sustainability

MDPI

Article

Opportunities to Improve Sustainable Environmental Design of Dwellings in Rural Southwest China

Adrian Pitts *, Yun Gao and Vinh Tien Le

Centre for Urban Design, Architecture and Sustainability, Department of Architecture and 3D Design, University of Huddersfield, Huddersfield HD1 3DH, UK; y.gao@hud.ac.uk (Y.G.); vinh.le@hud.ac.uk (V.T.L.)
* Correspondence: a.pitts@hud.ac.uk; Tel.: +44-1484-473288

Received: 29 July 2019; Accepted: 1 October 2019; Published: 6 October 2019

check for updates

Abstract: This paper addresses the need, established following consultation with stakeholders, for more detailed environmental design guidance to support construction of more sustainable and comfortable rural dwellings in Southwest China. Despite increasing focus on sustainable design in urban developments in China, there are considerable gaps in research and information dissemination for sustainable building in more diverse rural areas. Multiple methods of investigation and analysis have been utilized. Contextual research was undertaken in relation to location, ethnic group, site/location, and building construction options. Visits to typical villages allowed discussions with stakeholders and the gathering of data on existing and new dwelling types and their surroundings. This led to the conclusion that there is insufficient attention paid in understanding residents' knowledge and skills related to design options; further specific accessible guidance is needed. Resulting from this, quantitative analyses using climate data for 46 locations in Southwest China were used to determine the value of design opportunities to create comfortable internal environments. A need for a more detailed level of guidance that can be used by the stakeholders is presented, and 15 exemplar locations were studied in parametric fashion for typical dwelling design configurations. Outcomes indicated the value of location-specific design optimization; something now recommended for all new/redeveloped dwellings. These findings impact across a wide geographical area and could benefit daily living conditions across many rural settlements in China.

Keywords: dwellings; sustainability; comfort; climate sensitive design; rural revitalization; China

1. Introduction

1.1. Background

The introduction is split into three distinct sections: the first deals with the general description of the national context and provides a definition of the research questions and purpose; the second provides a specific and focused review of published research and other documents; the third summarizes the research gap identified and research required.

The context for this research is rooted in the major changes to the buildings and landscape of rural China currently taking place; something which is now happening at a level and scale to rival previous changes to the Chinese urban environment over the last 30 years. The evident worldwide need for efficient use of resources and minimization of carbon emissions means Chinese dwelling design needs to adapt to these requirements and must incorporate better optimization for environmental comfort provision. The location of development in rural areas also means there are substantial consequent impacts on the landscape, particularly because of changes in the use of agricultural land around village dwellings. The specific emphasis of this paper reflects research and also dissemination activities with which the authors are involved through a stakeholder research network [1], and the requirements for informed change that they have identified. The following paragraphs give the background history that is needed to understand the flow of research before the activities of this paper are explained and findings revealed.

China is a country well-known for its fast developing urban economy [2], but the rural areas have not made the same economic progress by comparison; at the same time the physical fabric of rural villages has often deteriorated and has been accompanied by changes to the social structure. However, 2005 onward there was a significant government policy shift, first included in the 11th 5-Year Plan, the major component of which was assigned the title of "Building a New Socialist Countryside." It was widely reported at the time and subsequently [3], it has been the focus of much development as well as research and enquiry [4]. This national policy emphasizes on the rejuvenation and revitalization of rural/countryside areas as a part of spreading the benefits of economic development more widely across the country, and continuance of the approach was recently reaffirmed [5]. The policy has had some significant impacts linked to land use and redevelopment which is expected to be a long-term process [6]. A number of projects have been associated with this issue and were broadly summarized in a Chinese Ministry level report prepared for UN Habitat III Programme [7]. This report not only gave a historic review of changes in rural areas over several decades, it also indicated the contemporary importance of villages and rural areas from a cultural and sustainability perspective. In this context the role of landscape and landscape design is naturally incorporated into consideration of village infrastructure and layout, though the predominant thrust of change needs to consider how to make better rural dwellings. One of the other outcomes of this research is a design guide providing information and exemplars which can be used by individuals as well as practitioners and developers in rural areas.

Taking a regional view, Southwest China is unique in its history and in its cultural and natural environment: there are more than 30 ethnic groups in the region; each group with its own language, architecture, and distinctive dress. Part of the evolution of the national policy included identification of traditional (often ethnically focused) villages with the aim of developing means to protect and revive them and their associated communities [8]. The province with the largest number of designated traditional villages was Yunnan. The authors here concur with development policies which encourage such villages not simply to be preserved, but also to offer routes for economic expansion and for cultural industries development. This could make use of traditional craft and design skills linked to increased tourism; an idea reinforced by discussions about how to achieve rural village sustainability in the Chinese press [9]. This also aligns with the government policies which have increasingly put more emphasis on the sustainability of rural development and on opening new routes for transport and trade as exemplified by the "belt and road" approach. The climate and topography of Southwest China varies with weather conditions ranging from extreme cold to tropical hot-humid and altitudes from sea level to 4000 m.

The rural population in China amounts to approximately 576 million people who live predominantly in a village structured environment (be they "natural" villages or "administrative" villages). Though urbanization is taking place, there will continue to be a very large number of rural residents and more than that, the rural economy is needed to support urban areas with food and other resources. Rural redevelopment is therefore not only concerned with renovation of the fabric of dwellings and other buildings but also for supporting economic revitalization more generally. However, dwelling design and construction can be used as an indicator of change occurring and also of better understanding within communities; and as with urban areas of China, the construction industry can drive other economic benefits.

In Southwest China the range of ethnic groups to be found there means there is an extra dimension to be included in analyses as attitudes of village residents can vary as well as their requirements. Taken together with the aforementioned issues, these factors indicated the need for studies specific to SW China; studies into contemporary village development and also of attitudes and perceptions, not just among village residents but also among those likely to be involved in future revitalization.

The purpose of the research has the following narrative: First, it was necessary to research the circumstances of rural/village life beyond the mere physical attributes of the buildings in order to understand who designed and constructed them, how the construction took place, and what factors were being taken into account in the local decision-making process. Second it was necessary to appreciate the role of "bottom-up" processes/understanding since many rural dwellings are produced not by large-scale developers but by local residents building or renovating dwellings for themselves or their families and neighbors. Third, the intersection of climate and building design needed to be investigated in an organized fashion with qualitative and more importantly quantitative analysis of the outcomes of design/construction choices, and with opportunities appropriate to the location emphasized.

In order to provide geographical context, a map of China showing the provinces of interest in the research is shown in Figure 1.

Figure 1. Map of China showing the southwestern provinces.

1.2. Research Review

In recent years there has been an increase in the numbers of research projects and research outputs concerned with rural revitalization. Some of these projects helped to establish the historic, economic and cultural reasons for the types of development observed, which were initially based more on survival than development, for example as discussed by Zhou and Feng in [10]. Both internally and externally funded research such as the European Union "SUCCESS" project [11] have helped to focus attention and to identify some important themes, and particularly to move the debate about sustainability in China away from solely urban locations. This increased emphasis on rural sustainability has partly focused on how the vernacular aspects of village design and layout, in provinces such as Yunnan, can be understood and developed [12,13].

Several research groups have been investigating the specific circumstances in particular villages which has helped inform the direction of the research described in this paper, especially research on villages that are located in, or close to, Yunnan (the most southwestern of China's provinces). Xiaoyu and Beisi discussed changes in dwelling design and the transformation of the built environment in Xiaqiao Village [14], but this did not produce more generally applicable guidance. Dong and Jin [15] focused on the area now known as Shangri-La, and noted some difficulties in the understanding of cultural needs and problems when modern "urban style" dwellings are introduced. The introduction of new design paradigms and the variation from older style traditional dwellings is a source of contrasts; some research supporting the continuance and enhancement of tradition, other considering the socio-economic forces pushing toward adoption of new styles.

In order to help inform stakeholders of differing benefits and costs, a variety of decision support tools and assessment systems can be used. Environmental assessment tools have been developed in many countries over the past 20–30 years, but none of the most well-known can be applied easily in a rural China setting. Some good attempts have however been made to derive tools and methods based on specific circumstances in particular areas and which are related to SW China, for instance research of Wan and Ng [16,17], but this indicates a wider issue that must be considered—applicability in the regional context. Broader analyses have also been undertaken including for instance the more specific links to landscape [18], which also have greater relevance in rural locations. In this, some of the basic broadly set categories described are based on those in the UK's Building Research Establishment Environmental Assessment Method (BREEAM) [19].

Energy and environmental calculation techniques and assessments have been applied and published by several research groups (such as Evans and colleagues [20]), with many focused on energy consumption (this being a significant issue for resource conservation and pollution control). Most energy calculation methods have historically been associated with urban building types, but not exclusively so. He and colleagues [21] proposed a new theoretical approach for assessing rural building energy use with the aim to impact upon policy-making and assist decision-makers. Shan et al. [22] described surveys of energy use and environmental conditions for rural area examples located across China, though with a limited number of studies in the Southwest, and none in Yunnan.

There has also been research to help identify the building design features which are most closely linked to factors which determine the internal environmental conditions. Gou et al. [23], although working outside the region of SW China, identified which climate responsive strategies could be used to modify internal climate. This theme has been further developed by Pitts [24] in relation to Yunnan in the first stage of a design methodology development. These aspects are taken to a further level of analysis later in this paper where the results of climate design studies for locations across Southwest China are presented and discussed.

There are strong arguments for developing research on the sustainability of villages, such as expounded by Wang and Yang [12]. Some researchers such as Zhao et al. have however expressed concerns related to how social acceptance and public understanding of green buildings need to advance [25] and other research has shown how dwelling occupants might interpret their needs in terms of "green building" design and products post-completion of the main construction phase [26]. Gao [27] also found that there were differences between top-down and bottom-up approaches when dealing with rural village communities with specific ethnic groups; and that in some villages certain family/clan groups took a leading role in supporting development with their co-inhabitants.

The local government in Yunnan province has committed to connect all the villagers with road networks and provide better infrastructure; these features being designed and constructed by professionals. However, villagers' houses have frequently been constructed by themselves or by "amateur" construction teams with minimal checks on design for safety and performance. In the past, the shared beliefs and knowledge of building between builders and householders allowed flexible but coherent changes (for example in Dai traditional timber houses) as part of the ecological system. After new materials such as bricks and concrete began to be used for construction, the shared knowledge of building between builders and householders changed. The lack of knowledge of new materials and of understanding of the associated technology by villagers, not only led to dangerous structures being built in potential earthquake areas, but also added substantial wastes into the ecological system.

New houses with non-professional build qualities often needed repair, amendment, and rebuilding in a relatively short period, particularly because of the risks linked to flooding and earthquakes.

To mitigate the problems, guidance documents were distributed to professionals working on redevelopment sites and training workshops were held for villagers; the guidance focused on two aspects. The first concerned the technical issues with the guide entitled *Technical Guidelines for the Renovating Rural Settlements in Yunnan Province*, published by Yunnan Housing and Town and Country Construction Department and Yunnan Urban and Rural Planning and Design Institute [28]. It mainly considered environment and technology requirements for: waste collection, hygiene in public spaces, water supply, transportation, and electricity supply. The aim was to improve infrastructure and public services in order to rectify the problems of "overcrowding, congestion, dirt, and chaotic system" in the rural living environment. It also aimed to solve the pragmatic issues of residents' drinking water safety, waste disposal, sewage discharge, toilet reconstruction, and other problems, and creating more "clean, tidy, and orderly" environment in the rural villages.

The second guide [29] was particularly focused on design styles and needed to take into account 18 different types of vernacular houses of ethnic groups in Yunnan that had evolved over several centuries of Chinese history. Such vernacular houses represented the traditional way of building and included ethnic people's understanding of the relationship between human settlements and natural environment in the province (several texts provide background to understanding traditional design [30,31]). The guide was entitled *Guidebook for Improving and Renovating Vernacular House Styles and Features in Yunnan Province*, published by the Yunnan Housing and Town and Country Construction Department and Yunnan Urban and Rural Planning and Design Institute. It was developed in response to the announcement of the Five-Year Action Plan for Further Improving Urban and Rural Habitat Environment in Yunnan Province (2016–2020). It focused on the themes to build a "colorful Yunnan" and a "beautiful homeland." The actions would be led by the rural and urban planning authorities, and focus on improving the qualities of people's living space avoiding the monotonous design of rural villages.

Outcomes from the programme above are not yet available, however while they did have an important focus on such environmental concerns as clean water supply and adequate waste disposal they have not properly addressed the issue of providing comfort inside either new dwellings or renovated/redeveloped older style dwellings. Gaps in knowledge relating to environmental performance therefore deserve attention.

1.3. Research Gap

Despite much effort to research and enhance design of dwellings in rural areas it seems there are still aspects not yet addressed in a sufficiently direct manner. First, there exists no contemporary and wide ranging evaluation of development taking place in the rural villages of Southwest China that adequately considers the impact of new construction techniques and materials. Further there is no directly associated assessment of the opportunities to produce or understand options for more climate sensitive design of such dwellings in the specific locations of redevelopment.

A report into research published in 2015 [32] indicated that the institutional context was strong in terms of rural agricultural research and that government departments were well-funded. It also indicated that the top-down command and control system was being replaced by more of a bottom-up individual decision-making approach. A key omission it reported however was the poor communication between the individual small-scale participants and the experts working in the subject area.

It seemed clear to the authors that there were many occasions when information on optimal environmental design was not available and which in other circumstances might have been met by additional consultants being engaged to advise on projects; something that was, and is not, generally practical in this area. There is therefore an outstanding need to deliver useful information, to both architects and to building occupants/village groups, at an understandable technical level that relates to the local area. In particular it seems that there is a need to convince owners/occupants in an appropriate way to consider sustainable or green alternatives that is relevant to rural villages more than to urban cities.

The underlying hypothesis of the research described herein is that it is possible to understand rural dwelling design needs and that it is possible to produce suitably useful and focused design guidance. The research undertaken was broken down into two distinct categories: First, “contextual research” (including a survey of village dwellings and a residents’ questionnaire); and second, the process of enacting “climate sensitive design.” These research themes occurred sequentially and these are therefore reported in sequence in the following sections so as to maintain the logic of the narrative.

2. Contextual Research—Materials and Methods

2.1. Introduction

This section is split into three main segments. In the first, key features of visits to rural villages are described that involved observation and recording of information on dwellings and to meet local residents and other stakeholders took place. The second explains how a series of questions evolved from discussions; questions that could form the basis of prompting residents to review and potentially revise their opinions and attitudes to new building construction. The third section explains how those issues raised by villagers and other stakeholders were converted into a series of questions that were to be tested.

2.2. Village Visits

For the first stage of the research, structured observation was the main tool utilized. A series of visits to villages in SW China were undertaken over a period of eight years; these were developed in a more organized fashion over the period from early 2016. Specific explorations of villages initially located in Yunnan but later across other provinces took place. Over the intensive research period since 2016, over a dozen villages were explored in detail and documented with a number of others also visited in a less complete way. These additional visits are not reported here but form a background of knowledge for the authors and collaborators that support the research. The information from these together with the broader information available in the literature and from research network members, created the understanding upon which the majority of the first stage research was based.

The focus of several studies was the area around the city of Jinghong, the capital of Xishuangbanna Autonomous Prefecture in the south of Yunnan. The population of Xishuangbanna is made up of about one-third ethnic Han; one-third ethnic Dai; and one-third from other ethnic groups providing a special character to the location. The area receives many tourists each year, and to meet the demand for hotels, other attractions have been developed which have tourist villages themselves.

Other studies in Yunnan took place in areas close to the city of Kunming (the Provincial Capital) and also in Guizhou province. Visits to outlying villages close to the major cities of Chongqing and Guiyang also occurred.

The process was planned to be similar in each case:

- The research team was introduced to local residents by intermediaries—local Chinese members of the research network (normally academics who also had professional roles as architects or planners);
- Village residents were engaged in detailed discussions by the research team following a semi-structured process, recording was a combination of notes taken at the time and conversation voice recording electronically; there was also unstructured discussion about residents’ experiences and understanding;
- Surveys of dwellings including type and construction were carried out, including detailed photographic records;
- Different types of dwelling were visually identified;
- A review of outcomes between the research team and local academics followed the visits.

The locations of the villages were mainly within the province of Yunnan; however, the research collaboration team include participants from all the southwestern provinces shown in Figure 1. The approximate location of the villages discussed in Section 3 are shown in the more detailed map of Figure 2.

Figure 2. Detailed map of SW China showing the location of main villages visited.

2.3. Questions

As a consequence of the visits and meeting held it appeared to the authors that there were some issues which residents and stakeholders did not address during the process of selections of new dwelling design and construction. The most frequently raised issues were therefore collated and in consultation with stakeholders, a series of pertinent questions for consideration were produced. The series of potential questions were devised for two main groups:

For villager leaders: How long have you lived in the village? What is your role and how long have you been in the post? What is the main ethnic background of the residents/families? What are the major changes that have been experienced by the village? What opportunities were there for the involvement of the village leaders and villagers themselves? What have been the significant influences on how the redevelopment took place? What are the outcomes of the redevelopment? What environmental issues have arisen/been discussed? What will happen in the future?

For village residents: How long have you lived here? Where you involved in the design/construction of the dwelling? Who makes up the residents in the household? Are you content with the function/operation of the dwelling? What are the plans for the future for the dwelling—do you expect it to change? Are there any environmental issues relating to comfort and experience of using the dwelling?

2.4. Self-Reflective Questions

Following from the discussions with village leaders and residents it was concluded that there would be value in establishing a series of self-reflective, and at times provocative questions which could be used by local villagers to assess their needs. These question responded to the finding of three main types of dwelling often co-located within a village: an old traditional design (basic design with mainly wooden construction—Figure 3), a new modern design (contemporary layout and materials—Figure 4), and a hybrid design (incorporating elements of old and new—Figure 5). Discussions were developed with village stakeholders using these images to stimulate responses.

The practical limitations of working in this context meant that the authors could not meet every resident of every village and they were reliant on the village representatives for providing a fair opinion. As a result there may be bias within the results which could not be excluded in the circumstances, nevertheless even if taken as anecdotal evidence the outcomes do add to the stock of knowledge which is lacking on the topic within this area.

A series of statements developed by the authors with local collaborators was devised and suggested to the residents as being phrases that could be associated with expectation for each dwelling type to exhibit the characteristic. The categories chosen related to: understanding of construction methods and costs; the expectations of the physical fabric of the dwellings; the expected internal environments; operation costs; and of the types of occupant that might be suited to the different styles. Although respondent did not individually have experience of living in each variant of design the exercise would allow the communities collectively to consider important aspects for the future developments of their villages.

The statements were:

1. Built to last for a long time (i.e., the dwelling could be used for many years)—this question was chosen to investigate the perceptions of the expected lifetime of the design.
2. Can be constructed by local people or construction team—this question was chosen to test whether residents expect the construction process to be used within their community.
3. Expensive to build (high construction cost)—this question was chosen to examine perceptions of costs.
4. Creates comfortable (indoor) temperatures—this question was directly related to expectations of indoor climate.
5. Cost a lot to operate each year (to create/maintain comfort)—this question was chosen to examine perceptions of the costs for using heating and/or cooling systems.
6. Has good ventilation—this question was chosen to test if respondents expected high air flow rates which in turn would impact on comfort and operating costs.
7. Uses "green" (or local) materials—this question aimed to examine understanding of the source of building products.
8. Designed by an expert/professional—this question was selected to test if respondent thought particular dwelling types needs professional design input.
9. I would enjoy living here (in that house)—this question was a simple test of respondents dwelling type views.
10. Visitors (tourists) to the village would like to see it—since the village relied on tourists to visit to provide additional local income, views on whether different dwelling types meet the need would be valuable.
11. It is safe to live in if there is an earthquake—this question was chosen to test respondents' expectation about whether the different designs were more or less suited to meet problems created by seismic activity which is common in SW China.

12. This house is suitable for rural life—this question was used to examine if respondents felt the style of dwelling was suited to rural locations.
13. The owner has a good economic position (i.e., relatively rich)—this question was chosen to gain some insight into the perceptions of type with an occupants monetary worth.

Figure 3. Old traditional style of dwelling.

Figure 4. New style of dwelling.

Figure 5. Hybrid style of dwelling (under construction).

3. Contextual Research—Results

3.1. Villages Visits Observations

In this section information is provided on the villages visited and the outcomes of the studies undertaken. Twelve locations are described in order to illustrate the range of data sources though in fact the total number of villages visited during the main period of research since 2016 (which is ongoing) was significantly more. Additional material was obtained through a Chinese website with village level data available [32]. The locations of these villages are shown in the map of Figure 2.

3.2. Villages Overview

3.2.1. Damoyu

This village lies to the west of the city of Kunming at an elevation of 2200 m and situated in an agriculturally orientated area. It is becoming popular for city dwellers to acquire a property in this area to renovate as a weekend/second home investment, yet the previous local population is diminishing because of the allure of employment in the nearby city. The population is approximately 850 with the predominant ethnic group being Yi (90%) with Han (10%). It still has an area of cultivated land within the main village—approximately 0.6 km^2—of which about 20% is flat with water irrigation. Annual rainfall is 920 mm and there is associated reservoir of area 0.05 km^2. It has dwellings built in both traditional construction (mud/straw brick and adobe walls sometimes with rudimentary openings), and also an increasing number of modern glass/concrete designs. The traditional design could be expected to have low embodied energy content and to be better suited to the climate, whereas the large windows in the newer dwelling indicate potential for overheating in summer and cold in winter. The majority of older building required renovation and this is now beginning to take place; some further details can be found in Pitts [24].

3.2.2. Nuohei Village

Situated to the east of Kunming is Nuohei which lies close to the so-called Stone Forest (also known as Shilin—an area with many and often spectacular outcrops of Karst limestone). The population is approximately 1500 living in an overall area of 27 km^2 including substantial cultivated land areas. The main ethnic group is Sani (a branch of the Yi) and there is a cultural center explaining the traditions of the village. A trail leads to a hill top with structures and outlook over the area. The village was founded in 1816 and is at an elevation of 1985 m. Many of the dwellings are constructed using stone however concrete and concrete blocks are also widely used and in a number of cases they are decorated so as to appear to be made from stone and the village is often referred to as the Stone Village). Mud/straw bricks are also in evidence though as with Damoyu they are often in a poor state of repair. The village seems to be benefiting from tourism and also an influx of artists and associated professionals, perhaps because of its proximity to the Stone Forest tourist area.

3.2.3. Manzhang Village

This is a village with an already developing trade as a tourist visitor attraction in the area to the north of the main city of Jinghong in the Dai Autonomous Prefecture of Xishuangbanna in the south of Yunnan. The land area is 2.4 km^2 at an elevation of 660 m with substantial agricultural activity. There are approximately 120 households and a population of 500 almost exclusively from the Dai ethnic group. The housing was traditionally of wood structures and cladding but an increasing number of brick-concrete dwellings were being constructed. The village benefits by being located at a relatively short diversion off the main road leading to significant tourist attractions such as the Wild Elephant Park and areas where the traditional water splashing ceremonies take place. The villagers actively derive benefit from the visiting tourists by selling craft items and food as well as by performing traditional dances and other rituals.

3.2.4. Shayao Village

Also in Xishuangbanna the Shayao Township west of Jinghong was visited. It consists of four settlements covering an area of 21.8 km^2 at an altitude of 895 m. The area has a varied crop agricultural base and is populated by about 1200 inhabitants in over 250 households. The main ethnic groups are Hani (approximately 63%) and Lahu (37%) and the main housing construction varies between the traditional wooden structures and an increasing number of concrete-brick variations. The location was visited with a local guide who was able to facilitate discussions with local residents and this enabled opinions to be sought. There were few significant developments related to the tourist trade although along the main roads additional restaurants and small shops were emerging. Many dwellings retained their traditional characteristics and materials but were often over-layered with new construction and materials to create hybrid variations.

3.2.5. Manjinghan Village

This ethnic village is a relatively prosperous but modern village in the south of Jinghong consisting of eight sub-villages. The population was about 2700 with the vast majority being of Dai ethnicity. The area is suitable for planting a variety of crops and is well connected to the main city. Here the linkages between old and new seemed to be less contrasting and the village has a feel of organization and relative affluence. Buildings were almost universally of a modern style and most residents had employment links within the family to the nearby city. Traditional celebrations took place and there were some attempts to direct visitors to take advantage of local facilities including restaurants.

3.2.6. Jinga Mang Village

Jinga Mang has a number of component parts and lies at an altitude of 572 m. With a population of approximately 600 in about 130 households. Dwellings were a mixture of traditional wooden structures and modern brick and concrete. Within this area was a small settlement known as Meng Mong with an area of 2.25 km^2 which was identified as having a good collection of traditional Dai wood structure and wood clad dwellings, each of which was visited by a member of the research team. Detailed drawings were made to establish the basic parameters associated with the Dai ethnic group represented. There was little evidence of attempting to market the village for tourism and the traditional designs predominated.

3.2.7. Qinsou Village

Qinsou village is located in the region of Dali, a city with well-known tourist attractions in western Yunnan although this village is sufficiently remote that it draws little current tourist benefit and is relatively poor. The village has eight settlements within it and has an area of 29.1 km^2; it lies at an altitude of approximately 1976 m, and the main industry is agricultural crops. There are about 750 households and a significant population of about 3300 and the dwellings of both traditional and modern designs; however visits across several years showed that the older style traditional buildings which had been in a poor condition were being replaced by concrete structures.

3.2.8. South Wuligiao Village

This village is also located in the Dali area and has stronger potential for tourist related development. There are six ethnic minorities represented, of which the largest is a Muslim group but Han, Bai, Yi, Zhang, and Naxi are also found. A substantial amount of proactive development led by the locals has taken place in order for the villagers to benefit from tourists, including multiple restaurants and food shops as well as approximately 40 hotels. Traditional houses in this area were constructed from stone and skills in its use have passed down through generations, now three variations are visible depending on time-period of construction.

3.2.9. Qinkou Village

Qinkou village is located in Yuanyang County of Yunnan at an altitude of approximately 1575 m. It has a long history going back to 200 BC. The hilly location means the land has less cultivation potential and agriculture is dominated by rice production and the use of terracing for growing crops. The area of the village is 3.1 km^2 with 185 households and approximately 900 residents; the ethnic group is almost exclusively Hani. The village had few amenities until a development programme was introduced leading to the establishment of the Qinkou Hani Folk Cultural and Ecotourism Village in 2000. This had major impacts on the village in terms of construction and development and included establishment of franchise stores, handicraft shops, and hotels/household visitor accommodation. A feature of the dwelling construction is the "mushroom" dwelling, so called because of its shape, although modern variants are not always constructed in the traditional manner.

3.2.10. Dahuang Village

This village is located in Nayong County in the region of the major city of Guiyang; it is also in one of the most visited tourist areas famed for its flower displays. This area illustrated a different problem associated with the redevelopment that is associated with tourist enhancement. In this case villagers were being relocated to a new area and provided in the main with new style concrete and brick dwellings but with little obvious recognition of the local climate. Older inhabitants of the village were housed in more traditional wooden buildings. The authors were able to recognize an unmet need to information as well as resources to optimize dwelling design.

3.2.11. Manbayue

A number of villages, such as Manbayue, situated very close to the border with Myanmar were visited with the help of the local Design Institute in Jinghong. Manbayue is a village that lies at an average altitude of 920 m and split into two halves—one in a valley and one atop a hill covering an area of 1 km^2, and with a population of 190 people. These locations were considered significant because at the time it had been reported that some of them were of such poor quality and in a very bad state of repair that it was expected the villages would be demolished within a relatively short period of time. Such villages are very much "on the edge," quite some distance from the main towns.

3.2.12. Chenggong Urban Village

Chenggong was a rather different type of village and very much in contrast to the border villages; it was in a location that had been swallowed up by the expansion of the main city of Kunming in Yunnan. The wider area was designated more than 10 years ago as the center for a redeveloped university zone—effectively becoming a small city in its own right to house the major campuses of approximately a dozen universities. The original village was a rural affair separate from the city with flower cultivation and vegetable growing the predominant industries. With the redevelopment the village lost most of its land but was well-compensated. Many former residents now own apartments in the area though some of the original village still stands (as of 2019) and many buildings have been adapted to provide services for local university students and visitors. The village leader was keen to explain the benefits that had accrued from the redevelopment and the management processes that had been put in place for longer term community support schemes to operate.

A summary of the main village features and characteristics is provided in Table 1.

Table 1. Summary of village characteristics.

Village Name and Location	Population and Main Ethnicity	Topography	Type of Area and Connectivity	Predominant Original Housing Construction
Damoyu, Kunming, Yunnan	Pop: 850; Yi: 90%; Han 10%	Hilly area; elevation 2200 m.	Rural area; approx. 10 km from city; good road connections	Adobe brick
Nuohei, Kunming, Yunnan	Pop: 1500; majority Yi ethnic group	Hilly area; elevation 1985 m.	Rural area; approx. 90 km from city; adequate road connections	Stone materials
Manzhang, Xishuangbanna Yunnan	Pop: 500; majority Dai ethnic group	Flat area; elevation 660 m.	Rural area; approx. 10 km to nearest town; adequate road connections	Timber/bamboo; main family area raised on stilts/columns
Shayao, Xishuangbanna, Yunnan	Pop: 1200; Hani 63%; Lahu 37%	Hilly area; elevation 895 m.	Rural area; approx. 10 km to nearest town; just adequate road connections	Timber/bamboo; main family area raised on stilts/columns
Manjinghan, Xishuangbanna, Yunnan	Pop: 2700; Mainly Dai ethnic group	Flat area; elevation 580 m.	Semi-rural area; approx. 5 km to nearest town; good road connections	Timber/bamboo; main family area raised on stilts/columns
Jinga Mang, Xishuangbanna, Yunnan	Pop: 600; Mainly Dai ethnic group	Flat area; elevation 572 m.	Rural area; approx. 5 km to nearest town; adequate road connections	Timber/bamboo; main family area raised on stilts/columns
Qinsou, Dali, Yunnan	Pop: 3300; Mainly Bai ethnic group	Flat area; elevation 1976 m.	Rural area; approx. 5 km to nearest town; good road connections	Adobe brick
South Wuliqiao, Dali, Yunnan	Pop: 1500; Varying ethnic groups	Hilly area; elevation 2100 m.	Peri-urban area; approx. 5 km to nearest city; adequate road connections	Stone
Qinkou, Yuanyang, Yunnan	Pop: 900; Mainly Hani ethnic group	Hilly area; elevation 1575 m.	Rural area; approx. 35 km to nearest town; adequate road connections	Rammed earth walls with thatched roofs
Dahuang, Bijie, Guiyang	Pop: 1060; Han, Yi, Miao, Chuanqing, ethnic groups	Flat area; elevation 1470 m.	Rural area; approx. 15 km to nearest city; adequate road connections	Timber structure houses
Manbayue, Xishuangbanna, Yunnan	Pop: 190; Mainly Dai ethnic group	Hilly area; elevation 920 m.	Rural area; approx. 20 km to nearest town; limited road connections	Timber/bamboo; main family area raised on stilts/columns
Chenggong urban village, Kunming, Yunnan	Pop (whole area) 350,000; 7% ethnic groups	Flat area; elevation 1800 m.	Urban village/peri-urban area; main city 25 km; very good road connections	Traditional houses of timber structure with adobe bricks

3.3. Contextual Analysis Results from Village Visits

3.3.1. Dwelling Construction

In terms of building redevelopment, the authors found that although local Planning and Design Institutes should (and in some cases do) have a significant leading role, but in meetings with villagers they explained how residents often found ways to bypass advice in order to build quickly once the finance became available. Examples of contrasting styles that might result are shown in Figures 6 and 7; both are from the same village (Damoyu near the city of Kunming). Figure 6 shows a dwelling after being rebuilt using traditional techniques (mud and straw wall bricks); Figure 7 shows a much larger building with large windows—a dwelling which almost fills its whole plot. In this village as with many others there was also what seemed to be a degree of uncontrolled building on what had previously been agricultural land—Figure 8 illustrates one such example.

In discussions with local residents there does not seem to have been any account taken of environmental design needs or comfort in the design and construction process in the more modern examples. The outcome seems to be more of an attempt to emulate the kinds of dwelling features and conveniences found in urban developments; something to be aspired to; and yet something which appears to be a loss to the value and benefit of the rural site and landscape, with potentially negative impacts on the natural visual landscape. Observations of buildings designed and constructed by professionals (such as architects and engineers) also indicated that there was a lack of suitable material to support their decision-making.

Finding 1 from this research is a general lack of information and support to enable the detailed environmental design and control of construction of village dwellings; something which is particularly acute in relation to self-building by village residents.

Figure 6. Damoyu—renovated mud and straw brick/adobe building.

Figure 7. Damoyu—large scale new style dwelling.

Figure 8. Damoyu—new dwelling amidst agricultural land.

3.3.2. Demolition vs. Renovation

A second main outcome from the village visits was the discovery of an expectation among a significant number of residents/stakeholders that many traditional buildings would be demolished. This was almost a presumed outcome, thought of as automatic part of the rural revitalization exercise taking place in their locality. It was accompanied by an expectation that official recompense would provide sufficient funds to permit a new building to be constructed. This gave rise to more general preferences for demolition rather than renovation, so that some avenues for redevelopment were being excluded and within this no calculation of lifecycle environmental costs was being determined.

This situation had been found to be particularly prevalent in some areas of Xishuangbanna in Southern Yunnan. However, on a subsequent visit to the same area approximately 10 months later, policies seemed to have changed and a renovation/rebuilding manual had been produced in conjunction with the local Planning and Design Institute; this guided assessors as to the options. Four categories of disrepair were identified with remediation support rather than full demolition being considered in all but the worst cases. In addition, the manual offered detailed guidance as to how repairs ought to be undertaken and the linking of the assessment process to associated commissioned professionals meant that more and different outcomes became available. The promotion of this alternative route had both the potential to increase sustainability and also to maintain the traditional appearance of the villages.

A further related outcome concerned the changes to appearance taking place in villages which were being supported for tourist purposes: Figures 3 and 4 show dwellings that exist within 100 m of each other in the tourist village of Manzhang a little to the north of Jinghong in the Dai Autonomous Prefecture of Xishuangbanna. The traditional design evident in Figure 3 is most readily be associated with such an ethnic minority village using mainly wood construction and few modern materials. Yet there seems to be little restriction on the construction of concrete block and tiled roof dwellings in Figure 4 adjacent to the traditional styles. The modern designs enjoyed modern facilities which were attractive to residents although conversations with several families in the older properties did not reveal any particular areas of dissatisfaction.

Finding 2 is the need to offer some practical alternatives to demolition of older/deficient properties where possible and also to recognize that there was some value in the traditional design. In order to achieve this, design and reconstruction guidance documents need to be available. In this way renovation could provide some mitigation of the environmental and material resources costs of complete loss and replacement of a dwelling and also support the overall aims of the redevelopment/revitalization programme.

3.3.3. Hybrid Design Alternative

An interesting development found in several locations was the evolution of a "hybrid" design of dwelling—an option which retained some of the design characteristics of the traditional form but which incorporated a number of modern features. The term hybrid can imply a number of different possibilities. In this case it reflects the emergence of a form of design and construction which respects the cultural typologies, the methods and the materials found in traditional dwellings, but which are embellished by use of some modern materials and construction processes. These hybrids are not representative of a fake authenticity and are clearly evident as a different type. The willingness in some villages to embrace the new techniques also indicates potential for other variations that will be considered in Section 4 below.

In the example shown, the upper floor of Figure 5 incorporates glazed openable windows and provides for more control over the principal living space environments. These dwellings have shaded activity and storage space on the lower level and also the overall volumetric proportions and roof shapes were similar to traditional ethnic styles; in this way some of the traditional design values and appearance were retained.

Finding 3 is that alternatives to the simple "old vs. new" model of dwelling design can be found that have value. Opportunities to develop hybrid designs seem to have the benefits of marrying the old to the new and striking a balance between tradition and modern convenience.

3.3.4. Embedded Village Expertise

An important social feature of each village was the degree to which there was embedded level of expertise among the residents and interest to understand the environmental and green design. This was also linked to the degree of community engagement with the procurement and construction process that took place. Variations were found to exist between villages often located in the same area and to a certain extent it appeared to vary according to the ethnicity of the family background of the residents. This is important because many renovation projects require active participation by residents if the outcomes are to reflect ethnic styles and help support tourism. The value of knowledge and understanding among family and clan structures—particularly in the ethnically strong villages—allowed "bottom-up" influences to percolate through to improve final product quality. This reinforced previous studies into functioning of redevelopment at village level [27].

Conversely, a worrying trend found in some villages was a relatively poor standard of craftsmanship and attention to detail where "top-down" had been the predominant construction influence. Materials and construction methods giving an overall impression of matching to form and type were used but closer inspection indicated a poor level of finish and thus risks for the longevity of the finished dwelling. There were also occasions where even in older styled dwellings, traditional construction techniques and materials had been replaced with modern alternatives. This would seem to indicate a loss of local craft skills, something which ought to be addressed in the near future both to ensure the appearance of the buildings are of the quality that would be valued by tourists and also to avoid situations of danger or collapse.

Finding 4 was the identification of variations in embedded knowledge and skills within villages and sometimes a lack of community involvement in the redevelopment process. The fact that a village had a specific ethnic minority focus seemed to be more important in avoiding the difficulty than the identity of the ethnic group. This would indicate that a village with ethnic traits might have better potential to use intrinsic knowledge and skills capabilities required for successful redevelopment.

3.3.5. Socio-Economic Changes

In terms of socio-economic development many villages were populated during the day by the elderly and children, and among other residents there was a gender bias toward females. Depending on the distance from major towns or cities, a number of residents (predominantly male) were often absent during the day or for the working week (and often much longer) while employed elsewhere. The actual period absent seems to have been linked to the travel time to larger centers of employment. Accompanying this was an observation that the tending of the agricultural land was often taken on by the older generation (Figure 9).

Figure 9. Rural agricultural work becoming domain of older female residents.

It is also the case that as a result of tourist visits many villages have tried to develop their own activities offering food and drink, ethnically themed goods and souvenirs, and dance events or other rituals. This has brought economic benefits, which when combined with other support has allowed redevelopment and enhancement of the built environment in the villages. Those members of the village community engaged in such tourist-orientated activities were also more often likely to be older and female.

Finding 5 is that changes to the social structure of the village could impede development in the future because of gender and age biases, and that skills-based knowledge, understanding, and practice need to be supported and re-embedded within communities. This would give more authenticity to the tourist/visitor experience.

3.4. Contextual Research—Self-Reflective Questions

In order to test the value of using self-reflective questions they were embodied in a short questionnaire distributed to a limited number of residents in one of the villages visited. All villagers to whom the questionnaire was offered took part and all indicated it had value for them in considering options.

The testing of the questionnaire survey gave rise to 34 verified responses; the data are summarized in Table 2.

Table 2. Proportion of respondents identifying the house type matching to each statement (note totals may add up to more than 100% as respondents were allowed to vote for more than one option).

Matching Statement	"Old" Style	"New" Style	"Hybrid" Style
Built to last for a long time (can be used for many years)	21.2%	46.2%	32.7%
Can be constructed by local people or construction team	24.5%	51.0%	24.5%
Expensive to build (high construction cost)	8.3%	61.1%	30.6%
Creates comfortable (indoor) temperatures	23.3%	34.9%	41.9%
Cost a lot to operate each year (to create comfort/maintain)	30.8%	51.3%	17.9%
Has goodventilation	37.0%	17.4%	45.7%
Uses "green" (or local) materials	33.3%	7.4%	59.3%
Designed by an expert/professional	27.5%	40.0%	32.5%
I would enjoy living here (in that house)	8.1%	40.5%	51.4%
Visitors (tourists) to the village would like to see it	24.5%	2.2%	73.3%
It is safe to live in if there is an earthquake	50.0%	9.6%	40.4%
This house is suitable for rural life	50.0%	32.7%	40.4%
The owner has a good economic position (rich)	10.5%	76.3%	13.2%

The results in Table 2 indicate substantial variations in opinion even within a small community and is an indicator of a gap in knowledge and understanding. Finding 6 arising from this survey is that there is substantial value in encouraging local residents, who are increasingly having to make design and construction decisions for themselves in their own locality, to use self-reflective questions to stimulate discussion. The outcomes from such a process can then be used as part of the community decision-making process.

It was also clear from discussions with the test group that there was insufficient information available to understand or make informed choices. Conversations and discussions held with stakeholders about the sorts of information that would be valuable fell into several categories, prominent among which was the need for better guidance on choices to achieve climate sensitive and energy efficient outcomes. This led as consequence to the development of the environmental design assessment process explained in the following section.

4. Climate Sensitive Design—Materials and Methods

4.1. Bioclimatic Design Techniques

The authors considered the needs expressed and summarized at the end of Section 3 and the most effective ways in which these might be derived and communicated to stakeholders. The technique of Bioclimatic analysis and design seemed most appropriate and most closely related to the intrinsic knowledge and expectations of the stakeholder group; this technique was therefore chosen and developed for the local context.

Buildings exist to provide shelter and comfort for occupants. There are many variations in such features as orientation, envelope construction, and use of a building which will affect how comfort can be achieved. In order to meet the needs for guidance, bioclimatic analysis tools have evolved to help make choices in basic building design so as to optimize the performance in relation to climate. Their use is predicated on the notion that better environmental building design will reduce or eliminate the need for energy use in conventional heating and cooling systems to produce internal conditions suited to the occupants.

While historically there was an expectation that building designers/constructors would naturally use local and intangible knowledge to build using methods suited to climate, modern expectations for comfort mean better predictive tools are needed. Current techniques of bioclimatic design, which have great quantitative comparison potential, have developed from studies by a number of researchers and practitioners. Significant among these were the Olgyay brothers [33] and researchers such as Givoni [34] and Szokolay [35].

A knowledge of building technologies and techniques combined with information on climate enables preferential design choices to be made and the improvement in comfort to be assessed in a quantitative way. The analysis also provides a visual indication of the hourly values of climate data that can still provide comfort inside a building if appropriate techniques are used by projecting information onto a psychrometric chart (see Figure 10). There have been previous studies in China [36] using bioclimatic analysis, and of course the general techniques are well-known.

Although the potential for the use of such techniques has to some extent already been identified, there is still an assumption in some quarters, and indeed embedded with official documents, that China can be subdivided into just five climatic regions: severe cold region, cold region, hot-summer cold-winter region, hot-summer warm-winter region, and the temperate region. Although these simplified regions have been used in many studies such as those of Sun [37] the authors here content that more location specific analysis is necessary.

The version of the bioclimatic tool used here is that embodied in the "Climate Consultant" software package [38]. There are a number of variations of software product but this has been chosen because it is well-used and freely available. The climate data is usually provided in the EnergyPlus Weather (epw) file format though it can be initially generated by a number of methods. In this case data were downloaded via the EnergyPlus weather data website [39] which contains information on 46 locations in SW China (from the provinces/regions of Yunnan, Guangxi, Guizhou and Sichuan/Chongqing). In most cases Chinese Standard Weather Data (CSWD) files were used for consistency. These weather data files were developed as a database by the Department of Building Science and Technology at Tsinghua University and the China Meteorological Bureau [40].

The range of environmental design technologies and techniques that can be selected from within the software has 16 variations, including basic comfort conditions (that is those external conditions which are already in the comfort range) and also including conventional heat and cooling. The full list is shown in Table 3, however, for the purposes of the analysis here the options were restricted to those which are completely passive in nature—that is, they do not require energy to function in use. In this study any technique which might require significant intervention by the building occupant has also been classified as active.

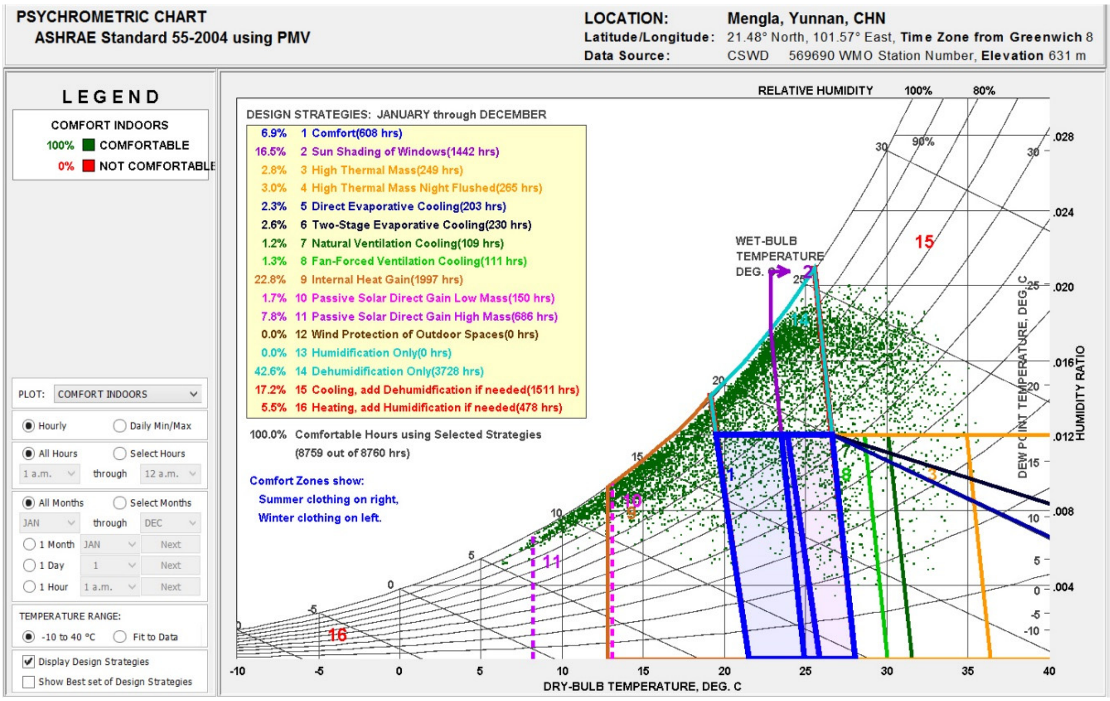

Figure 10. Example of bioclimatic analysis with visualization using the psychrometric chart for Mengla, Yunnan (image constructed using Climate Consultant Software [38]).

Table 3. Identification of environmental design techniques for bioclimatic analysis.

Identifier Number	Technique	Passive or Active
1	Comfort	Passive
2	Sun shading of windows	Passive
3	High thermal mass	Passive
4	High thermal mass night flushed (ventilated)	Passive
5	Direct evaporative cooling	Active
6	Two-stage evaporative cooling	Active
7	Natural ventilation cooling	Passive
8	Fan-forced ventilation cooling	Active
9	Internal heat gain	Passive
10	Passive solar direct gain low mass	Passive
11	Passive solar direct gain high mass	Passive
12	Wind protection of outdoor space	Passive
13	Humidification only	Active
14	Dehumidification only	Active
15	Cooling add dehumidification if needed	Active
16	Heating add humidification if needed	Active

The comfort calculation option chosen was that of the "ASHRAE Standard 55 and Current Handbook of Fundamentals Model" incorporating the predicted mean vote (PMV) modelling process. In addition, changes were made in compiling the data to take into account the potential for adaptive behavior for the occupants of the dwellings as set-up within the software. Data for the 46 locations in Southwest China were used to determine the predicted improvement in comfort as a percentage of hours for the year for those passive options. Outcomes are summarized below in Section 5.

4.2. Detailed Prediction of Internal Conditions

In addition to making an assessment of the potential of passive techniques to be used for each of the 46 locations for which climate data are available, it was also chosen to carry out a more detailed energy analysis in the form of a parametric study for a smaller representative range of locations. The purpose of this was to quantify in more detail the building features that were linked to significant variations in internal conditions and thus to enable design guidance suitable for use by stakeholders, to be determined.

In order to test and demonstrate the potential for the localized technique, 15 locations from the original 46 were selected. This selection consisted of the capital cities of each province and 10 further locations which were representative of a wide range of rural climates and which would not be expected to experience heat island effects. In any choice that is to be made here there is a degree of selectivity but the purpose of the activity is not to provide a complete design guide for all locations, but rather to indicate the value of carrying out such an activity. This then supports advocacy for the process for any village development location that might occur at some point in the future.

The location list used was: in Chongqing—Shapingba, and Youyang; in Guangxi: Hechi, Longzhou, and Nanning; in Guizhou: Bijie, Guiyang, and Sansui; in Sichuan: Chengdu, Huili, and Songpan; in Yunnan: Deqen; Kunming, Mengla, and Yuanjiang.

The analysis tool chosen to perform the analysis was EnergyPlus—this is also well-known and generally freely available so that researchers based in China would have opportunity to develop outcomes further.

A simple building model was defined in conjunction with Chinese collaborators/stakeholders which was based on typical new dwelling design being constructed in villages. The reason for this choice came from the analyses of the villages and the choices being made by their inhabitants. The new modern style of swelling was becoming the predominant choice for new builds yet the survey of residents had suggest a significant degree of dissatisfaction. Other studies reported earlier also indicated a lack of guidance for local village stakeholders more generally and that the development of a systematic evaluation was required. The analysis undertaken aimed to provide guidance which would be of most value to those involved with designing "new" style dwellings rather than renovation of traditional styles, though of course the information would still be of use more generally, if applied sensitively by professional designers.

A relatively simple but representative building model of the new design option was set-up and a number of features varied in a parametric fashion in order to derive simulated outcomes for comparison. For this stage of the research the number of options was limited so as to enable identification of strands for development in the future.

The main characteristics/features of the simple building were:

- Key external dimensions: width: 7.8 m; depth: 8.1 m; 2 floors—floor to floor height 3 m; intermediate floor 0.1 m concrete;
- Double wood door to front elevation 2.4 m high, 1.4 m wide;
- Walls: main component thickness (without insulation or cavity) = 0.24 m;
- Windows: 1.5 m in height; bottom of window 0.9 m above floor; glazing only to front (main) façade and rear façade; variations in window size accommodated by changing the width;
- 2 occupants per floor (1 met activity level); clothing insulation value: 0.7 clo; no other heat gains apart from occupants were incorporated due to the level of complexity.

A series of parametric alternatives were then chosen for other building features:

- Four principal orientations: north, east, south, west;
- Three glazing options (all single glazed): low glazing ratio: front window to wall area ratio (WWR) = 0.2, rear WWR = 0.15; medium glazing ratio: front WWR = 0.35, rear = 0.25; high glazing ratio: front WWR = 0.5, rear WWR = 0.35.

- Three variations in construction with different thermal impacts: Heavyweight: load bearing concrete frame with dense brick infill walls plus 0.015 m internal plasterboard finish; concrete roof structure 0.1 m thick, concrete floor 0.1 m thick; Lightweight: lightweight concrete block walls plus 0.015 m internal plasterboard; concrete roof structure 0.1 m thick, concrete floor 0.1 m thick; Lightweight with Insulation: lightweight concrete block walls with internal insulation of 0.1 m; plus 0.015 m internal plasterboard; concrete roof structure 0.1 m with 0.1 m internal insulation, concrete floor 0.1 m (no insulation).
- Ventilation rates: 0.25/0.5/1.0 air changes per hour.

A sketch illustration of the building basic model is shown in Figure 11; thermal properties for the construction elements were those available from the standard libraries of data for EnergyPlus.

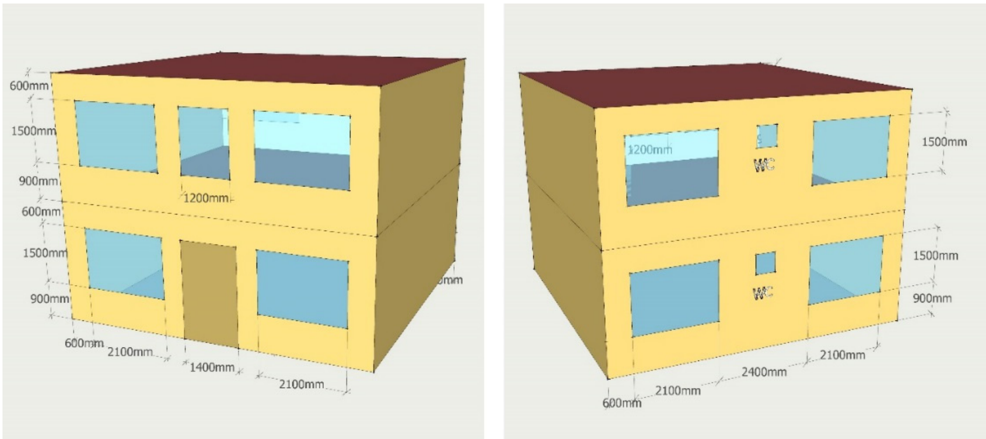

Figure 11. Sketch of dwelling prototype used in environmental simulations: left image shows the front elevation; right shows the rear elevation.

The reasons for choosing the specific variations in parameters are as follows:

- The three alternatives for wall construction represented the two most frequently observed new construction with an addition of a layer of insulation to the form most easily adapted to allow it. Heavyweight construction represented the materials of either dense concrete or stone; lightweight represented the most frequently used form of blockwork construction;
- The three glazing options represented the range of new dwelling window to wall ratios observed in many village visits;
- The four orientations, while not providing exhaustive information did allow investigation as to whether this was likely to introduce significant variation;
- The three ventilation rates represented those associated with air-tight construction; modest air-tightness and also a relatively loose fit, again they were in line with observations (though not formal testing) within the villages;
- Simulations allowed discrimination between upper and lower floor conditions and therefore these alternatives were used as in actual village dwellings there were different uses for different levels—for future research further variations might be chosen.

The analysis procedure consisted of running EnergyPlus with no heating or cooling system in order to determine the free running internal conditions on an hour by hour basis for the year. The free running mode was chosen as for rural dwellings optimization will be led by optimizing passive performance and also to optimize comfort without use of heating and cooling systems. The range of choices in design provided 108 combinations of parameters using the location weather data available for the 15 locations (1620 combinations in total). The programme output was used to compute if the resulting conditions were comfortable using the predicted mean vote (PMV) methodology. As it is known that in these locations a degree of personal adaptation to comfort occurs the comfort limits were set to ±1.0 (that is expected reporting of experienced conditions would be between "slightly warm" and "slightly cool"). The number of hours that comfort was achieved was then compared to the total number of hours to calculate the percentage comfort hours over the year. The outcomes for the 15 chosen locations are summarized in tables presented in Appendix A (one table per location).

It is of course recognized by the authors that many more variations in the parameters could have been chosen or that different output data could have been calculated (such as energy requirements for heating and cooling); however, it was considered that the most valuable data in terms of informing stakeholders would be to present the information in a form that had direct meaning for affecting their comfort experiences.

5. Climate Sensitive Design—Results

5.1. Passive Design Techniques

The Climate Consultant software was used with the available weather data from the 46 locations based in SW China. The summary is shown in Table 4 with the locations separated according to provincial affiliation. A number of key points can be noted:

- The variation in combined potential comfort hours achievable by using all of the techniques combined is considerable: from 19% to 71%;
- The choice of most valuable techniques to be employed for each location varies considerably with the following each showing substantial benefits: use of internal heat gains; natural ventilation cooling; sun-shading of windows; passive solar direct gain (low thermal mass). It is however difficult to make generalized recommendations despite each of the sites being located in the same part of the country;
- There is a substantial need to optimize the heat gains to offset comfort deficit in cooler periods, hence benefits of internal heat gains and passive solar;
- There is a need in warmer areas to make use of ventilation cooling and sun shading of windows;
- It is also clear that even within each province substantial variations occur.

Table 4. Percentage improvement in comfort arising from using each passive design technique independently in "adaptive" mode (%) as calculated from the *Climate Consultant* software.

Techniques / Location	Comfort Conditions	Sun Shading of Windows	High Thermal Mass	High Thermal Mass Withnight Flushed Ventilation	Natural Ventilation Cooling	Internal Heat Gains	Passive Solar Direct Gain (low mass)	Passive Solar Direct Gain (High Mass)	Wind Protection of Outdoor Space	Overall (%) of Comfort Hours (Combined Effect)
CHONGQING										
Shapingba	5	7	0	1	22	22	1	1	0	47
Youyang	6	6	1	1	16	23	1	2	0	42
GUANGXI										
Baise	5	14	1	1	31	25	2	3	0	59
Duan	9	12	2	2	36	25	2	3	0	67
Guilin	7	12	1	1	28	24	3	3	0	56
Guiping	5	12	1	1	37	23	1	2	0	63
Hechi	8	10	1	1	31	24	1	2	0	60
Lingshan	5	14	1	1	38	21	2	3	0	62
Longzhou	6	14	1	1	37	23	1	3	0	63
Nanning	5	13	0	0	37	22	2	2	0	62

Table 4. *Cont.*

Location \ Techniques	Comfort Conditions	Sun Shading of Windows	High Thermal Mass	High Thermal Mass Withnight Flushed Ventilation	Natural Ventilation Cooling	Internal Heat Gains	Passive Solar Direct Gain (low mass)	Passive Solar Direct Gain (High Mass)	Wind Protection of Outdoor Space	Overall (%) of Comfort Hours (Combined Effect)
Qinzhou	5	14	0	0	41	24	2	3	0	67
Wuzhou	6	11	1	1	32	20	2	3	0	55
GUIZHOU										
Bijie	7	5	1	1	10	35	3	3	0	49
Guiyang	8	8	0	0	18	27	2	3	0	50
Sansui	4	7	1	1	15	22	2	1	0	39
Tongzi	7	5	0	0	17	26	1	2	0	46
Weining	8	1	0	0	7	36	7	5	0	47
Xingyi	11	7	1	1	16	33	3	4	0	56
Zunyi	5	5	0	0	16	25	1	1	0	44
SICHUAN										
Barkham	7	2	1	1	6	23	9	3	0	35
Batang	16	6	3	3	12	37	15	8	0	62
Chengdu	6	6	0	0	19	27	2	2	0	49
Garze	3	1	0	0	3	19	17	5	1	33
Hongyuan	1	0	0	0	1	10	18	1	1	24
Huili	16	6	1	1	17	42	10	9	0	67
Jiulong	6	1	0	0	6	28	8	2	0	37
Leshan	6	6	0	0	20	27	1	1	0	49
Litang	0	0	0	0	1	11	12	2	0	19
Luzhou	6	9	0	0	20	25	2	3	0	49
Mianyang	7	8	1	1	22	23	3	2	0	49
Nanchong	6	6	0	0	21	21	1	1	0	44
Songpan	4	1	0	0	4	18	8	2	0	26
Wanyuan	9	7	2	2	14	25	2	2	1	44
Xichang	16	7	3	3	18	39	6	6	0	66
Yibin	7	5	1	1	21	25	1	1	0	49
YUNNAN										
Chuxiong	20	5	2	2	18	43	10	7	0	71
Deqen	1	0	0	0	2	15	13	1	0	24
Kunming	17	4	0	0	14	47	10	10	0	71
Lancang	12	14	4	5	23	24	4	9	0	58
Lijiang	10	2	0	0	8	45	18	10	0	64
Lincang	16	8	2	2	21	38	8	10	0	69
Mengla	7	17	3	3	28	23	2	5	0	58
Mengzi	19	14	3	3	24	35	7	11	0	71
Simao	13	9	2	2	22	34	6	9	0	64
Tengchong	10	3	0	0	12	48	12	10	0	66
Yuanjiang	16	19	4	5	35	21	2	6	0	69

Two findings result which can be incorporated into the discussion and conclusions: finding 7 is that substantial potential to create comfort using passive bioclimatic design techniques exists; finding 8 is that there are so many variations in optimal performance that making choices based on simple regional climatic zones is insufficient to support accurate decision-making and that more localized outcomes ought to be addressed.

5.2. Parametric Environmental Evaluations

The second quantitative analysis technique was set up to investigate a specific sub-set of the overall weather data sites but with a similar aim—to assess comfort hours experienced by residents based on variations in building design/construction parameters. For each location 108 variations in design were assessed using the EnergyPlus software package for each hour of the year. The calculated internal conditions were used to determine if each hour could be considered to lie within the comfort range of predicted mean vote (PMV) −1.0 to +1.0. The calculated percentage of comfort hours is summarized for each location in the set of table presented in Appendix A. A close inspection of those values allows some observations to be made.

The analysis which has taken place has been driven by the need for information and guidance for those involved in designing and constructing dwellings in the villages of the region. In this the authors have the expectation that the information will be of most value to those connected to the "new" and "hybrid" styles rather than the older more traditional options.

Table 5 provides a summary of the data from Appendix A in the format of the maximum, minimum, and average percentage of comfort hours for each location.

Table 5. Variation in comfort hours—average, maximum and minimum values for each location from range of 108 parametric options studied (percentage annual values)—derived from Appendix A.

Location	Comfort Hours (%)			Optimum Comfort Hours Combination of Parameters
	Average	Maximum	Minimum	
CHONGQING				
Shapingba	23.8	28.7	21.1	lww+ins; low WWR; N; 1.0ach; G;
Youyang	26.2	31.3	22.3	lww+ins; low WWR; S; 0.5ach; G;
GUANGXI				
Hechi	21.0	25.2	18.5	lww+ins; low WWR; S; 0.5ach; G;
Longzhou	25.0	31.4	21.0	lww+ins; low WWR; S; 0.25ach; G;
Nanning	26.4	34.2	21.1	lww+ins; low WWR; S; 0.25ach; G;
GUIZHOU				
Bijie	28.1	39.6	21.8	lww+ins; low WWR; S; 0.25ach; G;
Guiyang	30.7	41.4	24.6	lww+ins; low WWR; S; 0.5ach; G;
Sansui	26.2	32.4	22.4	lww+ins; low WWR; N; 1.0ach; G;
SICHUAN				
Chengdu	28.2	35.4	23.1	lww+ins; low WWR; S; 0.5ach; G;
Huili	43.7	65.6	19.9	lww+ins; high WWR; S; 0.25ach; G;
Songpan	8.2	23.6	0.3	lww+ins; high WWR; W; 0.25ach; 1;
YUNNAN				
Deqen	4.5	20.7	0.0	lww+ins; high WWR; W; 0.25ach; 1;
Kunming	42.8	64.6	28.4	lww+ins; med WWR; N; 1.0ach; 1;
Mengla	36.0	51.4	23.7	lww+ins; low WWR; S; 1.0ach; G;
Yuanjiang	27.6	36.3	13.8	lww+ins; low WWR; S/N; 1.0ach; G;

Notes: Key to optimum comfort combinations: hww = heavyweight wall; lww = lightweight wall; +ins = with insulation; low, med, high WWR = low, medium, high window to wall ratios; N, S, E, W = main orientation North, South, East, West; 0.25ach/0.5ach/1.0ach = 0.25/0.5/1.0 air change rate per hour; G = ground floor, 1 = first (upper) floor.

Several outcomes can be identified from the tabulated data taken as a whole, however the authors believe that information of a general nature, can also be absorbed and adapted for use in specific locations by professions from that area.

Although building with significant amounts of insulation is not common in Southwest China for a large number of the climates investigated the highest proportions of comfort hours are often for a design making use of lightweight construction with insulation; indeed all of the optimum comfort combinations are shown in Table 5. That is not to say some other constructions can have value in certain locations and at certain times but overall it is possible to make the identification of the value of insulation finding 9 of this study.

The optimum window to wall ratio varied somewhat but in general the lowest ratio tested seemed to be frequently beneficial; finding 10 might therefore be to suggest lower window areas for providing suitable options to achieve comfort in many locations. The impact of orientation of the main façade varied according to the location as did the optimal air change rate and indicates scope for more detailed analysis. For most of the locations the floor level which yielded the higher comfort hours was the ground (lower) floor. At this stage there is insufficient analysis to identify the reason for this, which might be linked to the protection afforded by the floor above, but this again would be deserving of further investigation.

A consequence of encouragement to change the style and materials used in construction will be an impact on building materials being used; finding 11 is thus the need to assess and accommodate changes to building fabric needs in future years if more climate sensitive design is to flourish.

In addition to the above it also seems appropriate to add a final finding (finding 12) that in order to provide coherence, direction, and confidence for the future, design guidance in these topic areas needs to be produced. Further, in order to prove significant it needs to be advocated by practitioners and officials in order to make a step change to outcomes.

6. Discussion

6.1. Summary

The aim of the authors in carrying out the research reported in this paper was to first investigate important issues impinging on the design and construction of rural village dwellings in China and then to identify opportunities for change. Southwest China is a large and significant area with a number of characteristics which draw the provinces and areas together, these arise from climate and geography, culture, tourist potential and also to some important extent from the remoteness from the East Coast.

The research found a number of key influencing factors that need to be considered in supporting the development of more climate sensitive and robust dwellings in the region of study. This led to several focused areas of further enquiry which has resulted in the identification of recommendations within the findings listed (see Conclusions section below) and the need for more data to support local decision-making.

The paper has provided a significant amount of new data which suggest building climate-sensitive rural dwellings to be used by stakeholders. Since there seems to be more general movement from authorities to pass a greater level of responsibility to the end users then the provision of such advice is timely. Further the network of collaborators that was formed as a background to this research means that there are new avenues for dissemination and creating beneficial impacts.

The main outcome is that it is both possible and important to provide suitable guidance to those designing and constructing dwellings in rural villages in Southwest China. In this the guidance should be targeted particularly at the small scale and individual builder and developer as they are currently least well served by the systems in place. The focus on use of the information is also for use in guiding the design and construction of new dwellings, rather than renovation of older traditional styles. Although modifying the construction of a single dwelling will have limited impact, the sheer scale of change in China and the vast numbers involved mean that better choices for millions of new or renovated buildings can be communicated. The development and use of guidance information would have significant impacts in terms of energy use and material resources consumed.

Methods were applied consistently and with rigor in the various components of the research and the authors believe it makes a significant contribution to the development of knowledge and more importantly provides a foundation for the development of more formalized guidance and advice to stakeholders.

The outcomes while applicable to Southwest China also have potential for exploitation in rural areas of adjacent countries and areas—for instance Myanmar and Vietnam where similar weather exists and where there are also significant cultural and ethnic group influences.

6.2. Limitations

In any piece of multi-dimensional research there will be limitations and the authors have attempted to be clear about the processes they invoked in carrying out the research. Some of the limitations are set by the means of which stakeholders can be accessed by research workers and the types of techniques which are suitable for engaging in discussion with residents of sometimes remote villages. The number of people with whom it was possible to meet clearly represents a small subset of the total population, nevertheless the research team took care to try to ensure that they were indeed representative. The repetition of information in discussions across a wide geographical area and different ethnic backgrounds give credibility to the inferences drawn. The quantitative analyses were numerous and followed previous studies though of course many more iterations of the parametric simulations could be carried out. The research team intend to expand this in the future but suggest the variations in data input and ranges of data outputs suffice to demonstrate both the need for location specific research and that the methods yield useful outcomes that can inform stakeholders.

6.3. Further Work

It is the intention of the authors to work with collaborators and stakeholders to develop information in more detail in order to form a design guide document to be published which will also include examples of good practice. This guidance will be made available to professional and practitioners through research and practice network collaborators and through public dissemination activities. In so doing it should provide a source of information able to meet the gaps in knowledge identified within the research.

The parametric analyses can be extended to cover a greater number of variations in parameters and also in the reporting of outputs.

There is also considerable scope as more verified climate data records become available to extend the number of locations for which parametric analysis can be carried out to give a greater degree of discrimination between the summary of advice provided for different rural areas.

Visits to villages undergoing change are also worthy of development and are part of the ongoing research programme.

7. Conclusions

The purpose of this research was to understand the issues associated with the environmental design of dwellings for rural villages in Southwest China. The most important conclusion is that research into rural dwellings development is very much needed and that there are clearly identifiable requirements for additional guidance for stakeholders (both building residents and also local professional and industry staff).

The pressure for this comes from the changes in the ways in which the redevelopment process is being acted out. Rural villages in China sometimes have little contact with building and construction experts and thus when they need to make decisions about the redesign of their own home or community they are left with often only broad guiding principles or perhaps even misconceptions. In the process at the moment there is insufficient appreciation or differentiation in the support given for the fact that each village is different: there are differences in ethnic make-up; differences in intrinsic technical skills and understanding; differences in climate experienced (even from one side of a hill to another);

differences in resources and building materials available; and differences in wealth and economic outlook. Without more specific guidance documents and exemplars, the development process is likely to operate at sub-optimal levels and dwelling which are not tuned to the locality. Considering the ongoing development as part of the national rural revitalization strategies, such needs will continue and expand.

In terms of providing summary conclusions of the specific activities, in the main body of the text above a number of findings were identified, and these are collated below.

1. There is a general lack of information and support to enable the detailed environmental design and control of construction of village dwellings; something which is particularly acute in relation to self-building by village residents.
2. There is a need to offer some practical alternatives to demolition of older/deficient properties. Design and reconstruction guidance documents need to be available.
3. Alternatives to the simple "old vs. new" model of dwelling design can be found. Such hybrid designs seem to have the benefits of marrying the old to the new and striking a balance between tradition and modern convenience.
4. There are significant variations in embedded knowledge and skills within villages and sometimes a lack of community involvement in the redevelopment process. Villages with strong ethnic traits might have better potential to use intrinsic knowledge and skills.
5. Changes occurring to the social structure of villages could impede development in the future; and skills-based knowledge, understanding and practice needs to be supported and re-embedded within communities.
6. Discussions and survey indicated that there is substantial value in encouraging local residents, who are increasingly having to make design and construction decisions for themselves in their own locality, to use self-reflective questions to stimulate discussion and establish a community view.
7. There exists substantial potential to create comfort using passive bioclimatic design techniques.
8. Since many variations in optimal performance were observed for sites in SW China this means that making choices based on simple regional climatic zones is insufficient to support accurate decision-making and more localized outcomes ought to be addressed.
9. The use of insulation materials in the construction of dwellings would offer opportunities for better environmental performance.
10. The use of lower window to wall area ratios in dwelling design can have benefits in many locations.
11. The change in construction is likely to lead to a need for different availability of products used in building which could have further consequences.
12. Supporting design guidance and advocacy for its use is required from practitioners and official bodies.

Apart from the specific findings above it is also expected that the research and collaboration network that was established alongside the project will grow and enable more research, dissemination and particularly impact.

Author Contributions: Conceptualization, A.P. and Y.G.; methodology, A.P. and Y.G.; software utilization, V.T.L. and A.P.; validation, Adrian Pitts and Yun Gao.; formal analysis, A.P. and V.T.L.; investigation, A.P. and Y.G.; resources, A.P. and Y.G.; data curation, A.P. and Y.G.; writing—original draft preparation, A.P.; writing—review and editing A.P. and Y.G.; visualization, A.P. and Y.G.; supervision, A.P. and Y.G.; project administration, A.P. and Y.G.; funding acquisition, A.P. and Y.G.

Funding: This research was supported by the Arts and Humanities Research Council, UK, grant number AH/R004129/1 (Sustainable and Creative Village Research Network, SW China), and the University of Huddersfield. The APC was funded by The University of Huddersfield.

Acknowledgments: The authors acknowledge the multiple sources of help and support afforded through the Sustainable and Creative Village Research Network, SW China including but not limited to: Chongqing Jiaotong University (Distinguished Visiting Professors Programme); Yunnan Arts University; Guizou Minzu University; Kunming University of Science and Technology; the Chinese University of Hong Kong; Beijing University of

Technology; and Xian Jiaotong Liverpool University. They also acknowledge the help and support on many village leaders and residents contacted during the study

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

The following tables show values of percentage of comfort hours predicted using the EnergyPlus software package for the given combinations of building parameters for the 15 chosen sites within Southwest China.

Table A1. Chongqing—Shapingba; percentage annual comfort hours achieved.

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Heavyweight walls							
Low glazing	South	24.5%	22.9%	25.2%	23.3%	24.9%	22.1%
	North	24.6%	22.9%	25.2%	23.3%	25.0%	22.1%
	East	24.4%	22.7%	25.0%	23.2%	24.6%	21.9%
	West	24.4%	22.6%	25.0%	23.1%	24.6%	21.8%
Medium glazing	South	24.4%	22.7%	25.0%	23.2%	24.7%	22.0%
	North	24.4%	22.7%	25.0%	23.1%	24.8%	22.0%
	East	24.1%	22.4%	24.8%	22.7%	24.3%	21.7%
	West	24.1%	22.4%	24.7%	22.7%	24.3%	21.7%
High glazing	South	24.6%	22.5%	25.0%	23.1%	24.6%	22.1%
	North	24.4%	22.5%	24.9%	23.2%	24.6%	21.9%
	East	24.0%	22.2%	24.6%	22.7%	24.1%	21.7%
	West	24.1%	22.0%	24.6%	22.5%	24.1%	21.5%
Lightweight walls							
Low glazing	South	25.0%	23.0%	25.6%	23.5%	25.0%	22.2%
	North	25.0%	23.0%	25.6%	23.5%	25.0%	22.1%
	East	24.6%	22.8%	25.3%	23.2%	24.7%	21.8%
	West	24.7%	22.7%	25.3%	23.1%	24.8%	21.7%
Medium glazing	South	25.0%	22.9%	25.6%	23.3%	24.9%	22.0%
	North	24.9%	22.9%	25.6%	23.4%	24.9%	22.0%
	East	24.5%	22.5%	25.1%	23.0%	24.5%	21.6%
	West	24.5%	22.4%	25.1%	23.0%	24.5%	21.5%
High glazing	South	24.9%	22.7%	25.5%	23.3%	25.0%	21.8%
	North	24.8%	22.7%	25.4%	23.2%	25.0%	21.8%
	East	24.3%	22.2%	25.1%	22.6%	24.5%	21.3%
	West	24.1%	22.0%	24.8%	22.5%	24.3%	21.1%
Lightweight insulated walls							
Low glazing	South	26.8%	25.6%	28.1%	26.4%	28.6%	26.4%
	North	26.7%	25.4%	28.2%	26.3%	28.7%	26.1%
	East	25.7%	24.6%	27.2%	25.4%	27.5%	25.3%
	West	25.6%	24.4%	27.1%	25.2%	27.4%	25.3%
Medium glazing	South	26.0%	24.8%	27.3%	25.8%	27.5%	25.6%
	North	25.7%	24.6%	27.1%	25.7%	27.4%	25.5%
	East	24.9%	23.4%	26.1%	24.3%	26.2%	24.4%
	West	24.8%	23.0%	26.0%	24.0%	26.2%	24.0%
High glazing	South	25.4%	23.8%	26.6%	24.8%	26.7%	24.8%
	North	25.2%	23.6%	26.4%	24.7%	26.6%	24.7%
	East	24.1%	22.3%	25.5%	23.3%	25.5%	23.2%
	West	23.8%	21.8%	25.3%	23.0%	25.2%	22.8%

Table A2. Chongqing—ouyang; percentage annual comfort hours achieved.

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Heavyweight walls							
Low glazing	South	28.1%	24.6%	28.3%	25.1%	25.8%	23.8%
	North	28.0%	24.7%	28.2%	25.1%	25.8%	23.8%
	East	27.7%	24.4%	28.2%	24.9%	25.8%	23.6%
	West	27.7%	24.3%	28.1%	24.8%	25.8%	23.6%
Medium glazing	South	28.0%	24.3%	28.4%	25.0%	26.0%	23.7%
	North	27.9%	24.2%	28.3%	25.0%	25.9%	23.7%
	East	27.5%	24.1%	28.1%	24.7%	25.7%	23.6%
	West	27.4%	23.9%	28.0%	24.7%	25.5%	23.5%
High glazing	South	27.8%	24.0%	28.3%	24.8%	26.0%	23.6%
	North	27.7%	24.0%	28.2%	24.7%	25.9%	23.6%
	East	27.3%	23.7%	27.8%	24.5%	25.6%	23.3%
	West	27.1%	23.6%	27.7%	24.2%	25.6%	23.2%
Lightweight walls							
Low glazing	South	27.7%	23.8%	27.9%	24.6%	26.6%	23.3%
	North	27.6%	23.8%	27.9%	24.6%	26.4%	23.2%
	East	27.4%	23.6%	27.6%	24.3%	26.2%	22.9%
	West	27.3%	23.7%	27.5%	24.2%	26.2%	22.8%
Medium glazing	South	27.6%	23.6%	27.9%	24.2%	26.5%	23.1%
	North	27.5%	23.6%	27.7%	24.2%	26.4%	23.0%
	East	27.2%	23.2%	27.4%	23.9%	25.9%	22.7%
	West	27.1%	23.2%	27.4%	23.9%	25.8%	22.7%
High glazing	South	27.4%	23.2%	27.7%	23.9%	26.4%	23.0%
	North	27.3%	23.3%	27.7%	24.0%	26.3%	22.9%
	East	26.9%	22.9%	27.3%	23.6%	25.8%	22.8%
	West	26.8%	22.9%	27.2%	23.5%	25.7%	22.6%
Lightweight insulated walls							
Low glazing	South	30.1%	27.1%	31.3%	28.7%	29.8%	29.7%
	North	29.9%	27.0%	31.2%	28.8%	29.9%	29.5%
	East	29.2%	25.8%	30.8%	27.5%	28.8%	28.7%
	West	29.1%	25.4%	30.8%	27.2%	28.8%	28.5%
Medium glazing	South	29.0%	25.7%	30.8%	27.2%	29.3%	28.5%
	North	28.9%	25.8%	30.6%	27.4%	29.0%	28.4%
	East	27.5%	24.2%	29.8%	25.7%	28.4%	27.2%
	West	27.2%	23.7%	29.5%	25.3%	28.4%	26.8%
High glazing	South	27.9%	24.4%	29.5%	26.0%	29.1%	27.1%
	North	27.7%	24.5%	29.4%	26.2%	28.8%	27.0%
	East	26.1%	22.5%	28.3%	24.2%	27.9%	25.7%
	West	25.7%	22.3%	28.1%	23.7%	27.8%	25.2%

Table A3. Guangxi—Hechi; percentage annual comfort hours achieved.

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Heavyweight walls							
Low glazing	South	20.3%	19.2%	21.5%	19.9%	21.2%	19.2%
	North	20.3%	19.1%	21.5%	19.8%	21.2%	19.1%
	East	20.0%	19.0%	21.0%	19.4%	20.9%	18.9%
	West	19.9%	18.9%	21.0%	19.4%	20.9%	18.9%

Table A3. *Cont.*

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Medium glazing	South	20.4%	19.4%	21.3%	19.9%	21.1%	19.2%
	North	20.2%	19.2%	21.2%	19.7%	21.1%	19.1%
	East	19.9%	18.9%	20.7%	19.5%	20.5%	18.7%
	West	19.9%	19.0%	20.7%	19.4%	20.4%	18.7%
High glazing	South	20.5%	19.4%	21.3%	19.9%	20.9%	19.1%
	North	20.3%	19.4%	21.2%	19.8%	20.8%	19.0%
	East	20.0%	18.9%	20.6%	19.4%	20.0%	18.6%
	West	19.9%	18.9%	20.6%	19.3%	20.0%	18.5%
Lightweight walls							
Low glazing	South	21.1%	20.0%	21.6%	20.5%	22.0%	20.0%
	North	21.0%	19.9%	21.6%	20.4%	21.9%	19.8%
	East	20.7%	19.5%	21.3%	20.1%	21.4%	19.5%
	West	20.7%	19.5%	21.2%	20.1%	21.5%	19.6%
Medium glazing	South	21.2%	19.7%	21.7%	20.4%	21.8%	20.0%
	North	21.0%	19.8%	21.6%	20.4%	21.6%	19.9%
	East	20.3%	19.4%	21.1%	20.1%	21.1%	19.4%
	West	20.4%	19.2%	21.0%	19.8%	21.1%	19.4%
High glazing	South	21.2%	19.5%	21.9%	20.3%	21.6%	19.9%
	North	21.1%	19.6%	21.8%	20.3%	21.5%	19.9%
	East	20.4%	19.0%	21.1%	19.7%	20.9%	19.3%
	West	20.2%	18.8%	21.0%	19.7%	20.8%	19.2%
Lightweight insulated walls							
Low glazing	South	23.7%	24.3%	25.2%	24.7%	24.2%	23.2%
	North	23.5%	23.8%	25.0%	24.4%	24.3%	23.0%
	East	22.6%	22.4%	24.1%	23.1%	23.1%	21.6%
	West	22.4%	22.2%	23.9%	23.0%	23.0%	21.4%
Medium glazing	South	23.6%	23.3%	24.7%	24.1%	23.6%	22.6%
	North	23.1%	23.0%	24.2%	23.8%	23.3%	22.2%
	East	21.7%	21.5%	22.9%	22.1%	22.3%	20.7%
	West	21.7%	21.4%	22.8%	21.7%	22.1%	20.3%
High glazing	South	23.5%	22.3%	24.5%	23.1%	23.3%	22.0%
	North	23.0%	22.4%	23.9%	23.0%	23.0%	21.8%
	East	21.4%	21.0%	22.4%	21.3%	21.5%	20.0%
	West	21.2%	20.8%	22.1%	21.1%	21.2%	19.7%

Table A4. Guangxi—Longzhou; percentage annual comfort hours achieved.

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Heavyweight walls							
Low glazing	South	25.9%	23.7%	25.8%	23.9%	22.8%	22.4%
	North	25.8%	23.6%	25.7%	23.8%	22.7%	22.4%
	East	25.6%	23.4%	25.5%	23.7%	22.6%	22.2%
	West	25.7%	23.4%	25.5%	23.6%	22.5%	22.2%
Medium glazing	South	26.3%	23.3%	26.3%	23.6%	23.0%	22.3%
	North	26.0%	23.3%	26.0%	23.7%	22.8%	22.3%
	East	25.7%	23.1%	25.8%	23.3%	22.5%	21.9%
	West	25.7%	23.0%	25.8%	23.3%	22.5%	22.0%

Table A4. *Cont*.

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
High glazing	South	26.3%	22.9%	26.5%	23.2%	23.4%	22.2%
	North	26.2%	23.0%	26.2%	23.3%	23.0%	22.2%
	East	25.7%	22.7%	25.8%	23.0%	22.6%	21.9%
	West	25.5%	22.5%	25.7%	22.8%	22.7%	21.7%
Lightweight walls							
Low glazing	South	25.5%	22.6%	26.0%	22.8%	23.8%	22.3%
	North	25.4%	22.5%	25.9%	22.8%	23.7%	22.2%
	East	25.1%	22.2%	25.5%	22.5%	23.2%	22.0%
	West	25.1%	22.2%	25.5%	22.4%	23.2%	21.8%
Medium glazing	South	25.3%	22.2%	25.9%	22.6%	24.2%	22.1%
	North	25.3%	22.4%	25.8%	22.6%	23.8%	22.2%
	East	24.9%	22.0%	25.3%	22.2%	23.2%	21.6%
	West	24.8%	21.8%	25.1%	22.1%	23.2%	21.5%
High glazing	South	25.0%	21.9%	25.5%	22.2%	24.0%	21.8%
	North	25.0%	22.2%	25.5%	22.4%	24.0%	21.9%
	East	24.5%	21.7%	24.9%	22.0%	22.9%	21.3%
	West	24.4%	21.5%	24.8%	21.7%	22.9%	21.0%
Lightweight insulated walls							
Low glazing	South	31.4%	29.9%	30.3%	30.5%	27.0%	27.6%
	North	31.0%	30.2%	29.7%	30.8%	26.4%	27.3%
	East	30.4%	29.7%	29.1%	29.8%	25.4%	26.4%
	West	30.2%	29.3%	29.1%	29.5%	25.5%	26.3%
Medium glazing	South	30.2%	28.2%	29.6%	28.7%	26.6%	26.5%
	North	30.3%	28.9%	29.6%	29.2%	26.4%	26.7%
	East	29.7%	28.2%	28.7%	28.4%	25.3%	25.5%
	West	29.2%	27.8%	28.4%	27.9%	25.2%	25.1%
High glazing	South	29.2%	25.7%	28.8%	26.6%	26.3%	25.3%
	North	29.3%	27.5%	28.8%	27.7%	26.1%	25.7%
	East	28.6%	26.5%	27.9%	27.0%	25.0%	24.5%
	West	28.3%	26.1%	27.7%	26.5%	24.8%	24.1%

Table A5. Guangxi—Nanning; percentage annual comfort hours achieved.

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Heavyweight walls							
Low glazing	South	26.5%	23.9%	26.5%	24.1%	22.7%	21.6%
	North	26.4%	23.8%	26.4%	23.9%	22.5%	21.5%
	East	26.0%	23.5%	26.0%	23.5%	22.2%	21.2%
	West	26.1%	23.6%	25.9%	23.6%	22.3%	21.3%
Medium glazing	South	26.9%	24.1%	26.9%	24.3%	22.9%	21.8%
	North	26.7%	23.9%	26.7%	24.1%	22.7%	21.5%
	East	26.1%	23.6%	26.2%	23.8%	22.3%	21.2%
	West	26.1%	23.6%	26.2%	23.7%	22.2%	21.2%
High glazing	South	27.3%	24.3%	27.2%	24.3%	23.2%	22.1%
	North	26.9%	24.0%	26.9%	24.1%	23.0%	21.7%
	East	26.2%	23.7%	26.2%	23.7%	22.2%	21.3%
	West	26.2%	23.6%	26.1%	23.7%	22.2%	21.3%

Table A5. *Cont.*

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Lightweight walls							
Low glazing	South	26.6%	24.0%	26.6%	24.2%	23.6%	23.0%
	North	26.4%	23.9%	26.3%	24.2%	23.5%	22.8%
	East	25.9%	23.7%	25.9%	24.0%	23.0%	22.3%
	West	25.9%	23.7%	25.9%	23.8%	21.7%	21.1%
Medium glazing	South	27.0%	24.0%	26.9%	24.2%	24.0%	23.0%
	North	26.7%	23.9%	26.5%	24.2%	23.8%	23.0%
	East	26.2%	23.5%	26.1%	23.7%	23.1%	22.2%
	West	26.1%	23.4%	26.1%	23.7%	23.0%	22.2%
High glazing	South	27.2%	23.8%	27.1%	24.2%	24.2%	23.0%
	North	27.0%	23.7%	26.8%	24.1%	23.8%	22.8%
	East	26.3%	23.1%	26.3%	23.5%	23.0%	22.0%
	West	26.2%	23.1%	26.1%	23.4%	23.0%	22.0%
Lightweight insulated walls							
Low glazing	South	34.2%	33.2%	33.4%	33.6%	28.9%	30.5%
	North	33.4%	33.1%	32.6%	33.2%	28.4%	29.9%
	East	32.3%	32.0%	31.6%	32.0%	27.3%	28.3%
	West	32.2%	31.9%	31.5%	31.8%	27.2%	28.3%
Medium glazing	South	34.0%	31.6%	33.5%	32.5%	29.8%	30.5%
	North	33.4%	31.9%	32.8%	32.4%	28.8%	29.6%
	East	32.1%	30.8%	31.7%	31.1%	27.6%	28.2%
	West	31.8%	30.4%	31.4%	30.8%	27.5%	28.0%
High glazing	South	32.7%	30.0%	33.0%	30.9%	29.7%	29.7%
	North	32.6%	30.8%	32.6%	31.3%	29.0%	29.3%
	East	31.3%	29.5%	31.2%	29.9%	27.3%	27.4%
	West	30.9%	29.1%	30.9%	29.6%	27.2%	27.4%

Table A6. Guizhou—Bijie; percentage annual comfort hours achieved.

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Heavyweight walls							
Low glazing	South	28.8%	25.6%	28.4%	25.7%	24.8%	23.0%
	North	28.7%	25.6%	28.4%	25.8%	24.8%	23.0%
	East	28.1%	25.1%	28.1%	25.4%	24.6%	22.9%
	West	28.0%	25.2%	27.9%	25.3%	24.5%	22.8%
Medium glazing	South	28.8%	25.7%	28.9%	25.8%	25.0%	23.1%
	North	28.8%	25.6%	28.7%	25.7%	25.0%	23.0%
	East	28.0%	25.1%	28.1%	25.3%	24.7%	22.8%
	West	27.8%	25.0%	27.9%	25.3%	24.5%	22.6%
High glazing	South	28.8%	25.9%	29.0%	25.9%	25.2%	23.2%
	North	28.8%	25.8%	29.0%	25.9%	25.2%	23.2%
	East	27.6%	25.0%	27.8%	25.2%	24.8%	22.7%
	West	27.5%	25.0%	27.8%	25.2%	24.5%	22.6%
Lightweight walls							
Low glazing	South	28.4%	25.5%	28.0%	25.5%	24.3%	22.2%
	North	28.3%	25.4%	28.0%	25.4%	24.3%	22.1%
	East	28.0%	25.2%	27.5%	25.2%	23.9%	22.0%
	West	28.0%	25.0%	27.5%	25.1%	23.8%	21.9%

Table A6. *Cont.*

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Medium glazing	South	28.7%	25.5%	28.3%	25.6%	24.4%	22.2%
	North	28.6%	25.5%	28.3%	25.6%	24.4%	22.1%
	East	28.0%	25.0%	27.9%	25.1%	23.8%	21.9%
	West	27.9%	24.7%	27.7%	24.9%	23.7%	21.9%
High glazing	South	28.8%	25.4%	28.4%	25.4%	24.4%	22.5%
	North	28.7%	25.4%	28.3%	25.4%	24.3%	22.4%
	East	28.0%	24.5%	27.8%	24.8%	23.9%	22.0%
	West	28.1%	24.5%	27.9%	24.6%	23.8%	21.8%
Lightweight insulated walls							
Low glazing	South	39.4%	34.4%	38.8%	36.7%	29.2%	33.4%
	North	39.3%	34.1%	38.6%	36.4%	29.0%	33.3%
	East	36.2%	31.7%	36.8%	33.5%	28.8%	30.9%
	West	35.7%	31.4%	36.4%	33.1%	28.7%	30.5%
Medium glazing	South	38.0%	33.6%	38.4%	35.6%	30.3%	32.9%
	North	37.8%	33.0%	38.3%	35.2%	30.1%	32.4%
	East	33.9%	30.5%	35.5%	31.8%	29.2%	29.8%
	West	33.4%	30.2%	35.0%	31.3%	28.9%	29.5%
High glazing	South	36.4%	32.6%	37.2%	34.5%	30.5%	32.1%
	North	36.1%	32.2%	36.9%	34.2%	30.3%	31.7%
	East	32.2%	28.9%	33.7%	30.0%	28.8%	28.5%
	West	31.9%	28.6%	33.3%	29.6%	28.6%	27.9%

Table A7. Guizhou—Guiyang; percentage annual comfort hours achieved.

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Heavyweight walls							
Low glazing	South	32.2%	27.2%	33.6%	28.1%	32.0%	26.5%
	North	32.1%	27.0%	33.6%	28.1%	32.0%	26.4%
	East	31.6%	26.5%	32.9%	27.6%	31.6%	26.1%
	West	31.4%	26.4%	32.6%	27.4%	31.4%	26.0%
Medium glazing	South	32.1%	27.0%	33.2%	27.9%	31.8%	26.5%
	North	31.9%	26.9%	33.0%	27.7%	31.7%	26.3%
	East	31.0%	26.1%	32.3%	27.2%	31.1%	25.9%
	West	30.6%	26.0%	32.1%	27.0%	30.7%	25.6%
High glazing	South	31.7%	26.9%	33.1%	27.7%	31.5%	26.3%
	North	31.6%	26.8%	33.0%	27.5%	31.5%	26.2%
	East	30.2%	25.7%	31.7%	26.7%	30.5%	25.4%
	West	29.9%	25.4%	31.4%	26.4%	30.0%	25.1%
Lightweight walls							
Low glazing	South	32.5%	27.4%	33.3%	28.0%	30.6%	26.1%
	North	32.3%	27.2%	33.3%	27.9%	30.5%	26.0%
	East	31.6%	26.8%	32.5%	27.4%	30.1%	25.6%
	West	31.5%	26.6%	32.4%	27.3%	29.9%	25.4%
Medium glazing	South	32.0%	27.2%	33.0%	27.8%	30.4%	26.0%
	North	31.9%	27.1%	32.8%	27.5%	30.3%	25.8%
	East	31.2%	26.4%	32.1%	27.1%	29.7%	25.2%
	West	30.9%	26.1%	31.9%	26.8%	29.3%	25.1%

Table A7. *Cont.*

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
High glazing	South	31.9%	27.1%	32.8%	27.7%	30.3%	25.8%
	North	31.7%	26.9%	32.6%	27.6%	30.1%	25.6%
	East	30.4%	26.1%	31.4%	26.7%	29.2%	24.9%
	West	30.2%	25.5%	31.2%	26.4%	28.9%	24.6%
Lightweight insulated walls							
Low glazing	South	40.5%	35.5%	41.4%	36.7%	37.4%	35.6%
	North	40.3%	34.9%	41.2%	36.0%	37.3%	35.4%
	East	37.1%	32.5%	38.5%	33.4%	35.9%	32.3%
	West	36.1%	32.0%	37.6%	32.6%	35.6%	31.3%
Medium glazing	South	38.2%	33.7%	39.4%	35.0%	36.7%	33.8%
	North	37.6%	33.0%	39.0%	34.1%	36.5%	33.0%
	East	34.2%	30.3%	35.9%	31.2%	34.6%	29.6%
	West	33.2%	29.4%	34.7%	30.1%	33.8%	28.2%
High glazing	South	36.2%	31.8%	37.9%	32.9%	35.6%	32.3%
	North	35.4%	31.3%	37.2%	32.4%	35.2%	31.5%
	East	32.0%	28.3%	33.4%	29.1%	32.7%	27.4%
	West	31.2%	27.6%	32.3%	28.2%	32.2%	26.1%

Table A8. Guizhou—Sansui; percentage annual comfort hours achieved.

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Heavyweight walls							
Low glazing	South	26.6%	23.9%	27.6%	24.4%	26.5%	23.3%
	North	26.6%	23.9%	27.6%	24.4%	26.4%	23.2%
	East	26.1%	23.7%	27.1%	24.0%	26.2%	22.8%
	West	26.1%	23.7%	27.1%	24.0%	26.2%	22.8%
Medium glazing	South	26.5%	23.9%	27.4%	24.3%	26.6%	23.3%
	North	26.4%	23.8%	27.3%	24.2%	26.5%	23.1%
	East	25.9%	23.5%	26.9%	23.8%	26.1%	22.6%
	West	25.9%	23.5%	26.8%	23.8%	26.1%	22.6%
High glazing	South	26.3%	23.8%	27.2%	24.3%	26.4%	23.2%
	North	26.3%	23.7%	27.2%	24.2%	26.3%	23.0%
	East	25.7%	23.2%	26.4%	23.7%	25.7%	22.4%
	West	25.7%	23.2%	26.3%	23.5%	25.7%	22.4%
Lightweight walls							
Low glazing	South	27.4%	24.0%	28.4%	24.7%	26.8%	23.3%
	North	27.5%	24.1%	28.3%	24.8%	26.8%	23.3%
	East	26.8%	23.7%	27.9%	24.2%	26.4%	23.0%
	West	26.9%	23.7%	27.9%	24.1%	26.3%	23.1%
Medium glazing	South	27.4%	24.0%	28.4%	24.5%	26.7%	23.4%
	North	27.2%	23.9%	28.3%	24.5%	26.6%	23.3%
	East	26.7%	23.5%	27.7%	23.8%	26.0%	22.9%
	West	26.6%	23.4%	27.7%	23.7%	26.0%	22.8%
High glazing	South	27.2%	24.0%	28.5%	24.2%	26.4%	23.5%
	North	27.1%	23.9%	28.3%	24.2%	26.3%	23.4%
	East	26.3%	23.1%	27.2%	23.6%	25.8%	22.6%
	West	26.3%	23.0%	27.2%	23.6%	25.7%	22.6%

Table A8. *Cont.*

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Lightweight insulated walls							
Low glazing	South	30.3%	27.9%	32.3%	28.9%	32.4%	29.1%
	North	30.3%	27.5%	32.2%	28.6%	32.4%	28.9%
	East	29.4%	26.9%	30.8%	27.8%	31.0%	27.5%
	West	29.2%	26.7%	30.6%	27.7%	30.9%	27.5%
Medium glazing	South	29.2%	26.9%	31.1%	28.3%	31.3%	28.3%
	North	28.9%	26.6%	30.8%	28.0%	31.3%	27.9%
	East	27.9%	25.4%	29.4%	26.5%	29.3%	26.5%
	West	27.7%	25.0%	29.2%	26.2%	29.1%	26.4%
High glazing	South	28.6%	25.5%	30.1%	26.9%	30.4%	27.6%
	North	28.2%	25.5%	29.7%	26.6%	30.2%	27.3%
	East	27.0%	23.7%	28.4%	25.2%	28.2%	25.3%
	West	26.8%	23.3%	28.2%	24.7%	27.9%	24.9%

Table A9. Sichuan—Chengdu; percentage annual comfort hours achieved.

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Heavyweight walls							
Low glazing	South	28.5%	25.9%	29.1%	26.1%	26.6%	24.0%
	North	28.6%	25.8%	28.9%	26.0%	26.6%	24.0%
	East	28.2%	25.6%	28.6%	25.8%	26.4%	23.8%
	West	28.1%	25.7%	28.8%	25.8%	26.4%	23.8%
Medium glazing	South	28.3%	25.9%	29.0%	26.0%	26.7%	24.0%
	North	28.2%	25.7%	28.9%	25.9%	26.6%	23.9%
	East	27.9%	25.7%	28.4%	25.7%	26.2%	23.6%
	West	27.8%	25.5%	28.4%	25.6%	26.3%	23.6%
High glazing	South	28.5%	26.0%	29.0%	26.1%	26.6%	23.9%
	North	28.3%	25.9%	29.1%	26.0%	26.5%	23.8%
	East	27.8%	25.5%	28.3%	25.5%	26.2%	23.5%
	West	27.8%	25.5%	28.3%	25.5%	26.2%	23.5%
Lightweight walls							
Low glazing	South	28.8%	25.8%	29.0%	25.9%	27.3%	24.1%
	North	28.7%	25.7%	28.9%	25.8%	27.2%	24.0%
	East	28.2%	25.3%	28.6%	25.7%	26.8%	23.6%
	West	28.3%	25.3%	28.6%	25.5%	26.8%	23.6%
Medium glazing	South	28.7%	25.7%	29.0%	25.9%	27.2%	24.0%
	North	28.6%	25.6%	28.9%	25.8%	27.1%	24.0%
	East	28.1%	25.1%	28.4%	25.3%	26.5%	23.4%
	West	28.1%	24.9%	28.4%	25.3%	26.6%	23.4%
High glazing	South	29.2%	25.6%	29.2%	25.9%	27.3%	24.1%
	North	29.0%	25.6%	29.0%	25.8%	27.2%	23.9%
	East	28.2%	24.9%	28.4%	25.3%	26.4%	23.3%
	West	28.1%	24.8%	28.4%	25.1%	26.4%	23.1%
Lightweight insulated walls							
Low glazing	South	34.9%	33.5%	35.4%	34.7%	34.2%	32.1%
	North	34.7%	33.3%	35.3%	34.3%	34.1%	31.9%
	East	33.8%	32.3%	34.4%	33.2%	32.6%	30.7%
	West	33.7%	32.1%	34.4%	33.1%	32.7%	30.6%

Table A9. *Cont.*

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Medium glazing	South	34.5%	32.8%	34.9%	33.6%	33.6%	31.9%
	North	34.2%	32.5%	34.5%	33.3%	33.2%	31.4%
	East	33.1%	31.2%	33.6%	32.0%	31.5%	29.9%
	West	32.8%	30.7%	33.5%	31.6%	31.5%	29.7%
High glazing	South	33.8%	32.2%	34.5%	32.6%	32.8%	31.0%
	North	33.6%	31.8%	34.2%	32.3%	32.4%	30.6%
	East	32.2%	30.0%	32.8%	30.6%	30.5%	28.8%
	West	31.9%	29.7%	32.6%	30.2%	30.4%	28.3%

Table A10. Sichuan—Huili; percentage annual comfort hours achieved.

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Heavyweight walls							
Low glazing	South	46.9%	40.4%	45.5%	40.5%	35.8%	36.1%
	North	46.7%	40.2%	45.2%	40.3%	35.7%	35.9%
	East	46.7%	39.6%	45.3%	39.7%	36.2%	35.5%
	West	46.3%	39.4%	45.2%	39.5%	36.2%	35.4%
Medium glazing	South	47.7%	40.5%	46.2%	40.6%	37.0%	36.3%
	North	47.1%	40.0%	45.7%	40.1%	36.7%	35.9%
	East	46.8%	39.0%	46.1%	39.3%	37.1%	35.3%
	West	46.6%	39.0%	45.5%	39.1%	36.9%	35.1%
High glazing	South	48.5%	40.4%	47.2%	40.6%	37.7%	36.2%
	North	47.8%	39.9%	46.5%	40.1%	37.3%	35.8%
	East	47.1%	38.9%	46.2%	39.0%	38.0%	35.1%
	West	47.0%	38.4%	46.0%	38.8%	37.7%	35.0%
Lightweight walls							
Low glazing	South	44.9%	37.6%	43.5%	37.5%	34.3%	32.8%
	North	44.5%	37.3%	43.1%	37.2%	34.0%	32.5%
	East	44.4%	36.6%	43.0%	36.6%	34.6%	32.4%
	West	44.4%	36.6%	43.0%	36.4%	34.5%	32.2%
Medium glazing	South	45.9%	37.9%	44.6%	37.6%	35.2%	33.1%
	North	45.2%	37.2%	43.9%	37.1%	34.8%	32.6%
	East	44.8%	36.5%	43.7%	36.3%	35.5%	32.6%
	West	44.6%	36.5%	43.5%	36.3%	35.4%	32.6%
High glazing	South	46.8%	38.1%	45.3%	37.9%	20.2%	29.6%
	North	46.0%	37.3%	44.5%	37.2%	19.9%	29.0%
	East	44.9%	36.5%	44.1%	36.2%	22.4%	29.1%
	West	44.5%	36.3%	43.8%	36.2%	22.4%	28.8%
Lightweight insulated walls							
Low glazing	South	57.7%	61.1%	53.4%	60.5%	40.2%	52.0%
	North	56.0%	58.3%	52.3%	58.1%	39.5%	50.2%
	East	56.9%	52.7%	54.2%	54.1%	42.5%	50.1%
	West	56.9%	52.2%	54.5%	53.5%	42.8%	50.1%
Medium glazing	South	62.2%	63.3%	58.0%	62.9%	43.9%	55.0%
	North	59.2%	57.2%	55.5%	57.7%	42.5%	52.0%
	East	56.8%	48.6%	55.8%	50.7%	45.6%	49.0%
	West	56.8%	47.6%	55.6%	49.6%	46.0%	48.3%
High glazing	South	65.6%	62.2%	61.7%	62.9%	47.2%	57.0%
	North	60.4%	56.7%	57.8%	57.2%	45.2%	51.8%
	East	55.1%	44.9%	55.0%	46.8%	47.1%	45.9%
	West	54.4%	44.5%	54.9%	46.1%	46.9%	45.3%

Table A11. Sichuan—Songpan; percentage annual comfort hours achieved.

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Heavyweight walls							
Low glazing	South	4.2%	10.1%	3.2%	9.6%	0.7%	6.7%
	North	4.1%	10.1%	3.2%	9.6%	0.7%	6.7%
	East	4.6%	10.5%	3.8%	9.9%	1.2%	7.0%
	West	4.8%	10.6%	3.9%	10.0%	1.3%	7.1%
Medium glazing	South	4.9%	10.5%	3.9%	10.0%	1.3%	7.0%
	North	4.8%	10.5%	3.9%	9.9%	1.2%	7.0%
	East	5.6%	11.1%	4.5%	10.4%	1.7%	7.5%
	West	5.8%	11.1%	4.9%	10.5%	2.0%	7.6%
High glazing	South	5.5%	10.8%	4.6%	10.3%	1.7%	7.5%
	North	5.4%	10.8%	4.5%	10.2%	1.6%	7.4%
	East	6.6%	11.5%	5.4%	10.9%	2.4%	8.1%
	West	6.9%	11.7%	5.7%	11.1%	2.7%	8.1%
Lightweight walls							
Low glazing	South	5.1%	10.6%	4.3%	10.0%	1.9%	7.5%
	North	5.0%	10.5%	4.2%	10.0%	1.8%	7.4%
	East	5.6%	10.9%	4.7%	10.4%	2.3%	7.8%
	West	5.8%	10.9%	4.9%	10.5%	2.5%	7.9%
Medium glazing	South	5.8%	10.9%	4.8%	10.5%	2.4%	7.9%
	North	5.7%	10.8%	4.7%	10.4%	2.3%	7.8%
	East	6.6%	11.2%	5.6%	10.7%	3.0%	8.2%
	West	7.0%	11.2%	5.9%	10.7%	3.2%	8.4%
High glazing	South	6.4%	11.4%	5.6%	10.9%	3.0%	8.2%
	North	6.3%	11.2%	5.4%	10.7%	2.8%	8.2%
	East	7.7%	11.6%	6.6%	11.2%	3.5%	8.5%
	West	8.0%	11.6%	7.0%	11.2%	3.9%	8.5%
Lightweight insulated walls							
Low glazing	South	6.0%	15.1%	3.8%	12.4%	0.4%	5.1%
	North	5.5%	14.9%	3.5%	12.1%	0.3%	4.7%
	East	9.2%	19.1%	6.0%	16.1%	1.5%	7.9%
	West	9.5%	19.8%	6.4%	16.7%	1.9%	8.5%
Medium glazing	South	7.8%	17.1%	5.3%	14.4%	1.2%	6.9%
	North	7.1%	16.4%	4.8%	13.7%	1.0%	6.3%
	East	11.9%	21.5%	8.5%	18.8%	3.0%	10.9%
	West	12.7%	22.1%	9.0%	19.7%	3.4%	11.6%
High glazing	South	10.0%	18.9%	7.3%	16.5%	2.8%	9.1%
	North	9.4%	18.0%	6.7%	15.7%	2.4%	8.4%
	East	15.0%	23.1%	11.3%	21.0%	4.8%	14.0%
	West	15.8%	23.6%	12.0%	21.5%	5.4%	14.5%

Table A12. Yunnan—Deqen; percentage annual comfort hours achieved.

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Heavyweight walls							
Low glazing	South	0.5%	6.4%	0.3%	5.9%	0.0%	3.2%
	North	0.4%	6.3%	0.3%	5.8%	0.0%	3.2%
	East	0.9%	7.1%	0.5%	6.5%	0.0%	3.8%
	West	1.0%	7.2%	0.6%	6.7%	0.0%	3.9%

Table A12. *Cont.*

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Medium glazing	South	0.5%	6.7%	0.3%	6.1%	0.0%	3.4%
	North	0.6%	6.6%	0.3%	6.1%	0.0%	3.4%
	East	1.2%	7.5%	0.7%	7.1%	0.0%	4.2%
	West	1.5%	7.8%	1.0%	7.4%	0.1%	4.5%
High glazing	South	1.0%	7.5%	0.5%	7.0%	0.0%	4.0%
	North	1.0%	7.3%	0.5%	6.9%	0.0%	3.9%
	East	1.8%	8.4%	1.3%	7.9%	0.2%	4.9%
	West	2.3%	8.7%	1.6%	8.2%	0.4%	5.3%
Lightweight walls							
Low glazing	South	1.3%	8.1%	0.9%	7.6%	0.1%	4.9%
	North	1.3%	8.0%	0.9%	7.6%	0.1%	4.9%
	East	1.6%	8.6%	1.3%	8.2%	0.2%	5.7%
	West	1.9%	8.7%	1.4%	8.3%	0.3%	5.8%
Medium glazing	South	1.5%	8.8%	1.2%	8.2%	0.1%	5.5%
	North	1.5%	8.6%	1.2%	8.1%	0.1%	5.4%
	East	2.3%	9.4%	1.8%	8.8%	0.5%	6.3%
	West	2.7%	9.5%	2.1%	9.0%	0.7%	6.4%
High glazing	South	2.0%	9.2%	1.6%	8.7%	0.3%	6.2%
	North	2.0%	9.1%	1.6%	8.6%	0.3%	6.0%
	East	3.3%	10.0%	2.6%	9.5%	0.9%	7.0%
	West	3.8%	10.1%	3.1%	9.6%	1.1%	7.3%
Lightweight insulated walls							
Low glazing	South	0.1%	6.3%	0.0%	4.3%	0.0%	0.4%
	North	0.1%	5.9%	0.0%	4.0%	0.0%	0.4%
	East	2.0%	11.8%	0.9%	8.7%	0.0%	2.5%
	West	2.4%	12.5%	1.3%	9.6%	0.1%	3.1%
Medium glazing	South	1.4%	9.9%	0.7%	7.5%	0.0%	2.0%
	North	1.3%	9.1%	0.6%	6.9%	0.0%	1.7%
	East	4.8%	16.2%	2.9%	13.5%	0.4%	5.6%
	West	5.8%	17.4%	3.7%	14.7%	0.8%	6.8%
High glazing	South	3.6%	12.5%	2.1%	10.3%	0.1%	4.3%
	North	3.1%	11.7%	1.8%	9.5%	0.1%	3.7%
	East	8.3%	19.7%	5.6%	17.5%	1.4%	9.3%
	West	9.3%	20.7%	6.6%	18.4%	1.9%	10.6%

Table A13. Yunnan—Kunming; percentage annual comfort hours achieved.

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Heavyweight walls							
Low glazing	South	48.0%	41.3%	44.9%	40.8%	31.3%	35.5%
	North	47.6%	41.1%	44.6%	40.5%	31.0%	35.2%
	East	48.1%	40.6%	45.4%	40.1%	32.3%	34.9%
	West	48.0%	40.4%	45.5%	40.0%	32.8%	34.9%
Medium glazing	South	48.7%	41.4%	46.0%	40.8%	32.8%	35.6%
	North	48.0%	40.9%	45.4%	40.4%	32.2%	35.1%
	East	48.5%	40.1%	46.1%	39.9%	33.8%	34.9%
	West	48.2%	39.7%	46.1%	39.8%	34.5%	34.6%

Table A13. *Cont.*

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
High glazing	South	49.3%	41.2%	46.5%	40.8%	34.1%	35.6%
	North	48.6%	40.6%	45.9%	40.2%	33.4%	35.1%
	East	48.3%	39.4%	46.4%	39.3%	35.2%	34.8%
	West	48.0%	38.9%	46.1%	38.7%	35.6%	34.4%
Lightweight walls							
Low glazing	South	45.8%	38.0%	43.2%	37.3%	29.8%	31.2%
	North	45.4%	37.5%	42.7%	36.8%	29.4%	31.0%
	East	45.4%	37.0%	43.2%	36.5%	30.8%	31.0%
	West	45.2%	36.7%	43.2%	36.4%	31.1%	30.8%
Medium glazing	South	46.5%	38.2%	44.1%	37.6%	31.1%	31.5%
	North	45.8%	37.3%	43.3%	37.0%	30.5%	30.9%
	East	45.4%	36.4%	43.6%	36.1%	32.0%	30.9%
	West	45.0%	36.3%	43.4%	36.1%	32.2%	30.8%
High glazing	South	47.1%	38.5%	44.7%	37.8%	32.2%	32.0%
	North	46.0%	37.3%	43.8%	36.8%	31.5%	31.1%
	East	45.0%	36.2%	43.6%	35.8%	32.8%	30.8%
	West	44.8%	36.2%	43.3%	35.7%	33.0%	30.7%
Lightweight insulated walls							
Low glazing	South	53.5%	61.8%	48.7%	58.8%	29.5%	47.6%
	North	52.1%	59.0%	47.4%	56.6%	28.4%	46.1%
	East	54.5%	56.6%	50.1%	56.1%	33.0%	49.0%
	West	55.5%	55.6%	51.0%	55.3%	34.7%	49.0%
Medium glazing	South	55.5%	64.6%	50.8%	62.2%	33.1%	51.3%
	North	53.0%	58.5%	48.8%	56.9%	31.3%	47.8%
	East	55.4%	52.1%	51.9%	52.9%	36.9%	48.3%
	West	55.9%	51.1%	52.8%	51.5%	38.9%	47.7%
High glazing	South	58.6%	62.4%	53.2%	61.7%	35.8%	53.6%
	North	54.1%	57.3%	50.1%	56.6%	34.1%	48.7%
	East	54.7%	47.7%	52.3%	48.8%	39.8%	45.8%
	West	54.2%	46.3%	52.5%	47.5%	40.8%	44.8%

Table A14. Yunnan—Mengla; percentage annual comfort hours achieved.

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Heavyweight walls							
Low glazing	South	37.6%	32.0%	38.5%	33.1%	41.5%	34.5%
	North	37.4%	32.0%	38.2%	33.2%	41.3%	34.5%
	East	36.8%	31.7%	37.4%	32.6%	40.0%	33.4%
	West	36.7%	31.6%	37.3%	32.5%	40.1%	33.4%
Medium glazing	South	37.2%	31.1%	38.2%	32.4%	41.9%	34.1%
	North	37.1%	31.4%	38.0%	32.8%	41.5%	34.2%
	East	36.4%	30.8%	37.0%	32.0%	39.6%	32.9%
	West	36.1%	30.4%	36.8%	31.5%	39.6%	32.7%
High glazing	South	37.0%	30.0%	37.9%	31.5%	41.3%	33.3%
	North	36.7%	30.5%	37.7%	32.0%	40.9%	33.6%
	East	35.9%	29.9%	36.6%	30.9%	38.5%	32.1%
	West	35.6%	29.2%	36.3%	30.5%	38.1%	31.5%

Table A14. *Cont.*

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Lightweight walls							
Low glazing	South	37.0%	30.7%	38.8%	32.5%	44.4%	35.3%
	North	36.8%	30.8%	38.6%	32.7%	44.3%	35.4%
	East	35.8%	30.3%	37.6%	31.9%	42.6%	34.3%
	West	35.8%	30.1%	37.5%	31.5%	42.5%	34.1%
Medium glazing	South	36.8%	29.9%	38.7%	32.0%	44.2%	34.7%
	North	36.6%	30.5%	38.6%	32.1%	43.9%	34.9%
	East	35.3%	29.5%	36.9%	30.8%	41.7%	33.3%
	West	35.1%	29.2%	36.8%	30.5%	41.6%	33.0%
High glazing	South	35.8%	29.2%	38.0%	31.1%	43.4%	33.9%
	North	36.1%	29.5%	38.1%	31.5%	43.2%	34.1%
	East	34.8%	28.5%	36.2%	29.8%	40.5%	32.1%
	West	34.2%	28.2%	35.8%	29.5%	40.2%	31.7%
Lightweight insulated walls							
Low glazing	South	42.6%	34.1%	46.2%	38.3%	51.4%	41.7%
	North	43.7%	36.1%	46.3%	40.0%	50.8%	41.4%
	East	41.5%	34.5%	44.3%	37.4%	45.0%	38.5%
	West	40.9%	33.7%	43.8%	36.7%	44.3%	38.1%
Medium glazing	South	38.1%	27.6%	43.2%	31.9%	47.9%	37.9%
	North	40.2%	32.1%	44.3%	36.2%	46.9%	39.3%
	East	38.0%	30.4%	41.6%	33.4%	41.3%	36.5%
	West	36.9%	28.9%	40.9%	32.1%	40.3%	35.6%
High glazing	South	33.4%	23.7%	39.0%	27.7%	43.9%	33.2%
	North	37.1%	28.0%	41.3%	31.6%	43.9%	36.1%
	East	34.4%	26.4%	38.4%	29.6%	38.8%	32.9%
	West	33.2%	25.3%	37.4%	28.4%	38.0%	31.6%

Table A15. Yunnan—Yuanjiang; percentage annual comfort hours achieved.

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Heavyweight walls							
Low glazing	South	31.2%	26.6%	32.5%	27.9%	30.5%	27.0%
	North	31.3%	26.8%	32.5%	28.0%	30.2%	27.1%
	East	30.9%	26.6%	32.1%	27.6%	29.7%	26.7%
	West	30.8%	26.3%	31.9%	27.6%	29.7%	26.6%
Medium glazing	South	30.4%	25.9%	32.0%	27.2%	30.6%	26.9%
	North	30.9%	26.4%	32.2%	27.6%	30.4%	27.0%
	East	30.6%	26.1%	31.7%	27.2%	29.8%	26.4%
	West	30.2%	25.8%	31.2%	26.9%	29.6%	26.2%
High glazing	South	29.9%	25.3%	31.3%	26.5%	30.7%	26.4%
	North	30.3%	25.8%	31.7%	27.0%	30.5%	26.6%
	East	30.0%	25.3%	31.1%	26.7%	29.7%	26.0%
	West	29.7%	25.0%	30.7%	26.3%	29.5%	25.8%
Lightweight walls							
Low glazing	South	30.1%	25.0%	31.3%	26.0%	30.7%	26.7%
	North	30.4%	25.3%	31.2%	26.2%	30.7%	26.7%
	East	30.0%	25.1%	30.9%	25.9%	29.9%	26.3%
	West	29.8%	25.0%	30.8%	25.7%	29.8%	26.2%

Table A15. *Cont.*

Wall Construction Glazing Ratio and Orientation		Air Change Rate and Floor Level					
		0.25 ACH		0.5 ACH		1 ACH	
		Ground	1st Floor	Ground	1st Floor	Ground	1st Floor
Medium glazing	South	29.6%	24.3%	30.8%	25.4%	30.5%	26.0%
	North	30.0%	24.8%	31.0%	25.8%	30.4%	26.4%
	East	29.5%	24.5%	30.5%	25.3%	29.6%	25.8%
	West	29.2%	24.1%	30.2%	25.0%	29.3%	25.3%
High glazing	South	28.4%	23.5%	30.0%	24.7%	30.1%	25.5%
	North	29.4%	24.2%	30.5%	25.3%	30.2%	25.8%
	East	29.0%	23.8%	30.0%	24.8%	29.1%	25.0%
	West	28.4%	23.3%	29.6%	24.5%	29.0%	24.6%
Lightweight insulated walls							
Low glazing	South	27.1%	21.1%	31.7%	25.5%	36.3%	31.4%
	North	28.8%	24.8%	33.1%	28.4%	36.3%	32.9%
	East	28.3%	24.6%	32.1%	27.8%	35.0%	31.7%
	West	27.9%	23.8%	31.7%	27.3%	34.5%	31.1%
Medium glazing	South	22.1%	15.9%	27.3%	19.9%	34.2%	26.7%
	North	26.0%	20.6%	30.4%	24.8%	35.1%	30.6%
	East	25.6%	20.3%	29.5%	24.2%	33.6%	29.2%
	West	24.6%	19.2%	28.7%	22.9%	33.0%	28.1%
High glazing	South	18.6%	13.8%	24.0%	17.3%	31.5%	23.1%
	North	22.5%	17.8%	27.5%	21.5%	33.6%	27.2%
	East	22.6%	17.6%	26.9%	21.1%	31.9%	26.1%
	West	21.7%	16.8%	26.0%	20.1%	31.1%	25.1%

References

1. UKRI. Sustainable and Creative Village Research Network SW China. Available online: https://gtr.ukri.org/projects?ref=AH%2FR004129%2F1 (accessed on 8 July 2019).
2. Lu, D. (Ed.) *The Great Urbanization of China*; Series on Contemporary China; World Scientific Publishing Co Pte Ltd.: Singapore, 2012; Volume 30, ISBN 13 978-981-4287-80-7.
3. Government of the People's Republic of China. Rural Development, Building a New Socialist Countryside, Special Report. 2012. Available online: http://www.gov.cn/english/special/rd_index.htm (accessed on 28 October 2018).
4. Ahlers, A.L. *Rural Policy Implementation in Contemporary China: New Socialist Countryside*; Routledge: London, UK; New York, NY, USA, 2014; ISBN 978-0-415-71846-2.
5. The Central Committee of the Communist Party of China. Village Revitalization Strategic Plan (2018–2022). Available online: https://mp.weixin.qq.com/s/Wi3IAkpDU2BeyFugY7B0SQ (accessed on 22 October 2018).
6. Long, H.; Liu, Y.; Li, X.; Chen, Y. Building new countryside in China: A geographical perspective. *Land Use Policy* **2010**, *27*, 457–470. [CrossRef]
7. Ministry of Housing and Urban-Rural Development. *China National Report Prepared for the Third United Nations Conference on Housing and Sustainable Urban Development (Habitat III)*; Ministry of Housing and Urban-Rural Development: Beijing, China, 2015.
8. Gao, Y.; Pitts, A.; Gao, J. *Whose Tradition?—The Role of Eco-Tourism in Sustainable Development of Qinkou Village, Yunnan, China from 2001 to 2013*; Traditional Dwellings and Settlements Working Paper Series; International Association for the Study of Traditional Environments: Berkeley, CA, USA, 2014; Volume 268, pp. 1–25.
9. Cheng, S. Heritage Revitalization Faces Hurdles. *China Daily*. 30 August 2018. Available online: http://www.chinadaily.com.cn/a/201808/30/WS5b873132a310add14f388873.html (accessed on 2 November 2018).
10. Zhou, Z.; Feng, J. Settlement Construction of Ethnic Minority Under Survival Pressure in Mountainous Area of Guizhou Province: A Case Study of the Biandan Mountain Area. *China City Plan. Rev.* **2016**, *25*, 64–73.
11. Drumreicher, H. Chinese villages and their sustainable future: The European Union-China-Research Project "SUCCESS". *J. Environ. Manag.* **2008**, *87*, 204–215. [CrossRef] [PubMed]

12. Wang, L.; Yang, Z. Evaluation of sustainable vernacular architecture and settlements in Yunnan. In *The Sustainable City VII*; WIT Transactions on Ecology and the Environment, Vol. 155; WIT Press: Southampton, UK, 2012; Volume 2, pp. 905–915. [CrossRef]
13. Renping, W.; Zhenyu, C. An ecological assessment of the vernacular architecture and of its embodied energy in Yunnan, China. *Build. Environ.* **2006**, *42*, 687–697. [CrossRef]
14. Lin, X.; Jia, B. Living Sustainably: Transformation of the Built Environment in Xiaqiao Village, China. *Proc. Eng.* **2016**, *142*, 48–55.
15. Dong, J.; Jin, H. The design strategy of green rural housing of Tibetan areas in Yunnan, China. *Renew. Energy* **2013**, *49*, 63–67. [CrossRef]
16. Wan, L.; Ng, E. Built Environment Sustainability Assessment of Poor Rural Areas of Southwest China. In Proceedings of the 30th International PLEA Conference, Ahmedabad, India, 16–18 December 2014. Available online: http://www.plea2014.in/wp-content/uploads/2014/12/Paper_3D_2427_PR.pdf (accessed on 2 November 2018).
17. Wan, L.; Ng, E. Assessing the Sustainability of the Built Environment in Mountainous Rural Villages in Southwest China. *Mount. Res. Dev.* **2015**, *36*, 4–14. [CrossRef]
18. Smith, C.; Clayden, A.; Dunnett, N. *Residential Landscape Sustainability: A Checklist Tool*; Blackwell: Oxford, UK, 2008.
19. BREEAM (Building Research Establishment Environmental Assessment Method). Available online: https://www.breeam.com/ (accessed on 1 July 2019).
20. Evans, M.; Yu, S.; Song, B.; Deng, Q.; Liu, J.; Delgado, A. Building energy efficiency in rural China. *Energy Policy* **2014**, *64*, 243–251. [CrossRef]
21. He, B.-J.; Yang, L.; Griffy-Brown, C.; Mou, B.; Zhou, Y.-N.; Ye, M. The assessment of building energy efficiency in China rural society: Developing a new theoretical construct. *Technol. Soc.* **2014**, *38*, 130–138. [CrossRef]
22. Shan, M.; Wang, P.; Li, J.; Yue, G.; Yang, X. Energy and environment in Chinese rural buildings: Situations, challenges and intervention strategies. *Build. Environ.* **2015**, *91*, 271–282. [CrossRef]
23. Gou, S.; Li, Z.; Zhao QNik, V.M.; Scartezzini, J.-L. Climate responsive strategies of traditional dwellings located in an ancient village in hot summer and cold winter region of China. *Build. Environ.* **2015**, *86*, 151–165. [CrossRef]
24. Pitts, A. Establishing Priorities for Sustainable Environmental Design in the Rural Villages of Yunnan, China. *Buildings* **2016**, *6*, 32. [CrossRef]
25. Zhao, D.-X.; He, B.-J.; Johnson, C.; Mou, B. Social problems of green buildings: From the humanistic needs to social acceptance. *Renew. Sustain. Energy Rev.* **2015**, *51*, 1594–1609. [CrossRef]
26. Pitts, A.; Gao, Y. Design of dwellings and interior family space in China: Understanding the history of change, and opportunities for improved sustainability practices. *Buildings* **2014**, *4*, 823–848. [CrossRef]
27. Gao, Y. Top-Down and Bottom-Up Processes for Rural Development and the Role of Architects in Yunnan, China. *Buildings* **2016**, *6*, 47. [CrossRef]
28. Yunnan Housing and Town and Country Construction Department and Yunnan Urban and Rural Planning and Design Institute. *Technical Guidelines for the Renovating Rural Settlements in Yunnan Province*; Yunnan Housing and Town and Country Construction Department and Yunnan Urban and Rural Planning and Design Institute: Kunming, China, 2018.
29. Yunnan Housing and Town and Country Construction Department and Yunnan Urban and Rural Planning and Design Institute. *Guidebook for Improving and Renovating Vernacular Houses' Styles and Features in Yunnan Province*; Yunnan Housing and Town and Country Construction Department and Yunnan Urban and Rural Planning and Design Institute: Kunming, China, 2018.
30. Deqi, S. *Chinese Vernacular Dwellings: People's Daily Life with Their Houses*, 2nd ed.; China Intercontinental Press: Beijing, China, 2010.
31. Wang, X. *Architecture of Chinese Ethnic Minority Groups*; China Intercontinental Press: Beijing, China, 2007.
32. Baidu. Information on Villages. Available online: https://baike.baidu.com/ (accessed on 26 July 2019).
33. Olgyay, V. *Design with Climate: Bioclimatic Approach to Architectural Regionalism*, 4th ed.; Princeton University Press: Princeton, NJ, USA, 1963.
34. Givoni, B. *Man, Climate and Architecture*, 2nd ed.; Applied Science Publishers: London, UK, 1976.
35. Szokolay, S. *Introduction to Architectural Science*, 3rd ed.; Butterworth-Heinemann: Oxford, UK, 2004.

36. Zhen, M.; Sun, C.; Goh, B.H. Simulating Passive Design Strategies of Rural Residential Buildings in Severe Cold Regions of Northeast China. In *Architecture and Design: Breakthroughs in Research and Practice*; Information Resources Management Association (IRMA), Ed.; IGI Global: Hershey, PA, USA, 2018; pp. 790–813.
37. Sun, F. Chinese Climate and Vernacular Dwellings. *Buildings* **2013**, *3*, 143–172. [CrossRef]
38. UCLA. Energy Design Tools. Available online: http://www.energy-design-tools.aud.ucla.edu/ (accessed on 8 July 2019).
39. EnergyPlus. Weather Data. Available online: https://energyplus.net/weather (accessed on 21 July 2019).
40. China Meteorological Bureau, Climate Information Center, Climate Data Office and Tsinghua University, Department of Building Science and Technology. *China Standard Weather Data for Analyzing Building Thermal Conditions*; China Building Industry Publishing House: Beijing, China, April 2005; ISBN 7-112-07273-3 (13228).