

# Study on Vernacular Architecture in GuanZhong Region in Complex Ecological Adaptation System

Qiong Wang<sup>1</sup>, Jingyuan Zhao<sup>1,\*</sup> and Xiaodong Wu<sup>2,3</sup>

<sup>1</sup> School of Architecture, Chang'an University, Xi'an, 710061, China

<sup>2</sup> School of Architecture, Xi'an University of Architecture & Technology, Xi'an, 710055, China

<sup>3</sup> Xi'an Academy of Fine Arts, Xi'an, 710065, China

\* Correspondence: zjyqt@163.com

**Abstract:** The development and evolution of traditional vernacular architecture is carried out in a complex dynamic open system. Traditional vernacular architecture has obvious regional characteristics, but even in the same or similar areas, the buildings will still show non-obvious different characteristics. This paper studies the characteristics of traditional vernacular architecture in the eastern, central and western the GuanZhong Regions of ShaanXi Province. Based on investigation and field test, it summarizes that the building characteristics of vernacular architecture in the complex ecological adaptation system are formed by multiple factors. The settlement relationship of folk houses is similar based on the typical blood relationship and geographical correlation, and the architectural spatial pattern is diverse depending on production and lifestyle. The building structure and building features are designed to adapt to the unique ecological and natural environment of the building site. Architectural aesthetics and architectural culture, along with sociological communication, have two modes, namely gradual change and mutation, which influence the construction of vernacular architecture. In the research, the scientific construction technology of traditional vernacular architecture is extracted and summarized to provide support for contemporary reuse.

**Keywords:** GuanZhong region; vernacular architecture; complexity; adaptability; environmental physical characteristics

## 1. Introduction

The development and evolution of traditional folk houses have typical regional characteristics. With the rapid development of economy, the improvement of agricultural economic model has brought about the improvement of rural living standards. Rural dwellings have been or are undergoing a lot of renovation and construction. Many architectural phenomena have brought about new research thinking. In many ways, newly built rural dwellings are different from traditional rural buildings. Architectural functions refer more to

urban living function mode. The structural type of the building changes with the use of new building materials. Comprehensive use of cement, ceramic tile, hollow brick and large area of glass and other industrial products. In terms of architectural culture, the historical and cultural authenticity of traditional vernacular architecture gradually disappears. The original spatial characteristics and identifiability of villages are reduced. However, a large number of similar building structures and building shapes are not ideal for the adaptability of the local environment. Survey data show that many new vernacular buildings need more energy consumption from construction to use.

In the face of such a phenomenon, it is particularly important to summarize the scientific content and reasons of its connotation by studying the practical experience gained by ancestors in the process of continuous trial and error in the use of traditional vernacular architecture for thousands of years. These scientific construction experiences with typical regional characteristics and their suitability under the influence of contemporary complex ecological and social demand factors have positive significance for the construction of new vernacular buildings.

Predecessors' the systematic study of the traditional dwellings conducted a lot of work, Liu Dunzhen research a large number of Chinese local-style dwelling houses with main characteristics, from the aspects of literature study and field research[1], Sun Dazhang Studies the typology of Chinese local-style dwelling houses[2], and get the detailed interpretation of the different regional residential and rural settlements space layout, building the structure characteristics of different areas of building types, such as materials adopted by the detailed content. The series of Chinese folk houses of China architecture publishing house also gives a comprehensive and complete description of folk houses. For the folk houses in the western region, Professor Wang Jun's northwest folk houses [3] classifies and analyzes the main types, site selection elements and building characteristics of folk houses in GuanZhong region. Vernacular architecture is more based on adapting to the local

ecological environment and providing comfortable living space for residents in the simplest and most optimized way. With the development of economy, the new vernacular architecture supported by traditional construction technology is a trend. Academician Liu Jiaping’s team has carried out a large number of tests and attempts to new-type rural buildings in western China [4], [5] and [6]. Through a large number of cases depth analysis, and proposed that the regional architecture of the green scientific system is the mapping of social life and ecological environment.

Based on the dissipative theory (IlyaPrigogine,1977) and synergetic theory (Haken Herman,1976), the construction and innovation process of vernacular architecture is analyzed. Its characteristics are carried out under the typical open information and technology system. Under the influence of the local clan and blood relationship, the geoculture is the main control factor for rural building. Local vernacular architecture maintains a limited exchange of architectural patterns, architectural information and building materials from outside region .The whole building system has been in the progressive development process [7].

The regional characteristics of vernacular architecture are constantly adjusted and changed in the process of adapting to the climate, the changes of social economy and the development of productivity. Similar to Haken Hermana’s description of self-organization, it is part of a complex system and contains key elements such as adaptability and self-reconstruction. It maintains a process from disorder to order, from simple level to complex level [8], [9], [10].The building process of rural architecture is a type of non-standard Architectures, which keeps the one-sided and selective development. However, in the process of development, the influencing factors are diversified, heterogeneous and uncertain [11] and [12].

Scholars have made a lot of theoretical and practical achievements in the study of traditional vernacular architecture.In addition, the development process of traditional architecture in the medium and long term is linear. Under strong external disturbance factors such as

new construction technology, new building materials, new architectural aesthetics and migration of population, nonlinear leap-forward development changes will also occur.However, there are few researches on the reasons for the differences in the construction patterns of vernacular buildings in the similar areas.By sorting out the regional characteristics of traditional vernacular architecture, the author intends to analyze whether rural architecture in the same region still has its own nonlinear development jump points, and how the formation factors of similarities and differences affect the adaptability of rural architecture construction technology. This paper studies the traditional vernacular architecture distributed in the eastern, central and western the GuanZhong Regions of ShaanXi Province. The correlation between use function and building-form, interaction between user and room-space, dynamic evolution of room structure and indoor device. The traditional construction culture with regional characteristics are analyzed of topography, climate, transportation, local material resources, key building technologies, and basic economic types engaged by local populations. It is intended to summarize the evolution elements of traditional vernacular architecture under the control of the theory of complexity science.

**2. Technical route and research method**

The study in this paper starts with the suitability technology of traditional vernacular architecture. Firstly, ArcGis software is used to analyze and study the natural geographical characteristics of regional locations and the main distribution of existing traditional vernacular architecture. Then, through sorting out the research results, the paper analyzes the physical characteristics such as ecological environment, historical, humanistic and social characteristics, and construction technology from three aspects. Twelve control elements are: terrain and climate, type of dwellings, building structure, decoration, construction materials, etc.Different aspects of the characteristics and main content, so as to determine the mutual influence degree, as well as the impact on building construction.

**Table 1.** Research contents and characteristics of traditional vernacular architecture

Research content		Environmental characteristics
Classification	Elements	
Physical characteristics such as ecological environment	Topography and climate, water system, solar radiation	The objective existence formed in the long-term development
Historical, humanistic and social features	Production development, characteristics of economic efficiency, social structure, primitive culture, creativity and cultural development,	Long-term cultural accumulation + floating population and floating jobs bring new information and experience
Construction technology	Building type, structure, material, decoration	Traditional experience summarization + exchange of techniques and materials

Vernacular architecture belongs to the category of residence in contemporary architecture. In the relationship between people and rural bilding, people are the users. As a dynamic and accompanying life, creating dynamic needs such as technology, aesthetics and people moving out and in changes the content of the residence

accordingly.Traditional residential buildings are built with traditional technology, traditional residential hierarchy system and traditional materials.

**3. Research contents**

3.1 Distribution characteristics of main landforms and vernacular buildings in the GuanZhong Region

Geography divides Shaanxi province from south to north into three areas, namely, QinBa Mountain area, HanShui basin, GuanZhong basin and loess plateau area. This paper mainly studies GuanZhong basin. This area starts from TongGuan in the east and reaches BaoJi region gorge in the west. QinLing Mountains south of the north foot, north BeiShan Mountains. WeiHei river system runs through it from east to west. The average elevation of GuanZhong basin is 520 meters. A large number of loess tableland of different sizes are distributed.

ArcGis was used to analyze the east-west WeiHei river basin at the northern foot of the qinling mountains, which is divided into the QinLing Mountains (Rocky Mountains) and beishan mountains (loess plateau). Rivers running through the two mountains converge into the wei river

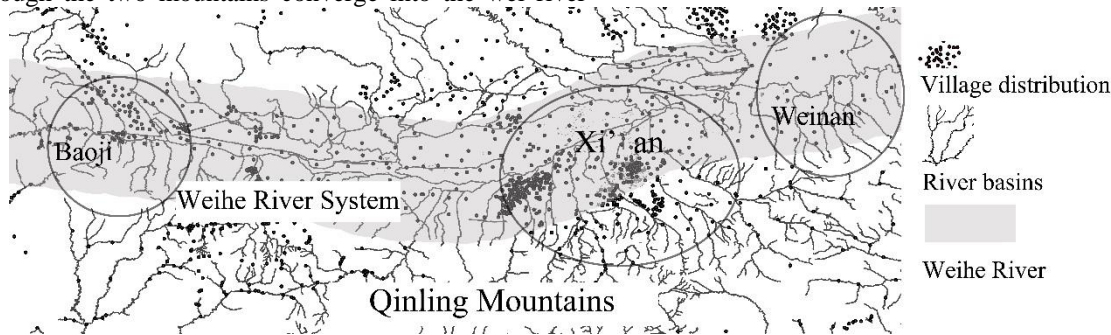


Figure 1. Distribution of major settlements around GuanZhong wei river basin

(Drawing source:Geographical Information Monitoring Cloud Platform, <http://www.dsac.cn/dataproduct/Detail/302711>, Download and add information drawing by the author)

According to the classification of building materials of traditional vernacular architecture in the GuanZhong Region, there are basically raw soil structure building, civil structure building, brick, stone and wood composite structure building. The influence of geological disaster is the key factor in rural architecture construction. Therefore, the beam frame system of civil structure mostly adopts the structure system of the back eave wall, the two gables closed on three sides and the front eave open on one side. In the western area close to BaoJi region, it is a typical form of GuanLong (GuanShan-LongShan system). This area is close to GanSu Province, and the ecological environment and

system. From the perspective of the distribution of traditional vernacular architecture settlement, the area adjacent to water system has a large distribution density. Settlements in the BeiShan area in the west are distributed in a step-like manner along the loess tableland. Some buildings in the middle reaches of the WeiHei river are mostly family units with raw soil courtyard, and cluster village settlements are formed through the roadway. It is characterized by complete settlement structure and large spatial scale. In the eastern region near the intersection of WeiHei river and Yellow River, mainly irrigated agricultural clusters are distributed in large Numbers along both sides of the river, and the density is more sparse than that in the central region. In the northern HuangLongShan region of the eastern region, there are a large number of hills with impacted soil along the Yellow River.

cultural language are similar. Most vernacular buildings are courtyards with cave caves and tiled houses with rammed earth structure. In the central area of XianYang and around xi 'an, the pit cave courtyard (Dikeng) and the civil structure courtyard in the form of narrow space, with adobe masonry enclosure. In the east of the GuanZhong Region, there are the most diverse architectural forms. Which region close to the junction area of ShaanXi and ShanXi Province, underground pit courtyard, baoshan cave cave or brick kiln with stone piled up and covered by loess, and narrow courtyard with two-story civil structure similar to Shanxi style.(Figure 2)

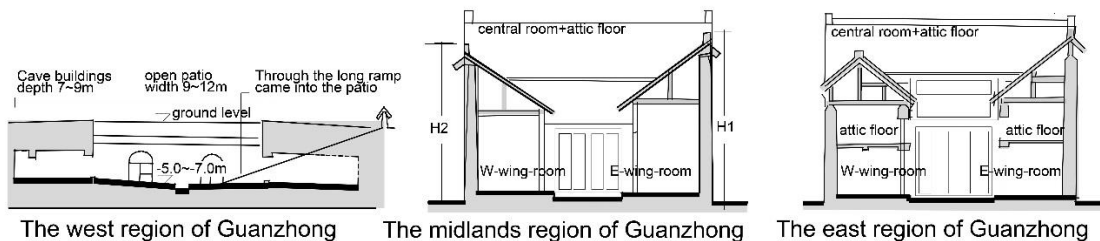


Figure 2. Profile of the Typical traditional residential courtyard Drawing source: author's drawing

3.2 agricultural economy and building characteristics of different regions

From the perspective of traditional agricultural economy, the GuanZhong Region is mainly characterized

by agricultural economy. In the west, it is close to GanSu Province, and there are some areas mainly focused on animal husbandry. There are medicinal herbs and economic crops in the mountainous areas of northeast China. The main types of rural settlements are banding and cluster. The architectural space functions of rural buildings are mainly to meet the needs of agricultural tools storage, grain storage, drying and so on.

In the central area of GuanZhong, vernacular buildings are mostly in the form of courtyards, and the main houses are set as far as possible in the north-south direction. The courtyards are in the form of three-heyuan, quadrangle and compound courtyards, etc. In some areas, one-character and curved shapes also appear. Most of the courtyards are built in the land area of 12 meters by 26 meters. In a typical GuanZhong courtyard, the ratio of length to width is large, which is called narrow courtyard. In the traditional GuanZhong narrow courtyard, the courtyard is the center. The main house at the end of the courtyard adopts the hard mountain roof with three openings and five purlins, covering black or blue tiles. Side rooms are not set on both sides of the main house. Opposite wing-rooms are set on both sides of the courtyard. The single-slope roof that slopes inward adopts the lifting beam type semi-roof frame and hard gable structure. One end of the beam is supported on a hidden column inside the rammed earth layer of the back wall. In a village with high building density, the back wall of the wing room of a family is close to the back wall of the wing room of the neighboring courtyard, and there is no path between the houses. The shape of the wing is high in the east and low in the west. The traditional living culture requires that the east wing is mostly occupied by the eldest son of the family. The distance between the eaves of the two sides of the courtyard is controlled within 2 meters. On the opposite side of the narrow courtyard and the main hall, there is an inverted room with three openings, and a courtyard door is set in the southeast one. According to different levels and economic conditions, the shape and structure of the courtyard door are quite different. The main material of the building is civil union, the area with better economy USES besmear black brick wall, but most still adobe wall or rammed earth wall, green tile drips eaves are set on the top of the wall, avoid wall body to rain damage, the metope of adobe wall and rammed earth wall USES grass mud after polishing, brush white lime or natural color.

The northwest edge of GuanZhong is close to Xiaoguan area and longshan area. Due to the convenience of landform, the traditional folk houses are mainly cave caves dug by the cliff of backer or ditch. There are single and porous types. Courtyards are set up in front of the kiln, with separate courtyard doors or combined with wing buildings to form triheyuan or other types of courtyards different from each other according to the topography. In the east of BaoJi region valley, close to chunhua, yongshou and gan counties of weibeï plain, there are few mountains and gullies, and only some mountains in the north. Local residents built

caves without mountains to rely on, so most of the flat loess tableland in the manual or mechanical excavation of the depth of about 5 meters rectangular pit, excavation hole in the pit wall. The total number of four pit walls and kiln holes in the underground courtyard is usually eight. The pit bottom is dressed as a courtyard. In the low-lying part of the courtyard, rainwater is collected and local plants are planted to achieve the ecological landscape effect. A continuous ramp was excavated at the side edge of the pit wall to the ground level.

The eastern part of GuanZhong is close to shanxi and henan provinces. WeiHei river flows into the Yellow River, surrounded by huashan and huanglongshan mountains. Geomorphology includes the alluvial plain area of the river and the impact gully area of the mountain area. In the history of development, this region has developed transportation, and occupies a high strategic position in history. The settlements were built on cliffs on three sides or on platforms facing the water, and rammed earth cities on all sides with small gates. The traditional vernacular buildings in this area are mostly in the form of courtyards. The main hall of the courtyard is a civil hall, and the front of the house is overhanging with eaves. In order to meet the lighting and beauty, the front of the hall is latticed with latticed doors and Windows. The wing houses are mostly in the form of occlusion kiln. The building materials are made of adobe or local stone. The side walls of both sides are divided into two parts, and the arch is made by overlaying. Have monolayer to bask in commissary to use for air, also build build to continue wooden structure 2. In this area, there are also residential buildings similar to the narrow courtyard style in GuanZhong, but the height of the buildings is higher than that in the central area of GuanZhong. The building is divided into upper and lower floors by means of wooden boards, with an additional attic floor. The lower floor is occupied by residents, and the upper floor is used for storage. The upper floor is also characterized by large-sized branch and pick Windows.

#### **4. Factors influencing the diversity of vernacular architecture in the region**

##### **4.1 historical development factors**

The main area of GuanZhong is close to the yongzhou area described in yugong. Due to the construction of large irrigation systems such as the zheng canal by the state of qin in the warring states period, the area has been called "GuanZhong fertile field", "tianfu land", "land and sea" and "jiaobuu" since ancient times. From the qin dynasty to modern times, the GuanZhong Region had many prefectures and counties successively, including several large population migrations. During the six kingdoms of qin, the rich gentry and nobles moved to xianyang bank on the north bank of wei river for each victory. During the sui and tang dynasties, a huge urban cluster centered on chang 'an was formed. During the period of the northern and southern dynasties and the sixteen kingdoms, a large number of people from various ethnic groups moved in. The cultural background and living customs of the

people living mainly in the guest house are different, and there are obvious differences in architectural requirements and decoration expressions. Different languages in the east and west of GuanZhong region bring different cultural contexts. It can still be seen that GuanZhong region is divided into two psychological regions, the east and the west, by different traditional folk customs.

4.2 Topographic and geomorphic environmental factors

According to the topographic data of GuanZhong, from the WeiHei river in the east to the Yellow River, the altitude is about 400 meters, to the longshan mountain area in the west, the altitude is over 2,000 meters, and the whole the GuanZhong Region spans 325~800 meters. GuanZhong occupies about 23% of the province's land area and 60% of its population. In terms of land use types, the GuanZhong Region is divided into alpine forest belt (west of BaoJi region), hilly dry land (BaoJi region area), plain hilly land (yangling, xianyang, xi'an, weinan, hancheng) and hilly dry land (north of hancheng area) from west to east. In urban construction, the contradiction between agricultural and construction land supply and demand always exists. The eastern part of GuanZhong basin is on the edge of shanxi vein in luliang, where huanglongshan area contains moderately dangerous geological development area, which is also a famous coal producing area in the GuanZhong Region, with less arable land for agricultural production. Ancient people in previous dynasties used flat land as agricultural land, and this area is the main channel from the eastern part of GuanZhong to northern ShaanXi style. Wars were frequent in previous dynasties at the Jin-Shaanxi crossing, so dwellings were mostly selected on the earth slope or steep cliff. In terms of land use characteristics, GuanZhong basin is mainly cultivated land with dense distribution of continuous urban clusters. Most of these

cities have appeared since ancient times. The fertile and flat land of WeiHei plain and loess tableland are suitable for large agricultural production. Therefore, a large number of people live together by blood or clan relationships, and the mostly names of villages are X jia cun, X jia zhuang, X jia bao and X jia zhai, (the words of Chinese pronunciation of cun, Zhuang, bao, zhai mean are villages). The styles of buildings all maintain strong self-similarity.

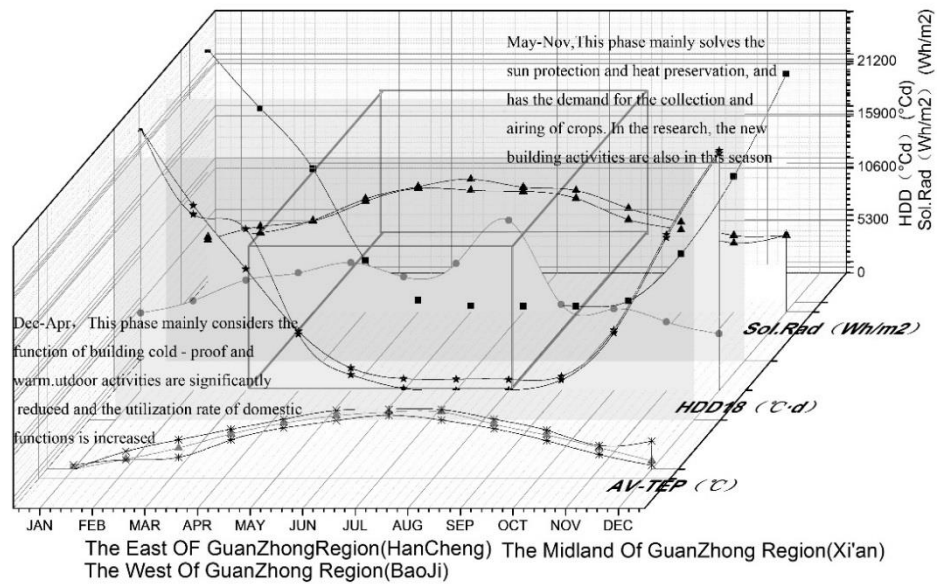
4.3 Climate adaptation factors

The narrow constructable area in GuanZhong is about 100 kilometers from north to south and 350 kilometers from east to west. Weinan region in eastern of Guanzhong, where is a Warm temperate continental monsoon type subhumid climate, the central part of the Xi'an region is warm temperate subhumid continental monsoon climate, BaoJi region is in the west of the warm temperate continental Monsoon climate. (Table 2), in the construction of zoning climate in the GuanZhong Region belongs to the cold climate, leading the direction of the wind for north east, the whole building warm in winter and summer in the GuanZhong regions both heat insulation, the layout of the yard and construction with north and south to decorate, when there is a relationship of roadway and cannot directly from the south into the narrow house, by the yard beside the roadway into direct guide way, set up a door or of north and south to guarantee the rooms. The BeiShan region near the west and the north of WeiHei river, due to the influence of cold air invasion from the northern shaanxi plateau to the south, the rammed earth layer on the wall on the north side of the building is thicker, with a thickness of up to 400mm, in order to meet the requirements of heat preservation. The north wall of the main room is thick and no windows or small window. All the windows facing the courtyard to facilitate ventilation in summer.

**Table 2.** Ecological climate characteristics of traditional vernacular architecture in GuanZhong region

	<b>West region of GuanZhong</b>	<b>Midlands region of GuanZhong</b>	<b>East region of GuanZhong</b>
C.A	BaoJi region, Yongshou, Qishan	Xi'an, Xianyang, Weinan	Hancheng
S.T	Rammed earth and cave, Wood structure	Brick-wood structure, Rammed earth and wood structure	Brick-wood structure, stone-wood structure Rammed earth and wood structure
M.T	Wood, earth, tile	Wood, earth, tile	Wood, earth, stone, tile
L.F	Mountains, rivers and and earth hilly	North of Qinling mountains, WeiHei river plain, dense river network, mostly loess hills	western Yellow river ,with mountains, earth plateau
C.T	Warm temperate monsoon climate, Most parts of the region's annual average temperature of 11 ~ 13 ° C , the coldest month average temperature is -4 ° C ~ -1 ° C, the average annual rainfall of 550 ~ 750 mm.	Warm temperate monsoon climate, The annual average temperature of 13.0 ° C ~ 13.7 ° C, the coldest - -1.2 ° C ~ 0.0 ° C, annual average precipitation is 522.4 ~ 719.5 mm, annual sunshine hours 1646.1 ~ 2114.9 hours	Continental monsoon climate, annual average temperature 13.5 ° C, the average annual rainfall 559.7 mm, sunshine 2436 hours

C. S



#### Explanation of symbols:

C.A: characteristic areas of a traditional building type according to administrative division

S.T: Type of building structure

M.T: various building materials in different types of projects

L.F: landform, the main topographic and geomorphologic features of the area

C.T: The main climatic features of the region include climatic zoning, annual temperature and precipitation

C.S: Analysis of major meteorological data in the region

AV-TEP: average Temperature.

HDD18: Heating Degree Day

Sol Rad: daily Solar Radiation (Wh/m<sup>2</sup>)

## 5. Conclusions and discussions

In this article, through analysis on specific geographic space within the category of the GuanZhong region construction characteristics of traditional vernacular buildings, summarizes in the category of large regional architecture for settlement by the local geographic landscape environment, climate characteristics, social structure, economic development and cultural roots of different, still can appear very much the same characteristics, and these differences, it is each kind of vernacular buildings for its living environment adaptability measures taken. The settlement relationship of vernacular architecture is similar based on the typical blood relationship and geographical correlation, and the architectural spatial pattern depends on the production and lifestyle with diversity. The structure and features of building are designed to adapt to the unique ecological and natural environment of the building site.

The construction process of traditional vernacular architecture is different from today's engineering activities, which is the mutual assistance between the same clan and the neighborhood. Under the guidance of local technical artisans, the buildings in this region have obvious stability in the longitudinal dimension of time. In the horizontal dimension between regions, the mutual connection of technology, culture and economy provides the constant evolution and renewal impetus of vernacular architecture. With the promotion of urbanization, the tension of urban development and the broader influence

of the city on population attraction make more advanced technology and production economic mode involved in the construction process of traditional vernacular architecture, thus forming two ways of expression of gradual and abrupt construction process. However, the end-user is still the local residents. Their adaptation to the environment and demand for building functions are explained by multi-factor complex adaptability under the synergetic effect to carry out the contemporary adaptive regeneration of traditional residential technology.

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