Study on Climate Adaptation in Architectural Technology in Rural Areas

Jingjing Wu * and Hongyang Wei
School of Architecture and Urban Planning, Chongqing University, No. 174 Shazheng Street, Shapingba District, Chongqing, China
Email: jingjing.2004_9@163.com

Abstract. Climate adaptation in architectural technology, as a communication medium between nature and human beings, has become a new development trend in response to climate change and to encourage energy conservation and environmental protection. This paper aims to deal with the problems from the perspective of architectural technology in modern new rural construction. Based on the theory of climate adaptation, this paper expounds the definition of climate adaptation in architectural technology, and presents two operating mechanisms to guide and to defend. A suitable technical roadmap is thus offered for the development of architectural technology in rural areas, which can be summarized as the better design of fundamental schemes, preferential selection of passive architectural technology, reasonable implementation of low-energy active architectural technology, and efficient use of active architectural technology with high energy consumption, in order to provide reference for sustainable development of new rural construction. The results show that the response of architectural technology to climate change needs not only to focus on the material level, but also to pay attention to the activities of users.

Keywords. Rural areas, architectural technology, climate adaptation, operating mechanism, technical roadmap.

1. Introduction
The architectural technology in rural areas is constantly updated and developed by artisans or residents who are familiar with the local climate, resources and culture in long-term practices. The climate-adaptive passive architectural technology received more attention while it was less mentioned in the modern architectural technology system [1]. The traditional architectural technology, in particular, is adaptive to various climates and terrains, perfectly integrating the architectures with nature [2]. The 20th century saw the huge impact on traditional architectural technology due to the rapid development of science and technology, urbanization and increasing living demands. However, new architectural technology does not value the impact of climate change, relying solely on indoors equipment to bring comfort [3]. As a result, it produces huge energy consumption, leading to a severe ecological crisis [4].

It was not until the 1970s that people realized that climate change would affect human society. Some countermeasures were proposed from prevention to mitigation and adaptation. Adaption theory was then becoming one of the cores of global change and an important principle of sustainable development [5]. Theoretical research on climate adaptation became a hot topic in scientific research [6], including in fields of architecture. The main concepts and methods taken by most researches included improving the performance of architectural materials [7-8] and the application of architectural equipment [9-11] as well as advocating the certification of energy efficiency ratings [12-
There were ways to achieve the goal of a precise thermal comfort environment. However, through investigations in rural areas, it is not difficult to find that rather than following the mainstream, architectural technology with an inadequate construction capacity and economic development, has blindly imitated modern styles, paying more attention to equipment such as air conditioners and solar collectors. This led to a series of energy-waste problems including less comfort and energy inefficiency. Another cause is a lack of active roles of house users.

With the re-emphasis on passive architectural technology responding to the climate in recent years [15], the architectural technology applied in rural areas entered into a new development stage, and began to pursue a balance among architectural form, passive and active technology [16]. The concept of climate adaptation it revealed has drawn wide attention [17]. Therefore, this paper starts from climate-adaptive traditional architectural technology, expounds the definition of climate adaptation in architectural technology, and presents its operating mechanism and technical roadmap, aiming to provide reference for the development of architectural technology in rural areas.

2. Definition of Climate Adaptation
Climate adaptation theory, originated from evolutionary ecology, refers to the adaptive characteristics of individuals or systems that remain stable within a certain range under the conditions of external climate change. In the context of architecture, climate adaptation study includes the impact of climate change on the comfort the physical environment brings, the weather resistance of building structures and materials, as well as the response to climate change and sudden natural disasters [18]. This means of climate adaptation does not exactly match the meaning of it in English, but closer to the meaning of climate response.

Architectural technology, as a communication medium between people and nature, is one of the three basic elements related to climate adaptation. Among them, architectural technology is seen as a tool for people to adapt to the climate (nature). Thus, the climate adaptation of architectural technology embodies two meanings, one is to build a comfortable artificial environment, and the other is to maximize humans’ intervention. The two facets are interconnected to jointly build a moderately comfortable artificial environment. Although further research shows that a comfortable thermal stable environment optimizes human functioning [19], it is important to give moderate hot and cold stimulation [20]. This shows that a moderately comfortable artificial environment is the most suitable for living, and climate adaptation will be the development direction of architectural technology.

Therefore, climate adaptation of architectural technology serves as a filter for different external environments, a process of adaptation, regulation, and coordination to cope with climate change. It aims to build an acceptable indoor artificial environment instead of providing precise thermal comfort. The specific strategies mainly include the full use of favourable external climate factors such as solar radiation, temperature, humidity, precipitation, wind and natural light, the avoidance of adverse factors and a dynamical balance of indoor heat [21] (figure 1). Meanwhile, it is also necessary to pay attention to the weather resistance and durability of building structures and materials, and to improve the safety of architectural technology in response to sudden disasters.

3. Operating Mechanisms of Climate Adaptation
Climate adaptation refers to the ability of architectural technology to adjust the indoor artificial environment to respond to climate change and to avoid harm. Hence, the climate adaptation of architectural technology should conform with the local climate and combine its own technical characteristics to create a moderately comfortable indoor artificial environment, and keep in harmony with nature. However, there are contradictions between nature and the artificial environment. Architectural technology, as the communication medium, serves to adjust and give feedbacks between the two to achieve a balance. Then to an orderly, coordinated and efficient operating mechanism can be established to enhance internal stability and external resilience. One of the most important variables that affect the indoor environment is the climate, deciding what kind of operating mechanism is implemented.
3.1. **The Introducing Mechanism**
When climatic factors such as solar radiation, temperature, humidity, and wind serve as advantages to the indoor environment, architectural technology, the filter between the nature and the artificial environment, should integrate external climatic factors into the room in a proactive manner to regulate and to improve the artificial environment. Passive technology such as natural lighting, natural ventilation, shading facilities, and water storage roofs are taken to meet the requirements of indoor comfort and achieve the goal of energy conservation and emission reduction.

3.2. **The Defensing Mechanism**
Architectural technology shelters humans from the wind and rain, as an effective and solid safety barrier to maintain the balance of a comfortable indoor environment, which will be affected by harsh weather conditions. Mainly used architectural technologies include thermal insulation, rain and moisture resistance, heating and cooling to mediate the adverse climate impact, and coordinate with the active architectural technology to regulate the indoor artificial environment in a dynamic manner. However, these technologies usually cost a painful price of high energy consumption and severe pollution.

Therefore, the climate adaptation of architectural technology must respond to climate change with ration, and select the optimal operating mechanism in accordance with the needs of indoor users for a comfortable artificial environment. Usually, a hybrid approach mainly based on passive architectural technology and supplemented by active technology is used, allowing a switch between the introducing mechanism and the defence mechanism in different seasons and periods (figure 2). In addition, the strength of climate adaptation of architectural technology is closely related to this switching efficiency.

**Figure 1.** Coordination of climate adaptation technology between external and internal factors.
The 6th International Conference on Environmental Science and Civil Engineering
IOP Conf. Series: Earth and Environmental Science 455 (2020) 012207
doi:10.1088/1755-1315/455/1/012207

Figure 2. The relationship of two mechanisms.

4. Technical Roadmap of Climate Adaptation
The challenges for the development of architectural technology in rural areas in China mainly comes from the complexity of climate and the diversity of needs: necessity to avoid the heat in summer and to resist the cold in winter. Due to the limitation of the building capability and the less developed economy, the rural area takes different path from the city. Their climate adaptation of the architectural technology is a dynamic result with comprehensive consideration of all factors such as materials and anthropic activities, and it is in line with the requirements of sustainable development. Therefore, this paper started from local climate factors in order to better solve the problems in architectural technologies taken by rural areas, learned from previous experiences and practices, and formulated a specific and feasible technical roadmap in terms of light, ventilation, heating, cooling and energy consumption, etc.

4.1. Improvement of the Fundamental Performance
In the early stage of designing, we need to analyze and evaluate on local climatic conditions, and improve the fundamental performance of the architectural technology in site selection, layout, orientation, and shape factor. First, in order to obtain better sunlight and ventilation, choose the sunny and sheltered areas according to the terrain and landform and arrange them parallel to the contour lines. Second, to assure a better ventilation condition, make use of sunlight, solar radiation and dominant wind direction to arrange the orientation. Finally, to control the shape factor, compare the energy-saving standards with functioning requirements. The point of this step is to improve fundamental performance of the architectural technology as much as possible, thereby reducing the use of supplementary architectural technology, saving costs and reducing energy consumption.

4.2. Preferential Selection
After the fundamental optimization, passive architectural technology with energy saving and environmental protection performance should be selected in order to better improve the indoor environment [22-23]. This selection is partly determined by the change of seasons and the shift of day and night. In this step, it is very important to choose passive architectural technology related to natural lighting and ventilation, cooling and heating, and energy consumption. This is the key for energy saving and environmental protection in rural buildings [24]. For example, in the outer envelope structure, architectural technologies such as double-walled walls or sun rooms, shading systems, or vertical greening are used to achieve thermal insulation. In the design of openings like doors and windows [25], the use of transparent and heat-insulating glass with higher economic efficiency can effectively reduce energy consumption.

4.3. Rational Implementation
After meeting the basic needs of the indoor, the implementation of low-energy active architectural technology is to build a more stable and pleasant indoor environment [26]. The main method taken is the active architectural technology using solar energy, such as solar photovoltaic power generation, solar water heaters and solar ventilation and cooling. In this step, the optimization and integration of active architectural technology is a key factor in improving overall performance [27]. Taking
Chongqing as an example, it enjoys a considerable solar radiation although its annual total amount is low in the country, especially in rural areas of an annual of 3500 MJ/m² compared to urban areas [28]. Thus, it can be seen that the reasonable selection of solar-related active architectural technologies is essential to satisfy the needs of indoor comfort in rural areas.

4.4. Efficient Use

When the previous step still cannot provide a comfortable indoor environment, traditional active architectural technologies with high energy consumption need to be set up. The point is how to ensure the efficient operation and coordinated interaction of different architectural technologies when conflicts and contradictions among traditional active architectural technologies will certainly emerge. The most commonly used are air-conditioning systems, mechanical ventilation systems to improve indoor artificial environments in extreme climate conditions. However, the application of them should be reduced due to the high cost.

The above four steps reflect the easy-to-difficult regulation of architectural technology in response to the climate, and the role of human regulation is also inseparable. As shown in table 1, the initiative of human intervention is a support and response to the regulation of architectural technology, but it also gives an adverse effect. Only when people's regulation coordinates with the that of architectural technology can we better promote the development of architectural technology in climate adaption.

| Architectural technology       | Human intervention                                    |
|-------------------------------|-------------------------------------------------------|
| Step 1 Improve the design     | Raising the awareness of energy conservation          |
| Step 2 Preferential method: passive architectural technology | Avoiding technology abuse, alternatively choosing applicable methods |
| Step 3 Supplementary method: active architectural technology | Introducing renewable-energy-related technologies to meet demands |
| Step 4 Selective method: high energy-consumption active architectural technology | Bearing with conception of moderate comfortable, keeping a balance among active architectural affordability diversity and comfort |

Above all mentioned, based on the principle of climate adaptation, the development of architectural technology in rural areas should select the most appropriate technical roadmap for regulation and integration and consider factors such as local climate conditions, construction costs, construction capabilities, and functioning requirements, making the method simple, economic, and environmentally friendly to take. People need to take a proactive attitude to cope with complex climate change and achieve sustainable development of architectural technology.

5. Conclusion

Humans use architectural technology to respond to nature. While the climate factors are relatively stable in a region, it is necessary to study the development of architectural technology from the perspective of climate adaption. Previous researches focus more on creating a precise and comfortable artificial environment, including using mechanical equipment to regulate the indoor environment, while ignoring the necessity of harmonious coexistence between artificial environment and natural environment.

Rural areas, limited by inadequate construction capacity, economic development and human consciousness, need to be discussed under the climate adaptation in contemporary development of architectural technology. This paper saw the climate response as a trigger. Firstly, the definition of climate adaptation of architectural technology is explained. It is also pointed out that the regulation of
architectural technology and the user's regulation should be equally important, which was rarely talked about in the previous research. Secondly, the operating mechanism of climate adaptation in architectural technology is proposed, that the introducing mechanism and the defending mechanism can be freely switched between each other in order to better provide a moderately comfortable artificial environment. Finally, the technical roadmap suitable for rural areas is proposed featuring fundamental optimization, preferential selection, reasonable implement, and efficient use. This package of methods will be more open and feasible, and keep in line with the sustainable development goals, compared with the material-centered technology.

References

[1] Zhai Z J and Previtali J M 2010 Ancient vernacular architecture: characteristics categorization and energy performance evaluation Energ. Archit. 42 357-65
[2] Song Y H, Wang J L and Zhu N 2013 Pondering over the passive design strategy for native green buildings of China Archit. J. 07 94-9
[3] Bodach S, Wang L and Hamhaber J 2014 Climate responsive architectural design strategies of vernacular architecture in Nepal Energ. Archit. 81 227–42
[4] Hao S M and Song Y H 2016 An analysis of the concepts of climate response under various architectural systems Archit. J. 09 102-7
[5] Eriksen S 2009 Sustainable adaptation: Emphasising local and global equity and environmental integrity IHDP Update 02 40-4
[6] Cui S H, Li X Q, Li Y, Li F Y and Huang H 2011 Review on adaptation in the perspective of global change Prog. Geog. 09 1088-98
[7] Zhang J C, Zhang T T and Wu H J 2015 Study on fiber-reinforced aerogel board external thermal insulation system structure Constr. Tech. 16 60-3
[8] Huang S E, Wang Z P and Ding Y 2018 Scheme design and performance analysis of double-board composite thermal insulation material for roof New Build. Mater. 02 66-9
[9] Song M J, Mao N, Xu Y J and Deng S M 2019 Challenged in, and the development of, building energy saving techniques, illustrated with the example of an air source heat pump Therm. Sci. Eng. 10 337-56
[10] Li X, Lin A, Young C H, Dai Y J and Wang C H 2019 Energetic and economic evaluation of brid solar energy systems in a residential net-zero energy building Appl. Energ. 254 1-20
[11] Li L, Qu M and Peng S 2017 Performance evaluation of building integrated solar thermal shading system: active solar energy usage Renew. Energ. 109 576-85
[12] Wang J Y 2018 Establishment of a technology for energy efficiency evaluation based on green building Build. Energ. Effic. 12 32-5
[13] Yu J and Zhang L 2016 Study on energy conservation evaluation and energy efficiency identification of residential building Archit. Tech. 12 1124-26
[14] Jin Y and Hu J H 2015 Contribution of energy-saving technology based on energy efficiency evaluation for residential buildings in hot summer and cold winter area to energy-saving rate Build. Energ. Effic.08 80-4
[15] Lee K H, Han D W and Lim H J 1996 Passive design principles and techniques for folk houses in Cheju Island and Ullung Island of Korea Energ. Build. 23 207-16
[16] Li L X 2018 Thermodynamic architectural Prototype-Formal principles of environmental mediation, Time & Archit.03 36-41
[17] Nguyen A T, Tran Q B, Tran D Q, Tran D Q and Reiter S 2011 An investigation on climate responsive design strategies of vernacular housing in Vietnam Archit. Environ. 46 2088-106
[18] Xiao Y Q 2016 Thinking the essential Problems of climate-adaptive design of green building in subtropical regions World Archit.06 34-7,127
[19] Franca T 2013 Performance based envelopes: a theory of spatialized skins and the emergence of the integrated design professional build. 03 689-712
[20] Zhu Y X 2015 Thermal comfort, what level is adequate World Archit.07 35-7
[21] Mao P, Li J, Tan Y T, Qi J and Xiong L L 2018 Regional suitability of climate-responsive technologies for buildings based on expert knowledge: a China study J. Clean. Prod. 204 158-68

[22] Hooff T V, Blocken B, Timmermans H J P and Hensen J L M 2016 Analysis of the predicted effect of passive climate adaptation measures on energy demand for cooling and heating in a residential building Energ. 94 811-20

[23] Fatima H, Farouk F and Pascal H B 2018 Passive design optimization of low energy buildings in different climates Energ. 165 591-613

[24] Xia B and Li Xin 2019 Analysis and comparison on the potential of low-carbon architectural design strategies Sustain. Comput.: Inform. Syst. 21 204-11

[25] Min T Y and Zhang T 2016 Study on the climate adaptability of architectural interface opening in Suzhou’s regional residences Procedia Eng. 169 108-16

[26] Michael A, Gregoriou S and Kalogirou S 2018 Environmental assessment of an integrated adaptive system for the improvement of indoor visual comfort of existing buildings Renew Energ. 115 620-33

[27] Constantinos V, Aimilios M, Andreas S and Soteris K 2018 Improvement of passive behaviour of existing buildings though the integration of active solar energy systems Energ. 163 1178-92

[28] Ding Y, Lian D Q and Li B Z 2011 Potential analysis of architectural application of solar energy resource in Chongqing J. CQ Univ.02 165-70