs and other adjustable space technology strategy to achieve energy saving design purpose.

The layout of the village has a large influence on the thermal environment of the farmhouse, the high terrain height and the layout of the village are in line with the dominant temperature, and the thermal comfort is high, that is, the layout of the villages

conforming to the climatic characteristics of the dominant wind direction is favorable The formation of a more comfortable indoor greenhouse thermal environment. In the building environment, the local people feel very comfortable user experience.

6.1 Strengthening the Study on the Internal Relationship of Ecological System and Human Settlements

In the future research process, we should strengthen the study of the internal mechanism of ecological development in the field of human settlements, strengthen the application of complex system theory and computer simulation technology in the field of ecological development, combined with the theoretical framework of ecological development in the field of human settlements. The dynamic mathematical analysis model is constructed to simulate the internal operation process of the ecosystem and to identify the inherent mechanism of ecological development.

6.2 Study the Relationship of Ecological System and Human Settlements Through Acquisition of the Basic Data and Mathematical Analysis

The rapid development of geographic information technology provides a advanced and rich technical means for the study of ecological development in the field of human settlements. However, there is still room for improvement in the comprehensiveness, accuracy, accuracy and timeliness of data acquisition and processing. In the future, we can integrate geographic information technology with "big data" technology, establish accurate and real-time ecosystem monitoring system in data acquisition, improve the acquisition technology and method of basic data, and establish the whole people in data storage and processing Participation, dynamic and long-term ecological development information network platform for scholars to study, government decision-making, public supervision to provide help and reference.

6.3 Establishing a Systematic Management and Instruction for Better Ecological System and Human Settlement Environments

The process of ecological development is a dynamic process that is ongoing over a long period of time. Therefore, ecosystem monitoring should be strengthened as a factor to consider the construction of human settlements, especially in areas such as regional planning, urban planning and rural planning. Standards, the development of ecological development project guidelines, and further develop regionalized, type of engineering and technical standards to improve the ecological development of the project technical guidance; in the regulation, should strengthen the ecological development project implementation process and after the implementation of the ecological effect of continuous testing and management.

Absorbing traditional building energy-saving technology, and into modern technology, not only can improve the contemporary high-tech, so that it has ecological suitability, and can promote the development of traditional residential building technology. The ecological spirit and energy-saving technology embodied in the traditional architectural technology still shine the wisdom of light, so that architects can jump out

of modern high energy consumption and high pollution design thinking for the future of China's traditional villages in the ecological development of the coupling relationship with the environment Provide some effective measures and strategies.

Acknowledgements. We thank the National Natural Science Foundation of China (51278194) for the financial support. We also thank the School of Architecture Huaqiao University for the support.

References

1. John, R.J.: The seven lamps of architecture. J. Southeast Univ. (Philos. Soc. Sci., Nanjing) (2009)
2. Frampton, K.: Modern Architecture: A Critical History of European Oriental Rientalism, Beijing (2005)
3. Rao, X.: Review of the works of Charles Correa. Arch. Worlds **27**(1), 5–9 (1996)
4. Ken, Y.: Shell Energy-Saving Plan. Zhan's Bookstore, Taibei (1997)
5. Zhang, W., Chen, L., Yang, Y.: Research progress on human settlement evolution. Progross Geogr. **32**(5), 710–721 (2013)
6. Yu, K., Wang, X., Lin, S.: Urban design needs a "Big Foot Revolution" - practice of "Shuangxiu" in Sanya City. Urban Constr. **9**, 56–59 (2016)
7. Turnar, K.G., Anderson, S., Gonzles-Chang, M.: A review of methods, data, and models to assess changes in the value of ecosystem services from land degradation and restoration. Ecol. Model. **319**, 190–207 (2016)
8. ELD-Initiative: The rewards of investing in sustainability land management. In: Interim Report for the Economics of Land Degradation Initiative: A Global Strategy for Sustainable Land Management (2013)
9. Wang, P.: Climate Oriented Architecture with a Critic on Vernacular Architecture and Its Climatic Strategy. Qsinghua University, Beijing (2001)
10. Zhao, Q.: Research on the Ecological Experiences and Pattern Language of Traditional Residential Buildings. Xi'an University of Architecture and Technology, Xian (2005)
11. Bai, H., Liu, J.P., Jiang, S.G.: Study on climate adaptability of traditional houses with earth-envelopment wall in Turpan. Key Eng. Mater. **517**, 274–280 (2012)
12. Lin, Q.: Subtropical Buildings: Climate, Environment, and Architecture. Guangdong Science and Technology Press, Guangzhou (1997)
13. Tang, G.: Lingnan Hot and Humid Climate and Traditional Architecture. China Architecture & Building Press, Guangzhou (2005)
14. Zeng, Z.: Ventilation Method and Its Application in Modern Architecture of Traditional Residential Buildings in Guangzhou. South China University of Technology, Guangzhou (2010)
15. Vitiello, M.: Ecoperspectives restoration second. In: International Study Forum on Life of Traders, Less More Architecture Design Landscape, pp. 185–194 (2012)
16. Vemuri, A.W., Costanza, R.: The role of human, social, built, and natural capital in explaining life satisfaction at the country level: toward a national well-being index (NWI). Ecol. Econ. **58**, 119–133 (2006)
17. Costanza, R., Argem, E.: The value of the world' s ecosystem services and natural capital. Nature **387**, 253–260 (1997)
18. MEA: Ecosystems and Human Well-Being: Synthesis. Island Press, Washing DC (2005)

19. Boumans, R., Costanza, E.: Modeling the dynamics of the integrated earth system and the value of global ecosystem services using the GUMBO model. Ecol. Econ. **41**, 529–560 (2002)
20. Robert, A., Pastorok, A., Anne, M.: An ecological decision environmental restoration projects. Ecol. Eng. **9**(1–2), 89–107 (1997)
21. Junker, B., Buchecker, M.: Aesthetic preferences versus ecological objectives in river restorations. Landsc. Urban Plan. **85**(3–4), 141–154 (2007)