Regional Sustainable Standard Exploration: The Case of Chinese Rural Areas

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Regional Sustainable Standard Exploration: The Case of Chinese Rural Areas

by
Jinzuo Zhang

A thesis submitted
in partial fulfillment
of the requirements for the degree of
Master of Architecture

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Golisano Institute for Sustainability

Rochester Institute of Technology
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Regional Sustainable Standard Exploration: The Case of Chinese Rural Areas
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PREFACE

As a significant direction of social development, sustainability should not only be limited to urban regions but also be expanded to surrounding areas of cities. It is well-known that urban growth usually depends on the supports of rural areas.

Taking China for example, some research suggested that the population urbanization level of China has been growing at an average annual rate of more than 1.01% percent over the last 30 years. Up to 2011, the national urban population has arrived 0.69 billion and account for more than 51% of the country's population [7]. During that period of time, an influx of rural population and supplies ensured the rapid development of urban areas. In contrast, large quantities of natural resources and infrastructures lack proper treatment measures in rural areas, resulting in the tension state of urban-rural relation and unstable resource supply chain.

In this case, the promotion of rural sustainable development will be a noteworthy issue of social development in the future [1]. In this regard, this research will not only improve the quality of rural life but also establish the link between sustainability and practical construction. Finally, during sustainable development, the idea of society as a whole will be further profound.
ABSTRACT

Evaluation criterion of sustainability is an effective method of protecting stable Eco-system, enhancing life quality and reducing the waste of resource.

Recently, with the emergence of resource shortage and environmental degradation, people started to shift their attention to the development of sustainability, which is to find the balance among social, environmental and economic factors. Especially in the end of the 20th century, the concepts of sustainability had been approved by the countries around the world [8]. Some developed countries took the lead in starting develop sustainable practices and set evaluation standard based on the real needs of project construction.

However, many sustainable strategies and standardized systems are often applied to various sites without considering the particularity of each zone such as the diversity of social environment and region discrepancy. Thus, these evaluations appropriate for low integrating degree fail to guide practical constructions and reduce the overall project performance of sustainability.

This paper analyzes the case of the mainstream evaluation tools from several professional organizations such as Leadership in Energy and Environmental Design (LEED) and Living Building Challenge. Most of them include aspects of environment, society, life, etc. In addition, based on the researches of regional condition and social features of Chinese different regions, it proposes two design improvements for rural sustainable development, regional evaluation emphasis and feasibility of Chinese situation.

This study reviews the concept of sustainable design for two Chinese rural zones and takes the regional features and social structure of these rural community groups into
consideration. The base standard content and proposed changes as a contrast, and the results prove that regional strategies and evaluation emphasis play an important role in improving the sustainable performance of rural area construction in China.

In conclusion, a set of variations related to the standard based on regional design can largely improve sustainable performance and life quality on grounds of different requirements to create a better model for rural constructions. And these regional sustainable standards also provide more references and instructive significance for relevant construction projects such as Rural Regeneration, Pollution Reduction, Energy use, Passive Design and Economic Benefit, etc.
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Chapter 1

Introduction

1.1 Outline

The remainder of this study is structured as follows:

Chapter one is divided into three parts to introduce background information and basic statements of this study. The first part focuses on the development and practice of sustainable concepts, particularly evaluation tools and rural area construction. The second part illustrates strategies and feasibility by four precedent studies, one for each emphasis. The third part describes an overview of Chinese rural area situations and makes the zoning based on climate, geographical features and historical and cultural backgrounds. The final result is demonstrated based on three study samples of different zones.

As for Chapter two, the first part presents the metrics by which each design will be evaluated. The second part studies the evaluation of target zones by existing tools, which decides the basic content and directions of later study. Meanwhile these results also become the main comparative objects for following design developments. The third part characterizes the backgrounds and conditions of three study zones,
especially social features, cultural features and the establishment of historical factors.

Chapter three explores the strategies used in the design process and raises the concepts and intents of each zone. These strategies put forward various proposals for various zoning with considering of above factors. Moreover, the interpretation of strategies and the emphasis of each zone are guided by comparing baseline with proposed design improvements.

Chapter four concludes the main findings and final results of this research as well as puts forward the expectations and highlights of future work. Finally, the appendix provides more information about Chinese rural zones referred in to this study.

1.2 Regional Standard Design

Since the 1950s of the last century, the world’s big picture has been gradually stabilizing. Countries have stepped into a new era of construction. With the development of new technologies and globalization, the model of traditional regional development is facing huge challenges. In particular, with technological development and demand changes in reality such as artificial environment system and resource dependence, it is necessary to keep a harmonious relationship between human society and the environment. Represented by rational use of resources and a more efficient construction system, specific strategies not only can be applied to the development of communities but also play a vital part in all of society.

Sustainable standards originally appeared in the 1980s. The initial intent of these is to meet human development goals and maintain the ability of natural systems in a balanced way. In this period, sustainable standards had not been largely put into practice. For the next 10 years, under the influence of environmental and resources problems, more and more countries & regions began to develop sustainable tools in
order to meet the double needs of economic development and natural protection. Many sustainable evaluation tools appeared at this time, such as LEED, BREEAM AND GREEN STAR. And after 2010s, the sustainability concept moved into the stage of rapid development on the foundation of rich experiences and technical support. Whether building design or community construction, sustainable concepts have made satisfying achievements with public recognition.

Although modern concepts and technologies could effectively improve living environment and nature conditions, there are no effective operational systems in many cases. Compared to the improvements of materials and instruments, the establishment of systems and standards are regarded as more important. The existing rating systems have achieved some success during the process of global sustainability, however, due to regional differences, a number of evaluation categories didn’t provide effective guidance with practical construction but contrarily put extra pressure on local environments.

For example, some rural areas blindly promoted the using of solar system for the purposes of reducing environmental pollution and resource waste. The original intention was good and should not be criticized, but the improper climate conditions lead to many problems; the predominant one was low solar radiation. Unstable supply of energy not only has a negative impact on actual application, but also can reduce the capacity of solar system utilization. In view of this situation, people often tend to oppose related equipment. Finally this result leads to waste of materials and energy sources, which is contrary to the concept of sustainability [4]. This phenomenon could make an impact and bring huge waste of resources, especially in rural areas. Currently, over 40% of the total annual energy consumption in the world is used to create a comfortable life environment, particularly in those cases of mechanical systems and environmental renovation work [2].
In view of this situation, the establishment of regional sustainable standards in rural areas is needed, which will not only adapt to different natural conditions and social backgrounds, but also directly participate in local practical construction. In other words, these independent standards take natural conditions and regional features into account, directly guide the development of rural areas and eventually respond to local environment in terms of community construction, environmental protection, and building modes.

The rudiment of sustainability concerns derives from around 1950s and has gone through several developmental stages. It started from the bioclimatic design concepts by Olgay brothers in the 1950s, then developed into the sustainable idea in “Silent Spring” by Rachel Carson in the 1970s and finally is applied to the future sustainable plans for 2050 in some Nordic countries [3]. These cases indicate that sustainable development has a fundamental local characteristic. The blind applications of unified standard will cause major problems in regional practices. Of course, the common metric will not be totally discarded while the individual standards suitable for regional development better meet the needs of current development because these new standards not only focus on local developmental processes, but also play a positive role in reducing environmental burden and maintaining local historical background [5]. The initial sustainable metric for regional villages first appeared in the United States around 1990 and this attempt gradually has been recognized at the beginning of the 21st century [6]. Therefore, it can be safely concluded that regional need for rural sustainable standard becomes increasingly obvious.

Since the sustainability standards have the intrinsically regional influences, it will deal with challenges when people try to make a transformation between common standards and local standards. Due to the high dependence on regional conditions of sustainable standards, how to coordinate relationship with rating content and target environment becomes the key point of regional standard development. In this case, a balanced
approach is required to transform common standards into distinct local standards under the premise of the core objective---sustainable development. Chinese rural sustainable standards have been selected as a case study to demonstrate the feasibility and potential benefits of specific metrics applied in different regional construction.

This study will explore the existing typical metrics like Leadership in Energy and Environmental Design (LEED) and Green Star which are the sustainable rating systems respectively adopted by the US and Australia. The performance of regional standards would prove to be reasonable in specific projects. This research addresses the differences existing into two rural areas of China where not only the geographic conditions, but also cultural and social background differ. The new evaluation system fully respects local historical and cultural backgrounds and relies on modern design concepts and technologies, concentrating on the sustainable construction of rural areas and the improvement of regional vitality. This study also takes factors like the habits and characters of rural life into consideration in order to realize the significance of sound development in rural life on whole society. Eventually, the design improvements have some comparisons with the base content of each zone in terms of relevant categories and the results are analyzed by existing standards. In the end, a priority report of regional strategy’s emphasis is provided.
1.3 Existing Standards Analysis

The aim of regional sustainable standard is to "eliminate negative environmental impact completely through skillful and sensitive design in daily life".[1] Following this idea, reasonable utilization of technologies, minimum impact on regional environment and establishing harmonious relationship between local people and their environment lay the important foundation of sustainable construction. Against this background, many nations have issued different norms of sustainability assessments according to their national-conditions.

However, due to significant regional differences, each standard system has its own emphasis. Some of them focus on the macro factors, such as geography, climate, and economy, etc. And some others are more concerned with cultural life, green design and a series of detailed elements. Although these modes have their own pros and their cons, fundamental reasons of these differences are the objective regional conditions and the subjective design wishes.

Figure 1.31: World Sustainable Practices Distribution [9].
Up to 2010, there are more than 14,000 projects passed different sustainable assessments. However, it is worth noting that most of them were located in urban areas, including as many as 43.5% concentrated in central cities, as shown on Figure 1.31. This phenomenon shows that the distribution of sustainable practices is very uneven. The large number of rural areas have not received effective sustainable construction. The practices of sustainable standards is no competitors in rural areas, especially in developing countries, such as China.

Therefore, the analysis of existing standards can help people grasp some elementary knowledge of regional sustainable system. This research will explore the conceptual basis and design prototypes for following study on sustainable standards of Chinese rural areas.

1.3.1. Existing Standards Distribution

![Image of International Rating Tools](image.png)

Figure 1.1: Complex System of International Rating Tools [9].

Since the 1990s, an increasing number of standard systems appeared around the world. In this process, sustainable standards completed the transformation of operating mode from whole concept into decentralized practices. This phenomenon indicates that the
regional sustainable standards have more and more been applied and practiced in different places.

Faced with this situation, it is meaningful and necessary to have a clear understanding of evaluation design modes. In accordance with the existing information, sustainable assessment tool has two main design directions: common metrics and specific metrics [10].

![Figure 1.2: World map showing countries using the four predominate ranking system [9].](image)

For common metrics, the core ideology is to promote the international stakeholders to compare constructions in different cities by means of “common language”. This means that these metrics focused more on the common features of regions and working ranges. With the consideration, these metrics always maintain high flexibility and intelligibility at the same time.

From a district perspective, the common standards tend to occur in America, Britain and some developed countries. The reason being these countries need to face the complexity of regional differences and various demands. In this context, the common metrics can ensure both maximum adaptability and applicability in practice with its feature of highly open. The most paradigmatic examples of common metrics are
LEED (Leadership in Energy and Environmental Design) & BREEAM (Building Research Establishment Environmental Assessment Method). Apart from common case, specific metric is the other important mode of the current rating system in the world. These specific standards were developed by the governments and other relevant departments which focused on their own national conditions, such as Green Star (GS) & Comprehensive Assessment System for Built Environment Efficiency (CASBEE). It means that these establishments of specific metric are dependent on full consideration and preparations for the backgrounds and conditions of target areas. Following this concept, these metrics can maintain strong pertinence and practicality in the practical examples.

In general, be it common or specific metrics, as the core of the whole sustainable rating system, design direction can influence both the concrete evaluation content and the emphasis and quality of the final results.

1.3.2. Standards Case Analysis

- LEED

LEED system was developed by a nonprofit organization named U.S. Green Building Council (USGBC) in 1998. Its core intent is to enable an overall healthy and prosperous environment to improve quality of life. By detail the rating and management, LEED provides a common tool for the assessment of sustainable construction. This system has many different assessment categories to meet a variety of projects, such as Building Design and Construction, Interior Design and
Construction and Neighborhood Development. On the application side, LEED is widely applied in US, Canada, India and other regions.

The rich and varied content is another highlight of LEED. The existing evaluation categories cover a majority of sustainable typical elements, such as Site, Resources and Indoor Environment. In addition, based on strict evaluation standard and systematic credit policies, the final evaluation results usually maintain a high quality and efficiency of every LEED project. Currently, this system has released several versions. The latest one is LEED v4 which included almost all rating categories.

Following the theme of this study, LEED-ND is consisted of five main aspects, namely Smart Location and Linkage (SLL), Neighborhood Pattern and Design (NPD), Green Infrastructure and Buildings (GIB), Innovation and Design Process (IDP), Regional Priority Credits (RPC) respectively. These aspects contain not only the hardware ratings, but also the software management of overall project. Based on
this systematic design, LEED-ND provides a clear expression and explicit criteria for the builders and users at the same time. Apart from the content categories, the score distribution is also a clear indicator of the rating focus. From the weight proportions, NPD, GIB and SLL are the three major parts in this system. The total score of these three is 100, which occupy over 90% of total score. As the largest of the three, NPD accounts for almost 40% of the assessment \([n+2]\). This aspect covers transportation, mixed-use, accessibility and a series of categories of community constructions. Additionally, LEED-ND tool also attaches importance to performances of innovation and regional attribute. By providing with proper scores, these elements play a role of adjustment in assessment process.

The rating process of LEED-ND should follow a set of strict rules. From registration to final award, every project needs to go through three main stages in this assessment. The first is project establishment and submittal. This stage focuses on the projects in their initial planning phase which occurs before or at the beginning of the entitlement process. At this stage, approval can be used to garner supports during the entitlement process and offer certification to project designs. In the second stage, LEED tool pay attention to the projects which have not yet completed construction with the official approvals. As for design or concrete construction, every detail can been evaluated in this stage. The main task of the last stage is to award the final certification to the completed and occupied projects. After the rating and calculation of credit scores, every qualified project will be granted one of the four-level titles which ranges from Certified to Platinum. This is also the final part of the whole rating process.
Green Star is a voluntary sustainability rating system for regional development and building design in Australia. It was launched by the Green Building Council of Australia in 2003. This system aims at assessing the sustainability of projects at all stages of the built environment lifecycle [12]. The items of assessment services included *Communities, Design & Built, Interiors* and *Other Performance*. Green Star standards take into full consideration of a series of negative influences of local environment caused by building, decoration and regional development. Its aims are “to encourage leadership in environmentally sustainable design and construction, showcase innovation and positive achievements in sustainable practices” by the rational norm establishment and assessment regime [12].

Based on local situation in Australia, Green Star system mainly covers nine aspects, which contains the natural environment into design and construction, such as *Energy, Transport* and *Materials*. Unlike other tools, Green Star takes *Emissions* as an
important object of its evaluation system. This means that this standard focuses on not only the pre-construction stage, more importantly, but also the performance of post-production during actual using process. Thanks to this forward-looking design, Green Star system realize the long-time assessment and quality assurance for the sustainable performances. There are many different versions of Green Star standards which were used in the past time and the latest version is GREEN STAR v1.1 Standard, which was released in 2016 [9].

![Green Star Communities Credit Categories](image)

Figure 1.12: Green Star Communities Credit Categories [12].

Taking Green Star Communities as an example, its assessment content is classified into six major categories: Governance, Design, Livability, Economic Prosperity, Environment and Innovation. Unlike LEED-ND standard, the sustainable credit of Green Star are distributed in a more even manner. Except for Innovation, each of the rest five categories occupies around 20% of the total [9]. This average distribution method not only ensure the balance between human activities and natural ecology, but also reflect the social structure and character of Australia. It is also noteworthy to realize the key role of Livability in the whole Green Star system. As for evaluation contents, this standard focus on the optimizing of public events and people’s health. These standards are the positive response and profound thinking of sustainable concept to natural environment and daily lifestyle of Australian. However, although the Green Star rating system was faced with some skepticism by green groups, especially in the proposal of the forest certification of timber and composite timber
products, the Green Star standard did effectively increase the cognition and applied rate of Sustainable Construction in Australia from the perspective of real effect [9].

![Figure 1.13: Green Star Communities Assessment Procedure Diagram [12].](image)

The evaluation system of Green Star mainly consists of four parts: **Registration**, **Determine**, **Submit** and **Award**. Based on the final results, every qualified project will be divided into six levels, ranging from **One Star (Minimum Practice)** to **Six Star (World Leadership)** [13]. The entire evaluation expects and demands high quality communications and interactions between sponsors and professional organizations. The aim of this bilateral system is to enhance the rigor and authenticity in the process. In addition, each project has its own independent evaluation team and the team members are responsible for reviewing the project reports and actual results based on Green Star standards in order to rate their sustainable performances. Moreover, for some special contents, Green Star adopts the long-term assessment approaches, such as **Emission** and **Heat Island Effect**. The performance of this section help to adjust the final scores of the project. By 2013, more than 600 projects around Australia have met the standards of Green Star rating [14].

### 1.4 Chinese Situation Analysis

Currently in China, many rural areas are facing these severe development situations. Due to the effects of rapid urbanization, people always pay more attention on the urban development. As a consequence, a series of problems still exist in rural development, such as ill management, a lack of investment and rapacious resources exploitation.

Although this unsustainable situation is caused by many factors, among which three
of them are the main reasons that has affected rural sustainable construction. The first one is the regional disparity. It is difficult for different rural areas to use the same standards for their own developments due to their different natural and living conditions.

The second one is functional allocation. Compared with urban areas, rural areas focus on the agricultural production and other basic industries. Because of this, people have not given enough attention to the rural constructions over a very long period of time.

The last one is development priorities. Because China's economy has been in the transition period. Therefore, the government mainly put their development focus on urban areas over a long period of time in the past, which has directly led to the poor development in Chinese rural areas.

Although the above factors had negative impacts on rural developments in the past. However, with the development of Chinese economy and sustainable concepts, these issues have turned out to be the advantages of Chinese rural sustainable practices.

- Regional Disparity Analysis

<table>
<thead>
<tr>
<th>Types</th>
<th>Names</th>
<th>Homeland Proportion (homeland \ world)</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>LEED</td>
<td>85%</td>
<td>United States</td>
</tr>
<tr>
<td>2</td>
<td>BREEAM</td>
<td>82%</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>3</td>
<td>GREEN MASK</td>
<td>98%</td>
<td>Singapore</td>
</tr>
<tr>
<td>4</td>
<td>GREEN STAR</td>
<td>95%</td>
<td>Australia</td>
</tr>
<tr>
<td>5</td>
<td>CASBEE</td>
<td>100%</td>
<td>Japan</td>
</tr>
</tbody>
</table>

The data comes from governments and companies involved in the various projects, and from Network Statistics archives [2].

Figure 1.32: Working Condition of Sustainable Standards [9].
The first one is regional disparity. Up to now, there are many different sustainable tools in the world. The Figure 1.32 shows the service condition of some tools. Although many of these tools have no defined regional range of utilization, we can still see a trend that many tools have the highest utilization proportion in their own developed nations, such as LEED and Breeam. This phenomenon shows that sustainable standards is closely associated with the regional conditions. In other words, sustainable standards have obvious regional characteristics.

- Rural Function Analysis

![Construction Funds Investment of Central Government of China](image)

Figure 1.33: Construction Fund Investment of Central Government of China [7].

The functional allocation is another important factor. Due to the features of agricultural production, the economic growth is very slow in rural area. Meanwhile, because of the urban expansion and imbalanced material supply, Chinese rural areas face the production pressure and environmental threat at the same time. As a result, lots of rural resources and living environment lack systematic management and exploration, which also means that the sustainable standards have great development space in Chinese rural areas, as shown in Figure 1.33.
- Focus Development Analysis

![Development Changing Process of Central Government of China](image)

Figure 1.34: Development changing process of Central Government of China [20].

The last one is development priorities. Because of the specific developing road of China, the central government always highlight the urban areas as the developing focus over a long time in the past. Thanks to this strategy, Chinese economy has advanced greatly and made tremendous achievement. However, with the changes in the economy and the emergence of environmental issues, Chinese government have changed the focus from urban-oriented mode into urban-rural integration. This change not only shows that the keynote of the future development in China is rural area, but also means that the government will provide financial fund and policy supports for rural sustainable developments, as shown in Figure 1.34.

Based on the discussion of the above three factors (regional features, functions and developing focus) of rural areas, the development of Chinese rural sustainable standards is viewed as necessary and important for China's future development. Also, the ideals of the Chinese rural sustainable standard ideals including: *Improving the quality of Chinese rural life, Protecting stable rural Eco-system & Creating the sustainable standards which can better suit the different rural environments and production conditions in China.*
1.5 Chinese Regional Analysis

Because the regional conditions have a direct impact on the establishment of sustainable standards. So, understanding the backgrounds and circumstances of target areas is one of the most important foundations of the standard design process. For this study, analysis the situation of different Chinese areas and their features is a starting point of new system construction. Due to the complexity of China's realities, the following research would focus on the regional division from different aspects, such as geography, climate, population and economy.

1.5.1. Geography of China

![Map of China](map.png)

Figure 1.24: Map of China [19].
China is situated in the east and middle of Asia and on the west shore of the Pacific. It has an area of about 9,600,000 km² (3,700,000 sq. mi), ranking third after Russia and Canada. Due to the large territory and geographic scope, China represents nearly all of topographic types, such as lowlands, foothills, basins and tableland. In terms of altitude, the terrain of China is high in west but low in east. A bird's-eye view of China would indicate that China's terrain descends in three steps from west to east. Because of this, mostly of mountains and tablelands located in the western China, especially in the first ladder. Unlike upper levels, the third ladder has large tracts of coastal plain and inland plain which located from north to south in southeast China. These regions are extremely abundant in natural resources, with excellent geographical positions. Due to the great regional differences, China is usually thought
to be of four geographical zone: Northern Area, Southern Area, Northwestern Area and Tibetan Area. Among these regions, Northern Area and Southern Area are composed mainly of fertile lowlands and foothills, and is the location of most of China's agricultural output and human population. In contrast to that, Northwestern Area and Tibetan Area are dominated by sunken basins (such as the Gobi and the Taklamakan), rolling plateaus, and towering massifs. As the influence of formidable natural conditions, these areas have much lower agricultural potential and population [26].

1.5.2. Climate of China

![China Map of Köppen Climate Classification](image)

Figure 1.26: China Map of Köppen Climate Classification [21].

Due to the great differences of latitude, longitude and altitude, the climate of China is extremely diverse, ranged from subarctic in the North Area to tropical in the South
Area and alpine in the higher elevations of the Tibetan Area. Affected by the relatively large impact of the heat-absorbing capacity of the continent and the ocean, monsoon winds dominate the climate at most time. In the summer, the East Asian Monsoon carries warm and moist airflow from the Pacific Ocean and affords the main of the annual precipitation in much of the country. During this period, most of the country generally high temperature (except outside the Qinghai-Tibet Plateau), the north-south temperature not. In contrast, the Siberian anticyclone dominates during winter, bringing cold and comparatively dry conditions. However, due to the different geographical conditions, temperatures of the South Area and North Area differ sharply. The south is moist and warm, but north is dry and cold [n+3]. Besides temperature, annual sunshine duration ranges is the other highlight. Although seasonal patterns in sunshine vary considerably by region, but overall, the north and the Tibetan Plateau are sunnier than the south of China [27].

![China Map of Temperature Zones](image)

Figure 1.27: China Map of Temperature Zones [22].
Although most of the country lies in the temperate belt, its climatic patterns are complex. In structural terms, the cold temperate zone in the far north only occupy 2.1% of the country. The Qinghai-tibet plateau is composed primarily of alpine regions, account for 26.7% of China's total territory. There is only 1.2% land in tropical areas that located in the southernmost side. In addition to all the above, the other 70% territory belong to one of three climatic zones, including temperate continental climate, warm temperate zone and subtropical zone. Due to the superiority of climate types, most of the population live in these zones. This kind of situation caused the imbalance regional developments and population distribution [27].

1.5.3.Population of China

By the end of 2013, there are 1.36072 billion people live in mainland China, accounts for nearly 22% of the world's population. The Chinese average population density is 143 persons per square kilometer, population density is much larger than the world
average. In addition, China is also facing the issue of uneven population distribution. Southeast coastal areas maintain a high density, arrived 400 people per square kilometers. While the figure in midland is only 200 people per sq. km. The minimum number appeared in western plateau, about 10 people per sq. km. This variation trend is corresponded with three-level mode of Chinese terrain. Especially in recently years, there have been great changes of population distribution. The traditional inland-intensive distribution mode has gradually transformed into the zonal distribution around southeastern areas. This change not only mirror the economic shifts of China, but also pave the way for the serious environmental and social problems [28].

1.5.4 Economy of China

![Figure 1.29: China Map of Economy Distribution](image)

Under the influence of regional geographical conditions and climates, Chinese economy is faced with a very unbalanced situation, huge gaps existed among different
regions. The southeastern coastal areas is the largest proportion that account for up to 59.6% of China’s GDP. So for this reason the serious problems of high density population and environmental pollution have rushed into these areas. Besides Xinjiang region, the central economic zone is in good agreement with the range of the second level terrain of China. The economic index of it only bring in half that in southeastern, about 13.6%. Compared with other two, the west is probably the most noticeable zone. Although the west area accounts for about half of China, but its index of economic contribution often has been only 13.6%. The data with similarity to the features of the China population distribution. In general, there is a very high requirement for sustainable development of the southeastern and central, particularly in some rural areas which have a certain economic foundation and construction conditions. Conversely, boosting economy is still the primary develop priority in the west China [29].

1.5.5. Region Partition of China

![China Map of Regional Division](image)

Figure 1.30: China Map of Regional Division [25].
In most cases, people mainly use 7 regional system. This zoning plan considered not just the climate features of different regions, but also the elements of history and policy.

- **Northeast China**

This district is located in the northeast of China, borders North Korea and Russia. Its geographic coordinates is N50°- 40° and E120°- 130°. The regional population is about 1.22 billion, accounts for approximately 70% of the country. The northeast belongs to the zone of the temperate monsoon climate, with four different seasons, warm and rainy in summer and cold dry winter. The annual precipitation of it is about 750mm on average. In Northeast China, ring of water around the mountain and rich wealthy lands are the basic features of regional natural conditions. Based on the high-quality soil and abundant water, the south side of Northeast China has always been a major grain producing area. There is a large number of rural population work in agriculture. Because of this, many villages are located around the farmland, appeared as spot in district. Besides agriculture, rich forest and mineral resources provides Northeast China with a solid foundation of tourism and industrial developments [30].

- **Northern China**

North China is a geographical region of China is that between north of the Qinling Mountains and South of the Wall, The heartland of North China is the North China Plain. The population of there is about 1.68 billion. The geographic coordinates is N40°- 35° and E110°- 120°. Most areas in North China belong to the eastern warm temperate monsoon zone, semi-humid continental climate, four seasons, adequate light, with a long-time cold dry winter and high hot humidity summer. The terrain of North China is mountainous in north side, plains in the middle and oceansides in the east. These conditions provide a good development environment of the agricultural
and fish productions of this district. Despite all this, the rapid urbanization still causes many problems to rural areas in the region.[30].

- Central China

Central China is composed primarily of the areas which located in the lower and middle reaches of Yellow River and middle reach of the Yangtze River. It covers roughly 56,000 sq km, amounting to about 10.6% in the country. The geographic coordinates is N35º- 30º and E110º- 120º. Plains, hills and basins make up the main landform of this region. And it has a humid subtropical monsoon climate. Based on the abundant water resources, the central rural areas have favorable production conditions for planting and breeding. In addition, the other noteworthy part is the industrial structure, this region dominated by the secondary industry and tertiary industry. This phenomenon points to a widening gap between the rural and urban areas. Moreover, due to the unreasonable use and exploitation of natural resources, lots of rural areas are confronted with crisis of ecosystem destruction [30].

- Eastern China

East China is on the wealthy eastern seaboard, near the Pacific coast. The area of it is about 83.43 sq km, receipts now about 8.7% of China. There are various topography widespread in East China, and more than half of them belong to the plains. And this district is one of the most important economic center in the country, the regional GDP accounts 40% in total. The climate is controlled by a combination of the humid subtropical monsoon climate and temperate monsoon climate, the rainfall mainly focus on summer and winter snowfall occurs in the north side. Its geographic coordinates is N40º- 30º and E110º- 120º. East China has obvious coastal regional advantages and rich limnetic resources. Nevertheless, the high-density river-network also bring the risk of flood disaster of the rural agricultural and aquaculture production [30].
- Southern China

This district is located in the south of the country, adjoined the South China Sea and many southeastern countries, such as Malaysia and Brunei. The geographic coordinates is N30° - 20° and E100° - 120°. Climate in there is referred to tropical-subtropical type, year-round high temperatures and rainy, summer all the time and annual precipitation is about 1400-2000mm. The damp and rainy environment make plants grow well that form the rich resources of precious rainforest. In addition, the southern coast is an important economic center in South China. Rich marine resources promote the steady development of the district economy and plays a basic role. Although South China has fine climate conditions, while lots of hilly lands creates potentially massive amounts of rugged terrains, the area of farmland is quite small [30].

- Southwest China

Southwest China's topography is varied and complicated, with towering mountains, basins of different sizes and undulating plateaus and hills. Its geographic coordinates is N35°- 25° and E80°- 100°. Regional population is about 1.99 billion, over half of those live in basin areas, especially among Sichuan and Chongqing. The climate in there shows enormous difference, east part bears a subtropical monsoon climate, and the weather is relatively moderate with high humidity air. Conversely, the south of region belongs to plateau mountain climate. And the year-round balmy conditions are good for the production of forestry and planting industries. Besides those areas, the Qinghai-Xizang Plateau also in this region. The severe natural conditions and high altitudes have a grave impact on the local agricultural production [30].

- Northwest China

The Northwest region covers a huge area, accounted for a high of 30 percent of the country, but its population makes up only 1% of the total. The geographic coordinates
is N45°- 35° and E80°- 100°. The Northwest China mainly to the mountains, plateaus and basins, only only a few river frontages are belongs to plain. Due to the inland situation and far from the ocean, Most of Northwest under the influence of temperate continental climate, cold dry winter and hot summer with rare rain. Because of this, planting industry has a small proportion of in the production conditions of countryside. On the contrary, many rural population work with the animal husbandry [30].

Considering that the close relationship between regional conditions and sustainable standards, the selection of study areas is very critical for the setting of rural standards. Based on this consideration, the second chapter will make an analysis of Chinese situation in order to find the target areas in this study.

1.6 Precedent Study

Following above analysis, Here put several existing sustainable project as a president case, for the subsequent study’s reference. The following precedent studies exemplify the potential impact of sustainable practice in the construction of rural communities. These projects were all representative examples of neighborhood development. Although China has its own special conditions, but the following projects have great reference value for this study. The main difference is that the target areas of this study are emerged with the culture background and social structure in China, whereas the examples are the rural construction abroad.

More than the concrete practices, the rational assessment focus also plays an important role in the rural sustainable development. Because different areas have their individual circumstances and conditions, so the single assessment standard can hardly meet the practical demands in the various rural areas. The examples below shows that formulating the specific evaluating strategies on the basis of adequate analysis for
regional information is one of the best way to promote rural sustainable development.

From regional features, to construction content, to assessment focus, this design system can not only resolve the localized issues of sustainable development, but also provides the individual practical evaluation criteria and clear goals. Upcoming sections follow this research system to create the corresponding assessment tools for the sustainable construction in three Chinese rural areas.

1.6.1. BedZED Ecological Village

BedZED is located in the neighborhood of Sutton, south London. It is a maritime climate-winters are not too cold and summers are not too hot. The air humidity keeps a high degree in the whole year. This rural project was founded by Peabody which is the largest non-profit association of welfare housing in London. And the designer of ZED Factory Architects and WWF employees also involved in the process. BedZED project is the UK’s first large-scale, mixed use sustainable community with 100 homes, office space, a college and community facilities. And, to some extent, this project proves the possibilities and validity of the connection between sustainable life and social impact.
As the system figure shows, BedZED project contains two parts. One is the housing construction, these new residential buildings were equipped with the low cost and high efficiency at the same time. From one bedroom to four-bedroom, the designers the exterior and detail design which tallies with local basic characteristic of historical and cultural elements, the whole community completely preserved original harmonious neighborhood and social system. The other part in this project is the artificial sustainable system. Through the reconstruction of water resource management, energy use and transportation systems, this sustainable project reshaped the daily operation mode and social activities. The whole village effectively reduce daily carbon footprint (147.1t/year) and stronger the regional vitality by the work of proper circulation in resources utilization and environment amendment(population +15%).
This project mainly presents its feature in three aspects. First is regional connection, the design team made an adequate consideration of local situation and created the appropriate strategies for target on local conditions (local resources use over 50%).

Secondly, BedZED maintain the original social state of the English countryside and offered enough respect and appropriate protection to the local historical culture background. And these concepts lead local people to better accept regional improving and sustainable practices in both. The last one is the longevity of sustainable construction. This project focuses on the common development between economic and environmental benefit. Through the long-term monitoring of regional economics and the environment, BedZED achieved over 15% economic growth and reduced 50% resource consumption after its completion in 2002. In general, this project provided a feasible sustainable mode for Chinese rural areas. From environment to demand to design, the system effectively integration of natural ecology and sustainable living, especially in concept and design of energy use, it had very important significance for the establishing of new regional standards.
1.6.2. ReGen Villages with Vertical Farms Community

The project site of ReGen Village is located in Almere, the Netherlands. This area has a pleasant climate with four distinctive seasons, the rainfall is rich. Unlike BedZed, this project is working on exploring a new developing mode for suburb and rural areas. ReGen Villages B.V. and EFFEKT Studio share design and building responsibility in the whole process. Facing a series of social problems, such as global warming, food crisis and resource scarcity, the design team hoped to undo the harm of human settlement environment by the reasonable development mode, particularly in regional sustainable agricultural construction.
The designers created an output system that used sustainable agricultural mode instead of the original input foundation. This concept combines a variety of innovative technologies, such as energy positive homes, renewable energy, waste-to-resource systems and vertical farming. In this sustainable village, these tools and ideas be integrated into a community operation system, thus providing clean energy, water and food right off resident’s doorstep with the least cost of natural ecological environment.

![Figure 1.19: ECO Social Structure [16].](image)

This project broke down the traditional pyramidal social structure and introduced the highly interactive network in this community. Through the redistribution of regional resources, the designers reinstituted the connections between human and nature, production and consumption. By this way, the suburb areas can improve not only the environmental stability, but also the social value with the sustainable community constructions. In addition, stereoscopic agriculture and multiple consumption provided an effective and stable growth in the environmental and economic benefits. This balanced interactive system has a great guiding significance for further considering the constructions of villages. On one hand, it can improve employment rate and stability of population in Chinese rural areas. On the other hand, it can also
add the rural market energy and reduce bad competitions between cities and the countryside.

1.6.3. Development Banks of the Meurthe

The village located in 9 Rue Alphonse Adam, France, along the banks of the river Meurthe. Climate in here bearing obvious features of continental climate, dry summers and cool, variably rainy winters. This project used the co-development mode for the public and natural space. As the primary actor, the design team of Atelier Cite Architecture strove to create the sustainable development and environment exploitation in target area. The appropriate strategies of area ecological environment and self-sustaining public lighting solution became the major highlights of this village project.
This project built the rural sustainable practices from two aspects, the protection of local natural resources and the use of traditional ore structure and local materials. Based on this, the continuity between riparian ecosystem and social activities has been reinforced by a direct and profound way. On the other hand, the positive public activities is the focal point that people pay close attention to. Through the link of accessibility system, agricultural production, natural resources and common activities formed an organic whole. The efficiency walkways provide rich experience modes for people accessing to the nature with no distance. Not only can this sustainable concept improve stability of the riparian ecosystem. But it can also leave enough spaces for the multiplication and the growth of local cultural life.

Beyond that, another point worth noting is the village public lighting system. Depending on the supports of sustainable technologies and local resources, this system can meet various requirements, such as environment protection, energy conservation and sensory experiences. Simple layout and rational distribution of night lighting provides a secure and comfortable atmosphere. And the project set-up optimizes the overall energy consumption by using materials with a high luminous efficiency and dazzle control. In addition, the lamp component which were made of wood also reduce the adverse effect to environment and ecology ecosystem, especially to prevent and reduce caustic pollution during use. In general, this project provided a feasible sustainable mode for Chinese rural areas. From environment to
demand to design, the system effectively integration of natural ecology and sustainable living, especially in concept and design of energy use, it had very important significance for the establishing of new regional standards.

1.6.4. Elastic band: The Immortal Treasure of Kazan

Figure 1.22: Siteplan of Kazan Suburb [18]. Scale not defined.

Elastic band in a regeneration project for suburban areas in Kazan. Riparian ecosystem and low-density pattern are two significant characteristics of this site. After the competition, Turenscape and MAP architects eventually won the design right. On the basis of full investigation of local natural environment and historical background, the design team determined the core design concept as “To establish a continuous system of landscapes along the bank line, which will preserve the cultural and historical memory and become a basement for future stage-by-stage development”.
Following this idea, design team created a new linear connection mode, integrating surround ecology, local culture, living space and transportation network into an ordered whole. This system consists of three aspects, the first is renovation of site ecosystem. Simpler and effective plant protection measures and management of waste water purification have effectively increased of site ecological stability.

The second is the restructuring of local historical resources and cultural heritage. Based on the features of riverland, this design created a large amount of effective social infrastructures, such as waterborne platform and green passages. These equipment provide broad space for the contact between people daily life and local cultural atmosphere.

The last one is the establishment of comprehensive system. Because the project site is located in a continuous strip, various social functions represents the linear distribution along the river. In view of this situation, design team formed a two-in-one road system. The combination between the creating of low-speed transport, especially the bicycle
transport and improvement of public transport system can not only increasing the life efficiency and regional accessibility, but also build the cultural tourism industry with local conditions. This win-win situation to both social impact and economic benefit is a solid proof that the sustainable concept plays an important role in regional stable development. In view of relatively backward economic development of Chinese rural areas, to development infrastructure construction and cultural industries can efficiently solve the conflict between economic development and environmental protection. Additionally, the concern about the historical background is one of the important measures for strengthened the regional identity of local people, specially one as ancient civilization as China.
Chapter 2

Methodology

2.1. Metrics Tools Overview

The methodology for this work is divided into three main phases, that are, investigation phase, design phase and analysis of the design. The concrete content includes focus on the study of sustainable developments of Chinese rural areas, particularly in the proposal of regional standards. This proposal will make adjustments to the contents and emphasis of rating system according to analysis of regional situations and conditions.

In consideration of the complexity of Chinese rural situations, the investigation work mainly contains three aspects: climate, existing sustainable performance and living quality. Depending on the existing rating tools, the specific works will analyze the Chinese rural areas in two aspects: climatic features and evaluation effectiveness. The regions are: Heilongjiang, Northeast China; Henan, Central China; and Jiangsu, Eastern China. The regional climate analysis will focus on the elements that closely related to the people's livelihood, such as temperature and humidity from the using data provided by ASRHAE 55. These data will give guidelines for setting up the
future sustainable standards in different regions, especially for building passive design. In addition, the investigation phase is to make references to the existing rating tools, for instance, Leadership in Energy and Environmental Design (LEED) and Green Star. And for follow-on work thereafter this phase will delve into more detail on some important rating categories based on different local conditions. Unlike others, the research of living quality is more concerned with the housing environments in peoples' daily life. This study will introduce various categories contained within the rating program of Living Building Challenge and summarizes the performances of Chinese rural areas in some representative sustainable aspects.

The final design will give proposal for regional sustainable standards in accordance with specific demands of three Chinese rural areas and provide correlation analysis of desired effect by calculations and measurements. The tools used are Autodesk Revit and Sketchup for lighting, energy, and solar analysis; Autodesk Formit 360 for energy, and Climate Consultant for climate features.

2.2. Metrics Tools Description

Regarding that each object region will be assessed by the aforementioned three tools, making the detailed explanations of them can help to aware the meanings of the post-study survey. And these rating tools will be used to determine the features and demands of different areas.

- ASHRAE Standard 55 Content Overview

The climate analysis work of this study relies mostly on ASHRAE 55. It was launched in 2004 by American Society of Heating, Refrigerating and Air-Conditioning Engineers. This system is a standard that provides minimum requirements for
acceptable thermal indoor environments. It forms the range of acceptable indoor environment to achieve the comfort zones which is the combinations of air temperature, mean radiant temperature and humidity that are predicted to be an acceptable thermal environment at particular values of air speed, metabolic rate, and clothing insulation [31]. The purpose of the standard is to specify the combinations of indoor thermal environmental factors and personal factors that produce thermal environmental conditions acceptable to a majority of the occupants. The whole rating system provides a variety of data types related to regional climates, such as wind, temperature, radiation and air humidity. In consideration of the subject of this theme, Psychometric Chart and Wind Wheel become the focus in the following study.

![Psychometric Chart Example: Tools Climate Consultant 6.0.](image)

In Psychometric Chart, different data has their own expression method. The dry-bulb temperature is the temperature of air measured by a thermometer freely exposed to the air but shielded from radiation and moisture, being the horizontal axis of a Psychrometric chart. raised gradually from left [31]. And the vertical axis is humidity ratio, increase in height. The blue line point out a comport zone of the target region.
including the comfortable scopes of temperature and humidity. The zone is divided into two parts, the comfort zone for the summer on the right and the comfort zone for winter on the left. It means that people don’t need any other additional strategy that meet the requirements of body comfortable. Besides comfort zone, the rest parts in this diagram should be adopted the extra weather adjustment. The left side of this chart stands represents cool climate conditions, required heating with additional energy. Conversely, the right side is the warm areas, with the demand of HVAC or natural ventilation.

![Wind Wheel Example](image)

Figure 2.2: Wind Wheel Example :Tools Climate Consultant 6.0.

Unlike Psychometric Chart, Wind Wheel provides the information of annual wind of the special regions. This chart converts the distribution and level of wind from the abstract data into visual image information through the graphics changes. According to these results, the designers can take the appropriate strategies of communities and indoor spaces to achieve the demands of comfort zone.

- **LEED for Neighborhood Development (LEED-ND) Content Description**

LEED-ND is a United States-based rating system that aimed at the measurement of
sustainability values of surrounding regions of city. Compared to *LEED-Green Building Design & Construction, Neighborhood Development rating* pays more attention on the establishing of sustainable community environment and healthy lifestyle. Similar with other LEED assessment types, this type used common fraction system of the project evaluations. The concrete contents can be divided to five aspects: *Smart Location & Linkage, Neighborhood Pattern & Design, Green Infrastructure & Building, Innovation & Design Process* and *Regional Priority Credits*. Each aspect has its own focus and corresponding bonus, as shown in Figure 2.3.

![LEED v4 for Neighborhood Development Plan Project Checklist](image)

*Figure 2.3: LEED for Neighborhood Development Project Checklist [11].*

- Smart Location & Linkage
  This section focuses on the harmonious relationship between community site and existing environment. There are two parts of the evaluation content, one is protection of existing environment, the other one is new site construction. This type of existing environment includes the resources of the natural ecology and agriculture, such as
Smart Location, Wetland and Water Body Conservation and Agricultural Land Conservation. Every category of this type must be selected of assessment process. It means that the stability of ecosystem is a significant basis emphasis of the whole rating system. Unlike above, new site construction focus on the improvements of community vitality and performance. Whether Brownfield remediation or Housing and Jobs Proximity, the intent of the most contents is maintaining a good relationship between community system and natural ecology. The score of this section is 28, about 25.4% of the total.

- Neighborhood Pattern & Design
The largest share of ND standard is Neighborhood Pattern & Design. It is encompass eighteen assessment items, a total of 41 points, about 37.2% in the whole system. This part takes a full consideration of the positive interaction between people’s daily life and community construction, especially transportation and public activities. As the focus of evaluation, rational traffic design and perfect community layout constitute the main body of evaluation criterion. Some categories focus on the sustainable trip mode and traffic efficiency, such as Walkable streets and Reduced parking footprint. Other are working on holding the open character and diversity of community projects, for instance, Connected and open community and Access to civic and public space. In addition, this part also puts forward higher request to the constructions of public infrastructure.

- Green Infrastructure & Building
This section focuses on building sustainable performance and indoor environmental quality. These standards give strict instructions on indoor space from a user's perspective. Concurrently, reducing the negative impacts of building and site is other intent of this aspect. Based on waste water management, building reuse and other measures, Green Infrastructure & Building provides a series of specified standards and solutions for the environmental problems from the community developments.
total score of this section is 31, three compulsory options involved.

- **Innovation & Design Process**

  The intent of this section is to encourage people who live or work in the community involved in planning and design of the project. Although there are 6 points, these standards act as a significant moderator of the overall performance of community. In addition, the emphasis on innovation and technology reflect the forward looking and participatory of sustainable constructions.

- **Regional Priority Credits**

  Unlike other section, **Regional Priority Credits** don’t have a fixed content, and only 4 points. The intent of it is to encourage the high adaptation of sustainable rating under the special geographically environmental, social equity, and public health priorities. This design not only embodies the flexible and practicable of sustainable construction, but also provides the adjusting space for different regional condition. Due to study topic, this section is becoming a hot highlight of after research and design.

- **Living Building Challenge Content Overview**

  Living Building Challenge is an international sustainable building certification program created in 2006 by the non-profit International Living Future Institute [32]. It is not only as propaganda and evaluation tool, but also the future development directions of sustainable construction. Comparing with other rating system, LBC has the more stringent requirements of projects, such as 12 months of operation and strict assessment criteria. Living Building Challenge comprises seven performance areas including **Place, Water, Energy, Health & Happiness, Material, Equity** and **Beauty** which were described as “Seven petals on the flower of building sustainability”. And these petals were then subdivided into twenty Imperatives, each of them focuses on a specific sphere of sustainable impact, as shown in Figure 2.4.
• Place Petal

This petal focuses on the interaction between people’s activities and ecological environment. The concrete content includes resources protection, green traffic, regional supply and a series of sustainable construction of building life. The intent of it is to establish a health building operation mode by the integration of existing conditions and life demands. By encouraging the green travel and regional concatenation mechanism, Place Petal hopes to improve both resources positive utilization and public recognition of sustainable lifestyle.

• Water Petal

Facing the situation of global water shortages, Water Petal wants to form a water circulatory system of community operation by the coordination between domestic
water and natural water. This petal consists of two aspects: water resources protection and collecting treatment of waste water. The proposed measures include reducing the water pollution and damage, enhancing utilization efficiency and reusing waste water, etc. Based on this strategy, the ultimate objective of Water Petal is creating a sustainable building mode with the perfect water-cycling system.

• Energy Petal

The intent of Energy Petal is creating a proposed building relies solely on renewable energy and operates with a pollution-free mode.[7] The existing unsustainable energy caused serious pollution to the environment and resources. Additionally, their process of producing and using also had a big impact on global warming issue. In view of this situation, this petal focuses on building a sustainable energy system. This system can not only provide low-emission renewable energy, but also has a positive impact on building surround microclimate.

• Health & Happiness Petal

This petal aims to create a building filled with happy, productive people. Unlike the traditional methods, Health & Happiness Petal pays more attention to building a positive and healthy life environment for users and provides the targeted solutions of different kinds of constructions, such as street, block, district and community scales. In addition, this petal also hopes to combine indoor and outdoor spaces through the public cultural activities and infrastructure construction. The ultimate objective is to achieve the complementary status between building optimization and user growth.

• Material Petal

Material Petal hopes to reduce environment pollution and resource waste by a successful materials economy in the whole project cycle. The content requires that the building must make a material management plan to ensure the sustainable operation
of buildings, landscapes and others public infrastructure. Its net effect is to achieve a nontoxic, transparent and socially equitable material using system

• Equity Petal

This petal focuses on nurturing the building identifying sense of people by the integration of design impact and development of users. Through the improvement and reforming of living environment, Equity Petal aims to change the negative social hierarchy between different people and provide equal services for various needs. As a successful building project, it not only works on the sustainable performances of energy and technologies, but also form an open platform for the mutual promotion between people and living environment.

• Beauty Petal

As the last part of evaluation, Beauty Petal encourages people to discover and create the good things around them. With the supports from public places and the institute of cultural activities, this petal hopes to enhance aesthetic experiences of people and shape public consensus of community beauty. This design not only focuses on quality of life and, but also has the function of pushing the optimization of living environment.
Chapter 3

Research

3.1. Object Selection

Regional sustainable standard is the result of the mutual action of different elements. This study attempts to analyze Chinese zones from three aspects: climate, population and economic strength. Two points should be considered in the choosing of factors. On one hand, regional sustainable standards are the reflections of local conditions to a great extent, particularly the climates. And diverse climate always tend to have a direct impact on the establishment of regional standards. As such, climatic analysis is an indispensable part of regional research. On the other hand, as the base for sustainable development, the population provides broad space for evaluation contents. In turn, regional standards would also serve the local people.

Therefore, choosing population as a main investigation factor can effectively improve the penetration of sustainable standards. In addition, a stable population base can also help people understand the real performances of regional standards in practice, including pros and cons. Besides the reasons discussed above, Financial expenditure and economic impacts of sustainable constructions and regional economic strength are also added as emphasis of the regional research. The intent is to select rational zones.
which have the potential for long-term investment and can stand the test of economic fluctuation in the process of sustainable development. Concrete analysis is as follows. According to Köppen Climate Classification method, China's climate can be classified into five types based on the annual average of temperature and precipitation, including Monsoon Climate of Medium Latitude, Humid Monsoon Climate, Tropical Monsoon Climate, Continental Monsoon Climate and Plateau Land Climate [21]. Accordingly, the Continental Monsoon Climate and Humid Monsoon Climate, which represent the most arable lands of China rural areas, will be analyzed in the last two paragraphs. Moreover, they also reflect the complexity and diversity of Chinese villages. Different climate conditions have a direct impact on standard design, especially in transportation, indoor environment and a range of aspects related to daily life. Due to the special geography and climate environment, the Tibetan plateau and west desert regions haven’t been covered in this study.

The second element is population density. In view of the long period requirement of rural sustainable process, maintaining a reasonable population density becomes an important foundation of project operations. Considering the fact that the Chinese population density is high in the east while low in the west, this study focuses on the eastern part of demarcation line of population, which contains several different zones from south to north. People who lived in these areas have their own lifestyle. In consideration of the dependence of sustainable constructions on local environments, this study focuses on 3 typical areas in order to explain the relation between Chinese rural sustainability and individual life traits.

The last one is economic strength. Since sustainable construction needs the government's investment and the public recognition, the regional development degree would exert a profound effect on the promotion of sustainability. And considering the relationship between sustainable construction and economic development, selecting target with a solid economic base is good for the practice of sustainable standards,
especially in rural areas. Compared with western rural areas, Eastern areas and Middle areas have more potential for sustainable development. Meanwhile, due to the difference in geographical location, the two researched areas represent different rural economic system respectively. And these special economic and production manners also determine the emphasis of their respective sustainable standards.

Considering the above analysis, the following two regions were chosen to exemplify the sustainable standards that can be incorporated into the design and construction of the rural areas for different natural conditions and region features (Figure 3.1).

• **Temperate: Northeast China, Heilongjiang. Continental Monsoon Climate (Dwb)**

• **Humid Subtropics: Eastern China, Jiangsu. Humid Monsoon Climate (Cfa)**

The main characteristics of Northeast China (Heilongjiang) is as follows: It has the continental monsoon climate with the air temperature changing sharply between winter and summer; The temperature varies significantly between day and night; With a high stability of precipitation, this place enjoys constant sunlight and rich soil. Heilongjiang belongs to temperate zone, and the air temperature is low in most time of the year with the annual average temperature being 5 °C. This district is located in lower latitudes, bordering the south of Russia.

Situated in central China, Jiangsu belongs to south-eastern coastal, humid monsoon climate with warm winter, hot summer and moderate rainfall in full year, which presents strong seasonal pattern. The lowest air temperature is about 2°C in January and the annual mean temperature is about 15°C. The terrain here is mainly the plateau which covers an area of 70,000 sq km, accounting for 70% of the region. Most of them have abundant water resources.
3.1.1. Northeastern China, Heilongjiang

Heilongjiang is located in the Northeast of China, bordering Russia to the north. Harbin, as the capital of Heilongjiang province, covers an area of 473,000 sq km with the population of 38.31 million. This region is mainly covered by plains and mountains and is low in the east-west and high in the north-south (Figure 3.2). As the main grain producing area, the climate is subject to mainland monsoon climate with four different seasons where the winter is long and the summer is short. Although located in the interior part of China, it is abundant in water resources. The predominant terrains in Heilongjiang are mountains and plains, with high terrain in the east and low in the west. The data source used for this climatic analysis is IWEC Data 509630 (CSWD). More details can be found in Appendix A1.
Figure 3.2: Topographic Map of Heilongjiang Provence. Scale not defined.

- ASHRAE Standard 55 Analysis - Heilongjiang

Figure 3.3a: Monthly Diurnal Averages for Heilongjiang: Tools Climate Consultant 6.0.
The temperatures in Heilongjiang varies widely throughout the year, especially in spring and fall. Its highest annual average temperature appears in summer, which is about 20°C. By contrast, the lowest one in winter is only -20°C on average. In the four seasons, the rainfall displays an uneven characteristic, which mainly falls in summer, and inadequate in winter. Figure 3.3 shows that the changes in precipitation and temperature have a significant effect on radiation, in which drier months have less radiation and lower diurnal would change the temperature while wetter months have higher direct normal radiation and diffuse due to the rainy weather and higher overall radiation. The information is taken from the file of Climate Consultant 6.0.

Due to the influence of high latitudes, Heilongjiang has longer night time than day time in whole year, except in summer. The normal radiation mainly focuses at about noon, moving from the northwest to the southeast. This objective conditions confer the south-north direction of building location and east-west direction of window opening. Figure 3.4 shows that the winds represents a uniform distribution state, and practically in all directions. The average winds in this region were up to 8.5 meters per second (Fig. A.2).
The psychometric chart in Figure 3.5 shows the comfort zone in Heilongjiang defined by ASHRAE Standard 55 during all of the hours throughout the year. The data mainly concentrates on the lower-middle part of the graphic where the weather is cold and dry for comfort rating standards. From the perspective of passive design, the regional strategies needed to focus on the insulation design at low temperatures and the effective sunlight exposure, which also helps increasing public activities, improving indoor environment and optimizing energy solutions.

3.1.2. Heilongjiang Categories Selection

Based on the above overview, this part will be concentrated in its sustainable standards. However, since the sustainability assessment criteria contains many aspects, it would be difficult to fully meet the sustainable requirements of the current economic and construction level in Chinese villages. Due to this consideration, this selection will base on the condition and characteristics of Heilongjiang to determine the focus of the local sustainable assessment. The goal is to maximize the effect of achieving sustainable practice in the rural areas of Heilongjiang.
(1). Agricultural Resources Protection

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Data based on “Chinese Ministry of Agriculture website”

Figure 3.10: Farmland Ranking for China: Chinese Minisitry of Agricultural Website [49].

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Data based on “Chinese Ministry of Agriculture website”

Figure 3.11: Crop Production Ranking for China: Chinese Minisitry of Agricultural Website [49].

Firstly, the protection of agricultural resources. As shown in Figure 3.10 &3.11, Heilongjiang has the largest area of farmland in China and is also the largest source of food production, so farmland protection needs to become a critical element of local standards. In addition, the Chinese government has put more emphasis on agricultural protection in recent years. The establishment of agricultural resources protection
standards is not only advantageous to rural area development but also in lines with government policies.

(2). Energy Sustainable Utilization

![Energy Consumption Ranking for China](image)

Figure 3.12: Energy Consumption Ranking for China: National Bureau of Statistics Website [50].

![Per Capita Fossil Fuel Consumption for China](image)

Figure 3.13: Personal Coal Consumption for China: National Bureau of Statistics Website [50].
In addition to agricultural resources, another noteworthy focus is the energy consumption in rural areas in Heilongjiang. As shown in Figure 3.12 & 3.13, Heilongjiang's electricity consumption is above average in the country, which mostly comes from the burning of fossil fuels. From the right figure in the bottom, we can see that the per capita coal consumption in Heilongjiang ranked first in the country. Conversely, the usage of renewable energy is much lower. In this case, the establishment of sustainable use of energy standards will not only help reducing the consumption and pollution of fossil fuels but also can promote the development of renewable energy in rural areas. Considering the fact that China has achieved remarkable development in the field of energy technology in recent years, there is a good development potential for the energy sustainability in Heilongjiang rural areas.

(3). Building Passive Design

Figure 3.14: Residence Buildings in Heilongjiang Rural Areas - 1.
The last is the passive design of building. Affected by economic conditions and cultural background, most rural houses still follow the traditional architectural style. These constructions not only lack uniform norms and guidance but also do not comply with the local climatic conditions. Also, due to historical reasons, most local residents lacked a basic understanding of sustainable lifestyle, which also made the rural buildings lag in time. Under this situation, it is necessary to develop sustainable standards for passive design of buildings.

Based on above analysis, the following part analyzes the sustainable performance of these three categories in LEED-ND and Living Building Challenge.

3.1.3. LEED-ND Analysis - Heilongjiang
According to the complex situations in Heilongjiang rural areas, this study will analyze and discuss several LEED-ND rating categories which have a strong correlation with the mode of local living and production. The intent is to find out the problems and defects that are likely to appear in regional practices.
Figure 3.4: LEED for Neighborhood Development Project Checklist [12].

(1). Agricultural Land Conservation- Heilongjiang

As one of the major agricultural production areas in China, Heilongjiang rural areas have great agricultural resources, particularly the fertile soil suitable for farming. Therefore, the issue of how to protect agricultural land becomes the most concerned one for local sustainable rating. And this section is included in the category of Agricultural land conservation. The contents have evaluated the interactions between agricultural land and construction projects from three aspects: infill and transit sites development, authorized sites development and land compensation, (more details see Appendix A3).

Considering the situation of the rural area of Heilongjiang, there are three primary reasons making it unsuitable for this region to adopt the existing standards as to the conservation of agricultural land. The first reason is the great fluidity of rural population. The huge outflow of rural labor force makes it difficult to ensure a stable
population and clear statistics, which will result in a series of problems in the local evaluation process with LEED standards. Secondly, the attributes of Chinese rural lands often change due to the adjustments of policies and development demands. In this case, it would be difficult to determine the confines and attributes of agricultural lands that need protection. So this situation makes it hard to adopt the current evaluative criteria. Finally, under the influence of economic development, the phenomenon that a profusion of other industries was eating up scarce farmland in many rural areas has appeared. And this destruction of agricultural resources can hardly get improved just by the legal restrictions and land compensation schemes. Hence, judging from the present situation, the emphasis of later design lies in how to provide effective protection for agricultural land and reduce the negative impacts of other daily activities on agricultural production.

(2). Renewable Energy Production - Heilongjiang

Renewable Energy is an important part of regional sustainable standards. The intent is to reduce the use of fossil fuels by increasing self-supply of renewable energy. As for LEED-ND, the category of Renewable Energy Production sets rules for the substitution ratio and resultant scores of renewable energy for annul use, (more details see Appendix A4).

According to the actual conditions of Heilongjiang rural areas, it would be difficult to receive good effects with the existing standards. On one hand, in view of the relatively scattered living mode of villages, massive fossil fuel has been consumed by individual energy installations, which not only reduces energy efficiency but also causes a lot of problems in relevant statistical works. As a result, the local performances of renewable energy are difficult to be evaluated by LEED-ND system. On the other hand, the current standards are unable to reflect the characteristics of farm produce on rating contents. In consideration of crop strains and planting features of this region, the regional standards should respond to the actual state of local
agricultural production. And more than any of these, LEED standards of this section is relatively in general terms with a lack of specific demonstration according to renewable energy production, especially in technical feasibility and price advantage. Therefore, providing necessary calculations and desired effects in evaluation contents will speed up the development of renewable energy in the region.

(3). Solar Orientation - Heilongjiang
LEED-ND standards makes detailed requirements of solar orientation from two aspects: deflection angle and aspect ratio. The aim is to increase energy efficiency by creating optimal conditions for proper strategies. (more details see Appendix A5).

Based on the conditions of Heilongjiang rural areas, it is hard for the existing strategies to obtain good results in evaluation practices for two reasons. The first is the local living habits. Under the background of Chinese traditional culture, people have the general understanding of building orientation that windows should face south.(more specific). While compared with main orientation, the local people don’t have much requirement and experiences for deflection angle and aspect ratio. And the second reason is the economic factor. Due to the complex economic environment and personal economy bearing capacity, there are many structures that can not be ensured to suit the strict mode and scale in actual constructions. And this situation makes it difficult to obtain the results that match the expectation of LEED rating system. In view of this, focusing on the flexible design proposals and real improvements of lighting effects are better suited to the sustainable evaluations of Heilongjiang villages.
3.1.4 Living Building Challenge Analysis - Heilongjiang

This part is similar to LEED-ND Analysis, and the researches will select the rating categories of Living Building Challenge as the objects that are closely associated with Heilongjiang rural areas. The intent is to explain the operational problems and standard mismatch in the practice of this region.

(1). Energy Petal - Heilongjiang

In this section, Living Building Challenge requires that buildings operation relies on a high degree of safety and none-pollution energy mode, especially for renewable energy supply. The aim is to reduce the waste of resources and dollars, and effectively control the widespread damage to ecosystems and living environment. From the view of concrete contents, Energy Petal mainly inspects the energy operation from three aspects: complete supply system of renewable energy; energy infrastructure without negative effects; clean, cost-effective energy production, (more details see Appendix A6).

Considering the characteristic of Heilongjiang rural areas, it is hard to make full use
of local situation with the existing evaluation requirements. The first is the ratio of renewable energy use. According to the local climate and equipment situation, most rural buildings may only use renewable energy in daily life as a supplementary energy, particularly for heating and electricity. Meanwhile, it is also hard to ensure a stable supply of local renewable energy under the effects of seasons and climate.

Secondly, due to the limits of technical conditions, many rural areas can’t replace the traditional fossil energy completely with renewable energy, which means that the traditional burning system is still the main body of daily energy supplies. This situation makes it difficult to achieve desired results in the rating of Living Building Challenge. The last one is the security of renewable energy. The safety of equipment is closely associated with the energy production modes. Some of them have good performances on safety and are non-staining, such as solar and wind. The rest of them carry some risks in production process, for instance, nuclear energy and biogas. According to the direct impacts of natural conditions on the choices of renewable energy, it would be difficult for the rural areas to ensure a completely secure state in production process which is the requirements of the existing standards. Additionally, the cost of energy manufacturing equipment is also a constraint for the developments of renewable energy in the region.

(2). Help & Happiness Petal - Heilongjiang
This category provides the sustainable demands for indoor environments, including daylights, air quality and a series of related factors. The intent is to focus on creating robust, healthy spaces rather than to address all of the potential risks of indoor space. The concrete standards are inclined to evaluate the sustainable performances of building in terms of interior environment by different tests and specific design proposals, (more details see Appendix A7).

In fact, neither tests nor proposals match the actual situation of Heilongjiang rural
areas. On one hand, many villages lack the capacity and profession to reliably perform a complex battery of building tests in relation to environmental conditions, which means that it is hard for people to obtain detailed data for comparing sustainable requirements of Help & Happiness Petal. And considering the cost and time investment generated in evaluation process, the existing standards are inappropriate to local conditions. On the other hand, many design proposals don't embody the regional characteristics and lack operability, such as independent vent system and smoking ban, which is resulted from the differences of living habits and lifestyle. As a sustainable rating system, Living Building Challenge could hardly request local people to make lifestyle changes to meet the evaluation standards. In this case, providing the intuitive performance improvements will give people a better understanding of the significance of sustainable construction, for instance, positive daylight ingestion and passive indoor temperature regulation.

3.1.5 Summary and Targets - Heilongjiang

Through the above analysis, we can see that the conditions of Heilongjiang have the following characteristics.

The First one is farmland problem. Due to the adjustment of China's socialistic market economy system, the traditional agriculture has been compressed by other industries. Therefore, environmental degradation and appropriation gradually became the biggest threats to agricultural resources.

The second is the negative usage of resource. The existing extensive usage mode has caused serious waste of resources. Additionally, the utilization of traditional energy resources has also led to a series of environmental problems.

The last one is poor sustainable performance of building. So the common building design can hardly meet the demands of local life and sustainability because of the
special climate conditions of Heilongjiang.

In view of this situation, developing the basic passive design strategies becomes a focus in the process of rural sustainable development. Given the above, the following three aspects were chosen to design and improve the regional sustainable standards of Heilongjiang rural areas.

- **Protection of Agricultural Resources** *(Environmental Section)*
- **Sustainable Utilization of Energy** *(Social Section)*
- **Building Passive Design** *(Living Section)*

### 3.1.6 Heilongjiang Sustainable Standard Proposal

![Sustainable Clover Challenge Project Checklist - Heilongjiang](image)

The new standard proposed here is called the Sustainable Clover Challenge, which provides a conceptual standards for the sustainable construction of Heilongjiang rural
areas. Again, sustainable standards include many aspects but here we only selectively discussed ones that fits into the study and fits into China's current condition. The performance of the standard is measured in credits based on the three concepts proposed earlier, thus enabling us to determine the total credits with giving either a bronze, silver or gold medal.

3.2.1. Eastern China, Jiangsu

Heilongjiang is located in the Northeast of China, bordering Russia to the north. Harbin, as the capital of Heilongjiang province, covers an area of 473,000 sq km with the population of 38.31 million. This region is mainly covered by plains and mountains and is low in the east-west and high in the north-south (Figure 3.2). As the main grain producing area, the climate is subject to mainland monsoon climate with four different seasons where the winter is long and the summer is short. Although located in the interior part of China, it is abundant in water resources. The predominant terrains in Heilongjiang are mountains and plains, with high terrain in the east and low in the west. The data source used for this climatic analysis is IWEC Data 509630 (CSWD). More details can be found in Appendix A1.

Figure 3.6: Drainage Map of Jiangsu Province [34]. Scale not defined.
The Monthly Diurnal Averages show that the humid monsoon climate has a small temperature difference between day and night, due to the high air humidity (Fig. 3.7). The annual diurnal temperature difference maintains stably in 3°C-5°C (see Appendix A8). The high occurrence of precipitation reduces the direct normal radiation, making it important to control the indoor humidity and passive sun exposure. Compared in general with other places in Heilongjiang province, this climate has a more moderate solar radiation and a higher level of air humidity, shown by the small difference between dry and wet bulb mean temperature.
As it is located near the mid-latitude areas, Jiangsu province has a stable sunshine hours in the whole year. During the hot and moist period of the summer, the sun is on the southern facade for more than half of the day. Either eastern or western facade also enjoys a considerable amount of solar radiation which needs proper protection as well. And the comfortable passive daylight is concentrated in the southern side. The prevailing winds in Jiangsu come from the Southeast, from the Pacific Ocean down to the south of this region (Fig. 3.8). The annual average wind speed is about 2.3m/s [35].

As the psychometric chart of Shillong shows (Fig. 3.9), the climate in the comfort zone accounts for 7.9% of the hours of the year in Jiangsu Province. The regional weather is warm and humid with litter temperature gradient changing greatly. In view of this situation, it is important to have rational opening orientation and indoor ventilation to prevent overheating in daytime and heat loss in nighttime. The passive ventilation has to be removed from the air moisture carried by the proper speed winds and to preferably be adjusted before reaching the indoor spaces. Finally, high mass, night flushing and thermal control can help regulating the diurnal temperature differences and combating the effects of seasonal variations. The data source of this analysis is ISHRAE 582380 WMO, more details see Appendix A8.

Figure 3.9: Psychometric chart for Jiangsu Provence :Tools Climate Consultant 6.0.
3.2.2. Jiangsu Categories Selection

Based on the above overview, this part will be concentrated in its sustainable standards. However, since the sustainability assessment criteria contains many aspects, it is difficult to fully meet the sustainable requirements of the current economic and construction level in Chinese villages. Therefore, this selection will determine the focus of the local sustainable assessment based on the Jiangsu’s conditions and characteristics, aiming to maximize the effect of sustainable practices in the rural areas of Jiangsu province.

(1). Water Resources Conversation

<table>
<thead>
<tr>
<th>Chinese Water Resource Ranking (Province)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Top</strong></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
</tbody>
</table>

Data based on "Chinese Ministry of Water Resources website" [51].

Figure 3.17: Water Resource Ranking for China: Chinese Ministry of Water Resource website [51].
The first is the water resources conversation. As shown in Figure 3.17 & 3.18, Jiangsu has the highest reservation of water resource in China and is also the largest province of water resource per capita. Therefore, water protection needs to be considered as a critical element of local standards. In addition, as water becomes more and more scarce, the Chinese government has also emphasized more on water conservation in recent years.
(2). Wasterwater Management

![Table: Per Capita Water Consumption Per Day (Provinse)]

<table>
<thead>
<tr>
<th>Types</th>
<th>Province</th>
<th>Litre / Fresh Water</th>
<th>Increase Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jiangsu</td>
<td>308</td>
<td>2.10% (+)</td>
</tr>
<tr>
<td>2</td>
<td>Hebei</td>
<td>304</td>
<td>1.17% (+)</td>
</tr>
<tr>
<td>3</td>
<td>Zhejiang</td>
<td>287</td>
<td>1.52% (+)</td>
</tr>
<tr>
<td>4</td>
<td>Sichuan</td>
<td>261</td>
<td>1.36% (+)</td>
</tr>
<tr>
<td>5</td>
<td>Xinjiang</td>
<td>230</td>
<td>1.85% (+)</td>
</tr>
</tbody>
</table>

Data based on "Chinese Ministry of Water Resources website" [51].

Figure 3.19: Water Resource Per Capita Ranking Per Day for China: Chinese Ministry of Water Resource website [51].

The second noteworthy focus is the wastewater management in rural areas in Jiangsu. As shown in Figure 3.19, Jiangsu's personal water consumption is above the average level in the country, which mostly comes from natural water system. In this case, the establishment of standard of wastewater management will not only help solving the waste and pollution problem of regional hydrology, but also will promote the recycling utilization of domestic water.
(3). Building Passive Design

As for building passive design, Jingsu rural construction faces similar problems with Heilongjiang. Under the impact of the economic conditions and cultural background from the past, most rural houses have some deficiencies, such as lack of effective
management, resource waste and others. In view of this situation, developing the standard of building passive design can not only reduce the price of housing construction and maximize material utilization, but also optimize living condition, which is conducive to the overall development of Jiangsu villages and its resident's acknowledge.

Based on the above analysis, the following part analyzes the sustainable performance of these three categories in LEED-ND and Living Building Challenge.

3.1.3. LEED-ND Analysis - Jiangsu
This section will analyze the relevant rating categories of LEED-ND standards according to the features of Jiangsu province. The intent is to find out the problems and inadaptability of the existing contents in the local evaluation process.

(1). Wetlands and water body Conservation - Jiangsu
Jiangsu province is land famous for her abundant resources in China. It has lots of agricultural resources and an advantageous natural environment, particularly abundant water resources all over the region. Therefore, the conservation of local water resources becomes the primary focus of local sustainable evaluation. As for LEED-ND standards, the contents with this aspect are mainly found in the category of Wetlands and water body Conservation. The standards provide concrete demands to the conservation of water body from two aspects: buffer land scale and definition of sensitive area. Besides that, LEED standards also regard the residential density as an important parameter in the establishment of protected buffers. More details see Appendix A9.

From the observation of regional situation, there are mainly 3 problems in water conservation that causes the difficulties in the local implementation of LEED
standards. Firstly, the management of Chinese rural lands was relatively weak. The utilization and management right of the land in many riparian areas are hard to be defined in a rational way, which causes difficulties in the establishment of protected buffers, such as the land disputes and land compensation fees.

Secondly, the definition job of sensitive areas also conflicts with many problems in this region. On one hand, the lack of professional and relative regulation makes it hard to guarantee the validity and authenticity of local land evaluation. On the other hand, the definition of sensitive areas often has close relations with the environment. As such, it would be difficult for rural lands to remain their original status under the impacts of industrial transformation and population mobility. This unstable situation makes it hard to match the existing evaluating standards with the conservation strategies.

The last one is the areas of protected buffers. The current requirements mainly reference the regional population density and building types. This method struggles to juggle the regional natural conditions and the changes in population distributions. Additionally, considering the possible damages and pollution of rural water environment, LEED standards will not achieve a satisfying performance in this region because it uses land attribute as the primary evaluation parameter. Therefore, based on the current situation of Jiangsu, the key contents of local standards should be how to effectively conserve the integrity and security of water resources.

(2). Wetlands and water body Conservation - Jiangsu

As a priority of sustainable standards, wastewater treatment requires community projects which not only improve the utilization efficiency of water resources, but also reduce wastewater pollution in the environment. As for LEED standard, the category of Wastewater Management provides the goals and resultant scores of wastewater treatment for annual consumption. More details see Appendix A10.
Considering the situation of Jiangsu rural areas, LEED standards can not be effectively implemented in practices. There are two main reasons for the failure of evaluation of rating contents in that region. The first one is the conflicts in perceptions. Under the influence of local cultural background, rural dwellers find it hard to completely accept that the transition from wastewater to potable water. In addition, owing to different natural conditions and economic strengths, many villages lack related equipments and professionals. Therefore, it would be difficult to ensure the matching effect with LEED standards in local situations where conversion rate is used as a key reference point for wastewater management.

Secondly, the existing evaluation method takes no account of the relative backwaters of rural infrastructure. Lots of areas lack efficient management of daily wastewater, especially during collection and treatment phases. In view of this, more attention should be paid on the construction of centralized management system in terms of rural wastewater management. Contrarily, the inadequate infrastructure and equipment not only fails to guarantee a high efficient treatment of wastewater, but also would cause the problem of the environmental secondary pollution. Furthermore, LEED standards for wastewater management also lack specific instructions, particularly the interaction between reuse water and local agricultural producers. As such, the regional standards should provide the necessary technology introductions and various purposes of reuse water in order to improve the recognition and practices of wastewater management in Jiangsu rural areas.

(3). District heating and cooling - Jiangsu

The existing standards of temperature regulation evaluate the sustainable performances of projects from two aspects: energy consumption reduction and providing strategies for comfortable thermal indoor environment. More details see Appendix A11.
Judging from the present situation of Jiangsu province, LEED standards face two major difficult problems in local evaluations which focus on the data improvement. The first is data statistics. For historical and climate reasons, this region didn’t have a complete central air conditioning system. Lots of villages used mechanical system and fossil fuel as the major regulation measure to adjust indoor temperatures. And combined with the loosened living style in rural areas, it is difficult for people to gain detailed data for the requirements of LEED evaluation, particularly the energy consumption and output power of associated equipment.

Secondly, the existing evaluation relies mostly on other energy standards, such as ASHRAE Energy Design Guide and Advanced Buildings Core Performance Guide, which means that rural areas need a great number of professionals in their processes of sustainability which can give effective evaluation of building energy performance. However, because of the effect of huge gaps in fund and staff, it is hard to form a suitable environment in order to meet the requirements of LEED standards in rural areas. Therefore, emphasizing the natural ventilation and real improvements of indoor temperature regulation would be more conform to the needs in Jiangsu countrysides.

3.2.4 Living Building Challenge Analysis - Jiangsu

As for Living Building Challenge, this section will put emphasis on discussing the evaluation categories which have close connection with the features of Jiangsu rural areas. This study will analyze the practicality and effectiveness of existing assessment content in local practices.

(1). Water Petal - Jiangsu

In this section, Living Building Challenge requires the building operation to maintain a conservative and none-pollution state in water usage in this area, especially the recycling water resources. The intent is to establish a sustainable system of water
usage, providing efficient method of water resources utilization and natural hydrology conservation. From the content point of view, Water Petal mainly includes two aspects: closed recirculating water system and water body protection. More details see Appendix A12.

Judging from the present situation of Jiangsu Province, It is difficult for the standards of Water Petal to attain local recognition. The first one is the requirements of water circulation system. Under the influence of historical reasons and cultural background, many rural areas lack the constructions of water infrastructure, particularly in terms of wastewater collection and purification. Moreover, because the region has a sufficient water supply, the locals didn’t have much consciousness in water conservation, thus it is hard for them to adapt to recycling water utilization in daily life.

Secondly, the construction of water circulatory system often needs a great deal of manpower and fund. Considering the economy bearing capacity of villages, fully implementing the existing standards would not only fail to achieve the effect of water saving, but also cause the pollution and destruction of local water. The last is the conversation of natural hydrology. Many people lack knowledge about water protection due to economic reasons. The extensive lifestyle and industrial transformation, including modern mechanical utilization and large-scale industrial production, have caused great threat to regional hydrologic environment. Therefore, the region cannot provide perfect ecological environment for natural hydrology with no negative effects which is an important ideal of Water Petal.

(2). Beauty Petal - Jiangsu
This category focuses on the need for beauty as based on excellent capability to preserve, conserve, and better service. The aim is to elevate people’s spirits and inspire us to make them better. The concrete content mainly involves: public art,
usage experience and a series of related elements in people’s daily life. The core objective is to improve the positive effects of beautiful living environment. More details see Appendix A13.

There is a great gap between regional conditions and evaluating content of Beauty Petal in current Jiangsu. The actual problems mainly exist in rural infrastructure and public perception. On one hand, lots of villages still focus their policies on economic development. In contrast, other aspects are only used as additional methods for regional economic environment, such as amenity garden and construction of public environment. Meanwhile, constrained by fund and policy, many rural areas cannot offer adequate attention and support to beauty programs at this stage. On the other hand, In the history of rural development, spiritual life has rarely been emphasized in people’s daily life. People always pay more attention to the material benefits rather than the beauty surrounding them. In this context, a large number of villages lack the foundation of beauty construction and the correct opinion orientation, which make it difficult to reach agreement with the requirements proposed in this section. Therefore, providing concrete designing recommendation will help local people understanding and recognizing more deeply the meaning of beauty construction, such as environmental greening and the establishing of public space.

3.1.5 Summary and Targets - Jiangsu

To sum up, the above analysis shows that Jiangsu rural areas have several problems as follows.

First is the imperfect measures for local water protection. Due to the influence of human activities and economic developments the local hydrology faces potential negative influence from the surrounding environment, such as water pollution and damage. Additionally, considering the strong connection between water use and daily
life, developing relative conversation strategies becomes a big issue in this region which has relative abundant water resource.

Second is the wastewater management. Under the effect of living habits and unimproved infrastructure, many rural areas don’t have an effective management in processing daily wastewater, which not only has led to waste of water resources, but also has exerted grave impact on natural hydrology. Moreover, because of the diffusion of water pollution, especially affected by the variegated rivers, the partial pollution can lead to bad consequences for the whole drainage system. In this case, the influence brought by wastewater management becomes the highlight of local sustainable standards.

The last one is the performances of thermal comfort. Under the influence of regional conditions, the common building practices cannot adapt to local climate, especially the high humidity and low wind. In this situation, developing architecture passive designs based on climate is an effective way in controlling energy use and providing a healthy living space in order to reduce negative impacts on ecological environment.

Given the above, the following three aspects were chosen to design and improve the regional sustainable standards of Jiangsu rural areas.

- **Water Resources Conversation**  
  *(Environmental Section)*

- **Wasterwater Management**  
  *(Social Section)*

- **Building Passive Design**  
  *(Living Section)*
3.2.6 Jiangsu Sustainable Standard Proposal

The Sustainable Clover Challenge of Jiangsu province is similar to Heilongjiang’s case. Different evaluating methods have different requirements and credits, including water conversation, wastewater management and building passive design. Every project will be given corresponding credits after meeting related benchmarks within different aspects. All of projects will be rated according to their final scores.

Figure 3.22: Living Building Challenge Project Checklist -Jiangsu.
Chapter 4

Result

The results below are the proposed design and correlation analysis for two rural sustainable standards in Heilongjiang and Jiangsu, respectively. The main focus is to create the sustainable standards which can better suit the different rural environments in China. With fully consideration of their own characteristics and regional actual situations, these rural areas doesn't conform to the condition of pursuing the all-side sustainable development, which means that the goal is to improve the practicality and generality of regional standards instead of adopting single standard adjustment. It's important to note that this work will focus on two different environments with common rural features in order to achieve the most universality of sustainable constructions in target zone. According to the previous analysis, design contents will follow different actual demands in different areas and propose reasonable suggestion for the establishment of regional standards. Although the regional focuses are different, the passive design is being brought into all areas because living environment constitutes an important basis for country life.

4.1 Heilongjiang Sustainable Standards Concepts

Based on the above analysis, there are three key points for sustainable standards in
Heilongjiang, including Conservation of Agricultural Resources on farmland conservation, Sustainable Utilization of Energy for energy saving and renewable energy development, Building Passive Design for daylighting control and natural ventilation.

Agricultural Resources Protection are incorporated into three main aspects, namely agricultural land conservation, environment optimization and traffic system. The first two aspects often work together, considering that the better the conditions of soil and climate, the more successful agricultural production. However, the primitive transportation system can negatively affect the health growth of agricultural economy, so a balance among these three aspects was considered.

In agricultural land conservation, the main objective is to provide a healthy natural habitat of farmland and design related measures that help controlling the negative effects and pollution of people activities. The first strategy is to set the greening buffer, taking advantage of the intrinsic self-regulating effect of natural ecosystems. For example, the increasing trees planting used to improve the micro-climate of farmlands, strengthen the boundary between agricultural and living environment. The second strategy is to create a rational traffic network. Therefore, the original transport system will be refined to meet the different demands of rural production and living. Due to the special seasonal variation of agricultural industry, the scale of roadways have to respond to the changes of seasonal demands. The highlight in the design is to show the high flexibility of new standards that incorporates agricultural characteristics and sustainable concepts, as well as the local economic carrying capacity.

The second aspect of Heilongjiang’s case is sustainable energy utilization. Taking into consideration of the features of rural lifestyle and infrastructure level, this strategy has focused on reducing fossil fuel use and new energy development. As the main source of heat and energy, the traditional fossil fuels have a series of problems in combustion
efficiency and emission [36]. In view of this situation, developing central supply system can not only improve energy efficiency, but also enhance the management waste disposal. Moreover, developing renewable energy based on local environment is the other highlight of this aspect, such as solar power and bio-gas. These new energy sources will become an important referential index in the regional sustainable evaluation based on specific usage.

Building Passive Design is incorporated into the architecture in two main areas, namely, daylight, natural ventilation and opening. Daylight and Natural Ventilation are always closely connected with building opening, considering that the wider openings in good orientation, the better ventilation qualities and view experiences. On the contrary, the narrows have low illumination and stale air. And this uncomfortable indoor space not only causes the energy waste of mechanical system, it also can lead to physical deterioration. In view of this situation, this design will take into full account of the interactions between daylights, ventilation and opening.

4.1.1 Heilongjiang Sustainable Standards Strategies

The section of farmland conservation responds to the two main concerns of Heilongjiang rural areas, including setting greening buffer and adjusting farm traffic. The final design is increasing the amount of vegetation around the farmlands to provide a relative health natural environment and repair the farm lane to ensure the stable traffic activities and production safety. Based on the combination between farmland and road net, the new standards will provide a design baseline to meet the requirements of farming industry and modern lifestyle at the same time. Figure 4.1 summarizes the strategies employed in the design of farmland conservation, which will be presented in detail after.
Greening Buffer: Under the existing conditions of Heilongjiang rural areas, setting the greening buffer between agricultural zone and living zone has more advantages than the land compensation in LEED standards. On one hand, the greening buffers can serve as a spatial barrier that reduces the negative effects between farmlands and living areas. On the other hand, this simple and clear evaluation standard also enjoys great practicality in local constructions. And as for the selection of buffer plants, the best method is to use the native plants as the target, thus increasing the stability of farmland ecosystem. Meanwhile, selecting rational and utilisable way of planting technologies and planting density can ensure both greater amounts of sunlight and good vision. In addition, due to a high degree of solar incident angle, the buffer facing North and South avoids to plant high woody plant in order to get enough sun exposure of farmlands. Additionally, the buffer with high greening rate can effectively adjust to the microclimate within farm region, thus ensuring a good growth trend of crop, especially in the rainy season from June to August (Figure 4.4a & Figure 4.4b). Lastly, the scale of green buffer will be designed according to surrounding road conditions.
Country Road: The second part of Agricultural standard focuses on the adjustment of farm traffic. Based on the high stability of road conditions, taking the scale of rural road as a reference baseline for the buffer widths can avoid the risks of the policy change and the uncertainty of farmland boundaries. Therefore, this strategy focuses on the development of farm road, particularly in seasonality and practicability. By the two-layers structures design of country roads, the new standards are intended to
manage the different traffic modes in an orderly way and reduce environmental pollution through reasonable greenery. The wider roads are located nearby living quarters, serving as the best routes for daily travel. And the narrower way crisscross and swept over the fields, meeting the demands of mechanized farming and daily labor activity (Fig. 4.5).

![Efficiently Reduce the Negative Effects of Human Activities (Noise, Emission, Thermal)](image)

**Figure 4.5:** Strategies for Road System applied to Surrounding Farmlands.

The intents of Energy Sustainability are simple and clear, which is to raise utilization efficiency of traditional energy and to develop renewable fuels (Fig.4.2). The final design is using centralized supply power instead of individual power mode to reduce pollution and waste in energy manufacturing process and transport. The emission of fossil fuels can also be effectively reduced with centralized method, especially during the winter. The regional standards will make clear regulations about the scale of centralized supply based on the rural population, thus keeping the balance between energy conservation, emission reduction and actual use (Fig.4.6a).

Considering the close relationship between renewable energy selection and regional conditions, the high annual sunshine and wind distribution makes it suitable for Heilongjiang to develop solar energy system. And its reasonable price and advanced
technique also provide the powerful supports for solar energy use (Fig.4.6b). By taking sunshine angle and geographic location into consideration, new standards will propose concrete demand for equipment orientation and reliability of power supply.

In addition, according to the characteristics of local agricultural production, regional standards propose to promote the utilization of bio-gas, aiming to solve the problem of agricultural waste disposal in the development of bio-gas resources. This strategy not only suits the characteristics of local agriculture production, but also accords with the practical conditions of rural constructions, especially because of the operability and consumability of biogas technologies (Fig.4.6c). The final energy service conditions will be taken one kind of reference data into the evaluation scope.

Figure 4.2: Strategies applied to Heilongjiang Energy System.
Figure 4.6a: Strategies for Energy Supply System applied to Heilongjiang Rural Areas.

Figure 4.6b: Strategies for Solar Penal System applied to Heilongjiang Rural Areas.
Based on the above analysis of regional conditions, the standard of building passive design responds to the three main concerns of Heilongjiang rural areas including increasing proper illumination, optimizing natural ventilation and protecting building from rainy and snowy. The final design is an adjustment of opening mode to provide positive natural daylight. The proposal of roof opening improves airflow and an extension of the roof eaves minimizes the negative impacts of rainfalls and snow. Figure 4.3 summarizes the strategies employed in the design of this area.
Daylighting Control: Heilongjiang has lots of sunshine in the whole year with the monthly mean value being about 450 wh/sq.m, (data from China's Meteorological Administration website) [52]. The intent is to avoid strong direct sunlight, provide a comfortable diffuse reflection, in order to reduce surplus heat gain. Taking Chinese rural living habits and sunlight angle into consideration is important for the performances of openings. Almost openings are proposed to be located on the northern and southern sides, which can reduce the low angle daylights and overmuch thermal energy at the same time. Additionally, All the openings should be shaded using eave and vegetation. The local deciduous woody plants should be considered as priority which helps keeping a high sunlight reflection in summer and low in winter. Using passive design instead of mechanical system is more suitable because it also keeps low power consumption and carbon emission and provides a comfort space close to the natural environment (Figure 4.7).

Natural Ventilation: As the first strategy of ventilation, building orientation has a direct impact on indoor air circulation. And considering the intake of sunlight, the best orientation is to place the primary elevations facing North and South with centralized openings and the short sides on this east-west axis. According to the distribution of annual wind. The superior quality winds in Heilongjiang come from the Southeast, so it would be the best to control the building orientation degree between 0° to15° to provide sound ventilation environment and comfort thermal, especially in summer and winter, (data from Tools Climate Consultant 6.0). Moreover, the vegetation in the Northeast also contributes to the decrease of cold winds in winter and the intake of cool winds in summer (Figure 4.7).
Figure 4.7: Strategies for Daylighting Control applied to Heilongjiang Rural Areas.

The other strategy is to optimize the opening mode and location to achieve adjustable indoor airflow. Using larger openings instead of traditional small openings can significantly improve the distribution and quality of fresh air. In addition, according to the physical principle that hot air moves under the cold, the building are proposed to add upper openings to improve air flow. And considering the smooth natural ventilation even when it is raining, the louver system will be is recommended for use in upper openings, in order to meet the demands of high water resistance and control (Figure 4.8).
Figure 4.8: Strategies for Natural Ventilation applied to Heilongjiang Rural Areas.

4.1.2 Heilongjiang Sustainable Standards Analysis

- Agricultural Resources Protection

According to the above-mentioned analysis, the new agricultural resources protection standard has the following several specific aspects: first, the greening buffer scales are based on the Chinese road level, as Figure 4.10 below shows. The concrete requirements are affected by rural road quality levels and local plant species. Secondly, Since the purpose of buffer design is to reduce the negative impacts of human activities and optimize micro-climate, its design width shall be equal to or greater than
the actual road width, including garage and pedestrian system. Meanwhile, according to the solar radiation and visual experience, the height of buffer should follow the strategy of low in the east-west and high in the north-south, in order to meet the demands of plant growth and to reduce climate impact. Lastly, considering the importance of farmlands to rural areas, this standard will be recommended for a required entry, as one of the most important evaluation basis of Heilongjiang sustainable standards. Relevant information and calculations are as follow.

<table>
<thead>
<tr>
<th>Level</th>
<th>Motor Width</th>
<th>Non-Motor Width</th>
<th>Lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highway</td>
<td>3.75m / lane</td>
<td>N/A</td>
<td>≥2</td>
</tr>
<tr>
<td>1</td>
<td>3.75m / lane</td>
<td>0.75m / lane</td>
<td>≥2</td>
</tr>
<tr>
<td>2</td>
<td>3.75-3.5m / lane</td>
<td>0.75m / lane</td>
<td>≥2</td>
</tr>
<tr>
<td>3</td>
<td>3.5-3.0m / lane</td>
<td>0.75m / lane</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>3.5-3.0m / lane</td>
<td>0.75m / lane</td>
<td>1</td>
</tr>
</tbody>
</table>

Chinese rural roads mostly belonged to 3,4 Level

Figure 4.10: Classification of Chinese Roads [37].

**Level 3 Buffer Width Requirement:**

Road Width = 2 Motor Lanes + 2 Non-Motor Lanes = 3.0×2 + 0.75×4 = 9.0 m (min)

Min Buffer Width = 7.5 ÷ 2 = 4.5 m / each side

Road Width = 2 Motor Lanes + 2 Non-Motor Lanes = 3.5×2 + 0.75×4 = 10.0 m (max)

Max Buffer Width = 8.5 ÷ 2 = 5.0m / each side

**Level 4 Buffer Width Requirement:**

Road Width = 1 Motor Lanes + 2 Non-Motor Lanes = 3.0 + 0.75×2 = 4.5 m (min)

Min Buffer Width = 4.5 ÷ 2 = 2.25m / each side

Road Width = 1 Motor Lanes + 2 Non-Motor Lanes = 3.5 + 0.75×2 = 5m (max)

Max Buffer Width = 5 ÷ 2 = 2.5m / each side
Buffer Plants Requirement:
- Encouraging the use of native plants including woody plant and herbaceous plant
- Height Difference: High in North-South Direction    Low in East-West Direction
- Prior adoption of deciduous plants with deep rooting
- Establishing a periodic inspection and maintenance mechanism

Roads Classification Requirement:
- All lanes shall be installed at least at a 3% downward slope with low permeability
- Slope direction outward extension from road to farmland.

- Energy Sustainable Utilization

<table>
<thead>
<tr>
<th>%</th>
<th>Central Energy System</th>
<th>Individual Energy System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Combustion</td>
<td>90% - 95%</td>
<td>≦ 90%</td>
</tr>
<tr>
<td>Energy Conversion</td>
<td>40% - 45%</td>
<td>≦ 30%</td>
</tr>
</tbody>
</table>

Figure 4.11: Diagram of fossil fuel efficiency (coal) [38].

As shown in Figure 4.11, Central supply system has successfully improved the combustion and energy exchange efficiency of fossil fuel. Compared with the individual supply, central system has promoted about 40% of energy conversion and 5% of burning efficiency in energy production process [38]. In addition, based on the benefits of technology and equipment for large-scale production, central supply system performs better in the treatments of wastes and emission. As for this local standard, a peg to credit will be formed according to the percentage of central system.
coverage, thus playing the supervision role in rural energy supply (Figure 4.12).

<table>
<thead>
<tr>
<th>Types</th>
<th>Central System Coverage Rate</th>
<th>Credit Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40% - 50%</td>
<td>Certified</td>
</tr>
<tr>
<td>2</td>
<td>50% - 60%</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>60% - 70%</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>≥ 70%</td>
<td>3</td>
</tr>
</tbody>
</table>

Figure 4.12: Proposed Credit Requirement for Central System.

- Renewable Energy Development

![Figure 4.13: PV Price Movement](image)

![Figure 4.14: Worldwide growth of PV](image)

The local renewable energy development concerns mainly solar energy and biogas. The solar energy depends mostly on the solar panels. Its paved area and conversion efficiency directly determine the amount of available energy. A typical photovoltaic system employs solar panels, each comprising a number of solar cells, which generate electrical power, reaching 8%-16% percent of conversion efficiency and normal power output up to 100-365 watts [39]. Although the cost of solar equipment is evidently effected by environment, the price of PV penal has decreased year by year with technologic upgrading and material optimization (Figure 4.13) [39].
As the main trend of solar energy, PV penal becomes the primary demand of users because of its easy installation, low price, high efficiency and other advantages. Meanwhile, the fast-growing development of photovoltaic industry also laid a good foundation for photovoltaic generation in Chinese rural areas (Figure 4.13) [40]. Combined with Heilongjiang’s actual situation, the calculations below illustrate the desired effect of PV system in this region.

- The data comes from governments and companies involved in the various projects, and from Network Statistics archives [42].

- Taking a single Chinese household which has three people for example:

  **- Per capita household electricity consumption** [41]: 9 kilowatt-hour (kW • h) / day

  Total daily consumption: $9 \times 3 \times 1 = 27$ kW • h / day

  **- China Solar PV regularly costs:**

  USD 0.05-0.10 kW • h $\rightarrow$ $(0.05+0.10) \div 2 = 0.075 \times 6.88 = 0.516$ RMB (kW • h)

  **Chinese Residential electricity price** [43]: 0.6252 RMB (kW • h)

  $(0.6252-0.516) \div 0.6252 = 17.5\% \rightarrow Price\ Advantage$

  **- PV Solar Energy Production** [44]:
  
  Chinese common PV module scale: 1640 mm × 992 mm

  Generating efficiency: 3 $\text{㎡}$ PV $\rightarrow$ 2 (kW•h) / day   Basic capacity: 260Wp

  Average living space per person (Heilongjiang) = 24.82 $\text{㎡}$
A family house areas: 24.82 × 3 = 74.46 m²

PV penal area: 74.46 × 20% = 15 m²

Daily Generation: (15 ÷ 3) × 2 = 10 (kW·h) → Expected Value

Occupancy Ratio: (27-10) ÷ 27 = 63% (fossil fuel); 37% (solar energy)

Compared with solar energy, biogas is more dependent on the local agricultural resources. As for the current technical level, a common biogas system could produce about 200-300 liters of methane per day, and about 20% - 30% of the output comes from digesters in warmer climates. A large part of that will be converted to energy and water by burning [53]. The specific chemical formula is CH₄ (gas) + 2O₂ (gas) = CO₂ (gas) + 2H₂O (liquid) + 890 kJ [54]. Additionally, China has over 50 years of experience in developing biogas technology which provides good development conditions for biogas resources in Heilongjiang rural areas[55].

The purpose of this design is to suggest that one of the important evaluation criteria could weight the percentage of renewable energy utilization. Different use ratio will correspond to different credit, as shown in Figure 4.12. Both solar energy and biogas are in the range of this evaluation.

<table>
<thead>
<tr>
<th>Types</th>
<th>Renewable Energy Use Ratio</th>
<th>Credit Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>≥10%</td>
<td>Certified</td>
</tr>
<tr>
<td>2</td>
<td>≥20%</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>≥30%</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 4.36: Proposed Credit Requirement for Renewable Energy Development.

CHAPTER 4 : RESULT
Strategies to improve daylighting were successful in providing adequate levels of illumination and distributing the light more uniformly (Fig. 4.13). 93% of the area was within the acceptable level against 35% of the original model, considering national illuminance standard, which is a demand between 300 and 2000 lux. The remaining 7% was below the threshold and is concentrated at the edges and corners of the building. The highest level measured was 1542 lux and the lowest was 124 lux. In contrast, the original data are 1067 lux and 46 lux. The local standards will be recommended to assign different credits according to the daylight illuminance range, as shown in the figure below. Relevant data comes from Revit.
In consideration of the direct impact of the temperature of natural ventilation room, this local standards will evaluate the ventilation conditions based on the optimum degree of indoor temperature. As shown in Figure 4.14, the blue line on the diagram represents the dry-bulb temperature in this region, the orange line represents the optimized temperature and the yellow areas between them corresponds to the temperature adjusting range of natural ventilation. The local standards will be recommended to assign different credits according to the different average temperatures of the whole year, as shown in the figure below. Relevant data comes from ASHRAE 55-2010 Adaptive Comfort Model.
4.2 Jiangsu Sustainable Standards Concepts

Through a similar analysis like Heilongjiang conditions, there are three focuses of Jiangsu rural standards. The first one is Water Resources Conservation. The second is Wasterwater Management. And the last one is Building Passive Design on the climate of high humidity and low wind.

According to the above-mentioned before, Water Resources Conservation mainly consists of two parts, namely surrounding buffer establishment and pavement drainage. Natural water hydrology always correlates significantly with surrounding environments, and the better the design of buffer is, the more stable the natural water system will be [56]. Moreover, incomplete drainage system also has substantial impacts on the health condition of regional hydrology. Due to these reasons, the above-mentioned two points will be considered as the most significant factors for water conservation standards [57]. Taking into consideration that China has achieved development economic construction in recent years, sustainability infrastructure upgrading in Jiangsu rural areas has a good development potential [24].

As for Water Resources Conservation, the main objective is to maintain the health condition of Jiangsu’s water resources and formulate correlated strategies that reduce the water pollution from human activities and economic production. Based on the previous analysis of Jiangsu’s economic conditions and geomorphic features of having many plains and river system. The first strategy of water conservation standard

<table>
<thead>
<tr>
<th>Types</th>
<th>Temperature Optimization</th>
<th>Credit Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0°C - 2°C</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>≥ 2°C</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 4.40: Proposed Credit Requirement for Natural Ventilation Improvement.

CHAPTER 4 : RESULT
is to establish surrounding buffer and utilize the impacts of spatial barrier and self-cleanliness of natural environment. For instance, the scales and plants of buffer will be disciplined in accordance with various types of land utilization that reduces the negative effects of external contaminants in water through the parametric analysis and reasonable calculation. Taking the rainy weather and dense river system of Jiangsu rural areas into consideration, the pavement drainage system has great influence on the local water environment [57]. Therefore, the second water conservation strategy focuses on setting up an improved pavement drainage system. Following this concept, the original drainage system will be upgraded in order to accommodate different conditions of natural environment. Additionally, bearing in mind the special diffusivity of water pollution, the new drainage should be capable of addressing the complicated issue of pollutants [56]. The focal point of this section is to take local weather conditions into consideration, thus presenting high applicability of local standards which conform with rural features and sustainable development objectives.

The second aspect of Jiangsu Province is Wastewater Management. According to the above analysis of local natural conditions and infrastructure levels, reducing the contamination of domestic wastewater and increasing the utilization ratio of recycled water are the priorities in this section. In the first place, domestic wastewater mainly come from people’s daily life including sinks, showers, baths, clothes washing machines, dish washers and so on. Unlike natural precipitation, these types of wastewater often contain certain proportion of chemical and oily component which requires special purification treatment [58]. In view of this, development of central water disposal system can not only reduce occurance and dispersion of water pollution, but also can effectively recycling water resources if compared with direct sewage disposal. Secondly, considering the characteristics of local weather and lifestyle, particularly large amounts of personal water consumption in daily life (Figure 3.19), developing reprocessed water resources is another effective strategy for wastewater management, such as reclaimed water and natural precipitation [45].
These reclaimed water will be rendered as the main study objects to evaluate the local sustainable performances based on the proportion of actual use.

The last one is Building Passive Design, the concrete standards in Jiangsu rural areas consists of two main components: positive sun exposure and indoor temperature control. Either daylight or temperature has direct links with building openings. According to analysis of Jiangsu’s climate with Climate Consultant 6.0, better orientation can provide a longer comfort zone with more comfortable indoor temperature, humidity, as well as, abundant sunshine. Conversely, unreasonable opening design leads to blockade of indoor air flow and humidity accumulation which is harmful to people’s health. Besides, it will also increase the use of mechanical system and undermine regional natural environment. Therefore, this design will focus on the optimization of daylights, indoor temperature and natural ventilation in order to provide a healthy and comfortable living environment.

4.2.1 Jiangsu Sustainable Standards Strategies

![Diagram of Water Resources Conservation Strategies](image)

Figure 4.16: Strategies applied to Jiangsu Water Resources Conservation.

Based on the above analysis, the water conservation design in Jiangsu province
consists of two parts: the establishment of surrounding buffer and the adjustment of pavement drainage system. The final design is to establish different scales buffer based on complex rural situation for reducing the external pollutant effects on natural water and adjusting drainage system for rural areas in order to meet the needs of wastewater gathering and purification. With support from the integrated application between buffer program and drainage system, the new standards will provide rural development with a sustainable mode which addresses both water protection and wastewater treatment. Figure 4.16 summarizes the strategies employed in the design for farmland conservation, which will be presented in details as under.

Figure 4.17a: Strategies for Surrounding Buffer applied to Jiangsu Rural Areas.

Figure 4.17b: Strategies for Surrounding Buffer applied to Jiangsu Rural Areas.
**Greening Buff**: Establishing a clear buffer between human activity areas and water environment is the first emphasis of conservation strategy. The concrete designing proposal should be regulated according to road levels and surrounding land utilization condition in order to improve water resource security so that land utilizing efficiency can be ensured. Meanwhile, the greening work of buffer primarily adopt local plants. This design can not only reduce water and soil erosion of waterfront areas, but also improve the beauty construction and environmental quality of surrounding villages [56]. Under the local climate effects of high humidity and low speed wind, the surrounding buffer is unfit to grow high plants so as to ensure the fluent airflow and visual perception. In addition, the appropriate scale of buffer can effectively adjust the surface runoff which has positive sense for reducing the threats of flood disaster in rural areas, especially in the rainy summer seasons. (Figure 4.17a & Figure 4.17b).

![Diagram of Drainage System](image)

**Figure 4.18: Strategies for Drainage System applied to Jiangsu Rural Areas.**

**Drainage System**: This strategy focuses on surface drainage, especially on the validity and environmental protection of wastewater management. The system will conduct preliminary filtration of overland runoff and complete purification process of wastewater through central treatment mode [57]. Various level structures of drain are
to lead and collect surface water according to different runoff situations, aiming at reducing the climate impacts of yards, and promoting the efficiency of water resources recycling simultaneously (Figure 4.18).

Figure 4.19: Strategies for Wastewater Management applied to Jiangsu Rural Areas.

As the second focus of Jiangsu’s standards, the concepts of **Wastewater Management** are clear: to reduce negative effects of wastewater and increase the proportion of reclaimed water utilization. The final design is to solve household sewage issue through a central treatment system. This centralized management can not only reduce the dispersal and spread of pollution, more importantly, but also can improve the cycling efficiency and usage cycles of water resources, particularly in home cleaning and irrigation use (Figure 4.19). The local standards will propose specific requirements for the scale of centralized treatment according to regional domestic water consumption per capita in order to ensure the balance between water cycle efficiency and daily usage [59].
Unlike household sewage, natural precipitation does not contain chemical and oily composition. Besides, based on Climate Consultant 6.0 data, the climate conditions in Jiangsu Province are suitable for extensive collection of surface water because it has a warm, humid outdoor environment for most of the year [45]. Meanwhile, the local flat terrains and proven techniques for municipal construction also support the application of precipitation collecting system, as shown in Figure 4.20. In consideration of construction and climate factors, local evaluation contents will offer detailed standards of conversion ratio in precipitation circulation. Additionally, according to the features of regional environment, the new standards will also provide relative explanations about reclaimed water supply, such as economic and technical aspects in order to promote the local public’s acceptance of water recycle.

Based upon the aforementioned information, the whole strategy intends to form a sustainable water use and management mode which suits for Chinese rural situations. Eventually, the utilization of reclaimed water will be considered as a reference data for evaluation (Figure 4.21).
Figure 4.21: Wastewater Recycle System & Treatment Process applied to Jiangsu Rural Areas.

The third standard of Jiangsu province is Building Passive Design. Using the analysis from the previous section, The intents of building passive design responds to the three main concerns of Jiangsu rural areas, including daylight optimization, natural ventilation improvement and indoor temperature control. The final design is to adjust the opening orientation to reduce the seasonal effects of indoor heat, improve building opening design for increased indoor ventilation and extend roof overhangs for comfortable shade and climate protection. Figure 4.22 summarizes the strategies employed in the design of Jiangsu rural areas.
Figure 4.22: Strategies applied to Jiangsu Rural Areas Passive Design.

Figure 4.23a: Strategies for Daylight Optimizing applied to Jiangsu Rural Areas.
Daylight Optimizing: According to the previous analysis of climate conditions in above section, Jiangsu Province has the subtropical monsoon climate with full sunshine throughout the year. The objectives of this design are to control indoor overheating and provide comfortable daylight illumination in order to reduce the energy use in warm humid climates. According to the living mode and geographical conditions of rural areas, the best orientation of openings is to face south and concentrate principal openings in the direction (Figure 4.23a).

This adjustment can be successfully applied to reduce overheating at the same time while ensuring moderate sun exposure, especially in hot and humid weather. Therefore, the east and west sides of buildings are advised to plant high deciduous trees. On one hand, this design can help avoiding strong radiation directly in summer by lush foliages. On the other hand, it also enables sunshine in winters to serve a positive role in regulating indoor temperature control. In addition, due to the influences of sunlight angles, the surrounding greening are fit to plant beyond 45 degrees for each corner to ensure adequate intake of quality sunshine (Figure 4.23a). Reference data comes from Tools Climate Consultant 6.0.

And finally, the other strategy is to extend the roof overhangs. In view of the regional
climate situation, the primary facade of building should be shaded and weather-protected to adjust sunlight angles and provide a comfortable shady space (Figure 4.23b).

Figure 4.24: Strategies for Natural Ventilation applied to Jiangsu Rural Areas.

**Natural Ventilation:** Influenced by regional climate, the distribution of building openings becomes one of the major contributors to the ventilation conditions of indoor spaces. Under the impact of daylight performance, the best choice for building orientation is to place the larger facades facing North and South in order to receive moderate solar radiation and wind simultaneously. Meanwhile, considering the wind direction distributing in this area, the best solution is to place the larger openings towards the prevailing winds of the southeast monsoon. In addition, building openings also adopt displaced distribution in interior spaces instead of directly opposite one that
strengthens the controllability of indoor air velocity as well as avoids the negative impact of high wind on indoor activities (Figure 4.24). Reference data comes from Tools Climate Consultant 6.0.

Figure 4.25: Strategies for Natural Ventilation applied to Jiangsu Rural Areas.

The second strategy is to adjust building scale and heat-control mode for a comfortable indoor temperature. In view of the features of subtropical climate, the scale of buildings should be relatively small so as to maintain conservation of heat and cool energy of indoor spaces. In addition, compared with flat roof, double pitch roof is more beneficial in reducing the negative effects caused by heat radiation. Meanwhile, following the movement rule of airflow, adding vents at the bottom of the building can not only optimize natural ventilation and carry away the excess moisture in the air but also can enable the cool wind to cover most parts of buildings. In addition to all the above, setting ceiling fans in the top of building is the other method to provide cool indoor environment. In days of high temperature, ceiling fans can reduce indoor temperature by 5 degrees or more and thus reducing the consumption and usage of air conditions(Figure 4.25). Reference data comes from Tools Climate Consultant 6.0.
4.2.2 Jiangsu Sustainable Standards Analysis

- Water Resources Conservation

![Diagram of proposed requirement for surround buffer standard.]

Figure 4.26: Proposed Requirement for Surround Buffer Standard.

The standard design of surrounding buffer mainly considered relevant information about site population density and land use. In view of different site situations, the concrete buffers will respond to the conditions of regional hydrology in appropriate ways. Since the aim of buffer design is to decrease damage and pollution against local water resources in the process of rural constructions, the scale of surrounding buffers should remain appropriate proportion with sites to ensure adequate strength for protection and resistance.

Meanwhile, considering the advantages of natural water system in climate regulation and beauty aspect, surrounding buffers are more appropriate to form a regional benign interaction with nearby areas, especially in visual experiences and environmental greening. Additionally, based on the liquidity and seasonality of water conservation, surrounding buffers should also propose specific requirements for surface runoff management and drainage system in a bid to increase the stability of natural
hydrology and weaken precipitation impacts. This standard will be recommended as a compulsory component in the evaluation for sustainable standards in Jiangsu Province. Relevant information and calculations are presented as follows:

<table>
<thead>
<tr>
<th>Types</th>
<th>Population Density</th>
<th>Land Use</th>
<th>Width Ratio (Buffer/Site)</th>
<th>Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&gt; 0 and ≤ 25/acre</td>
<td>Residential</td>
<td>10% (≥ 7.5 m)</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>&gt; 25 and ≤ 45/acre</td>
<td>Residential</td>
<td>15% (≥ 10.75 m)</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>&gt; 45/acre</td>
<td>Residential</td>
<td>20% (≥ 15.0 m)</td>
<td>1.05</td>
</tr>
<tr>
<td>4</td>
<td>&gt; 0 and ≤ 25/acre</td>
<td>Nonresidential</td>
<td>15% (≥ 10.75 m)</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>&gt; 25 and ≤ 45/acre</td>
<td>Nonresidential</td>
<td>20% (≥ 15.0 m)</td>
<td>1.05</td>
</tr>
<tr>
<td>6</td>
<td>&gt; 45/acre</td>
<td>Nonresidential</td>
<td>25% (≥ 18.75 m)</td>
<td>1.05</td>
</tr>
</tbody>
</table>

Width Calculation Formula: Buffer Size = Site Width x Ratio (Res/Non) x Multiplier = final size ≥ baseline requirements

- The related data data from LEED-ND standards, yearbooks and government database as important sources.
- Drainage systems have at least cover over 75% of total site areas before an official project evaluation.

Figure 4.27: Classification of Surrounding Buffer [37].

The data comes from governments and companies involved in the various projects, and from Network Statistics archives [60].

The following calculations demonstrate two types of buffer width requirements for reference.

Surrounding Buffer Width Requirement of Area1:

**Example 1**, assume the following data focuses on **Area 1** situation
Site Average width is 100m, Land Use is residential and 35 people/acre Density

**Step1:** Net Buffer Width = 100 × 0.15 = 15m

**Step 2:** Real Buffer Width = 15 × 1.0 = 15m (≥ 10.75m)

**Example 2,** assume the following data focus on Area 2 situation

Site Average width is 150m, Land Use is Nonresidential and 45 people/acre Density

**Step1:** Net Buffer Width = 150 × 0.25 = 37.5m

**Step 2:** Real Buffer Width = 37.5 × 1.05 = 39.4m (≥ 18.75m)

**Buffer Setting Requirement:**

- Buffer shapes should follow the actual site plan on the premise of width requirement

- Utilization priority are given to native plants including shrub plants and herbaceous plants

- Buffer plants should maintain appropriate height in order to provide good views of regional hydrology

- Greening plants should have good performances in water-retaining and be easily-maintained

- The periodic inspection and maintenance mechanism should be established.
Site Classification Requirement:

- Project sites shall be set with proper slopes that direct surrounding drainage.

- Pavement structures are suggested to have a low permeability in order to reduce the negative effects of surface water and improve recovery efficiency.

- Wastewater Management

<table>
<thead>
<tr>
<th>Category</th>
<th>2000</th>
<th>2005</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Rate of Waste Water</td>
<td>52%</td>
<td>63%</td>
<td>83%</td>
</tr>
<tr>
<td>Compound Growth Rate</td>
<td>25.32%</td>
<td>24.64%</td>
<td>23.27%</td>
</tr>
</tbody>
</table>

Figure 4.28: Diagram of Wastewater Treatment Rate [45].

As shown in Figure 4.28, China has advanced considerably in wastewater management, especially in the recent ten years. During this period, the average treatment rate of wastewater has grown from 52% to 83% and the compound growth rate is also above 24.41% []. This phenomenon indicates the great potential and the bright prospect of wastewater management in rural areas. Additionally, considering the economic and technical demands of sewage treatment, developing central system can effectively improve the water treatment rate and prevent water damage and pollution. As for this local standards, the ratio of wastewater treatment and central system coverage will peg to rating scores so as to ensure the actual effects and continuity. Concrete judgment standard is as follows (Figure 4.29).
Figure 4.29: Proposed Credit Requirement for Wastewater Management Category.

- Reclaimed Water Development

As the main part of water conservation, reclaimed water utilization in China has gained obvious development in recent years. As can be witnessed from Figure 4.30, the usage amount of reclaimed water enjoyed over 20 percent of annual rate increase in the last decade [45]. The whole reclaimed water system includes mainly two aspects: wastewater collection and sewage purification. Measure adopted to promote water collection efficiency and purification have direct impacts on the output of reclaimed water. At present, China’s wastewater treatment commonly adopts reverse osmosis technique, which is a water purification technology that uses a
semi-permeable membrane to remove ions, molecules, and larger particles from drinking water. The osmotic process can remove many types of dissolved and suspended species from water, including bacteria and particulate matter and can reach 70% - 80% conversion efficiency based on large-scale municipal systems [46]. In addition, reverse osmosis technology can not only remove thermal energy requirement, but also obtain noticeable flexibility. Flow-through reverse osmosis systems can be regulated by high-pressure pumps. The recovery of purified water depends upon various factors, such as membrane sizes, temperature, and membrane surface area in order to meet the different demands of industry and agriculture [47].

Meanwhile, based on the reduction of material price and the accumulation of utilization experience in recent years, reverse osmosis system has a huge market potential and development perspective in Chinese rural areas. Combined with the actual situation of Jiangsu Province, the calculations below illustrate the desired effect and earning of reclaimed water use in this region.

- The data comes from governments and companies involved in the various projects as well as Network Statistics archives.

- Taking a single Chinese household with 3 members as an example:

- **Per capita household water consumption** [48]: 446.75 (L) / year

Total daily consumption: $446.75 \times 3 \times 1 = 1340.25$ (L) / year

- **China Reclaimed Water production cost: (reverse osmosis system)**

USD 0.4-0.5 / L → $(0.4+0.5)/2 = 0.45 \times 6.88 = 3.09$ RMB (L)

Chinese diversion project price [45]: $3500 \text{ RMB} / \text{L} = 3.5 \text{ RMB}(\text{L})$
(3.5-3.09) ÷ 3.5 = 11.7 % → Price Advantage

∴ Reclaimed Water system has more advantage of discounted prices than traditional water supplies.

- Reclaimed Water Production:

- natural precipitation or drinking water were not evaluated in this calculation.

Per capita household water consumption: 446.75 (L) / year

Collection Efficiency: 60% - 70% → (0.6+0.7) × 100% ÷ 2 = 65%

Average wastewater quantity per person (Jiangsu) = 446.75 × 65% = 290.39 (L)

Water purifying rate: 70% - 80% → (0.7+0.8) × 100% ÷ 2 = 75%

Average wastewater quantity per person (Jiangsu) = 290.39 × 75% = 217.80 (L)

Occupancy Ratio: (446.75 - 217.80) ÷ 446.75 = 52% (fossil fuel);

∴ Reclaimed Water system can provide at maximum 48% daily water usage

This design would suggest taking the ratio of reclaimed water utilization as an important index for evaluation. Different ratio would correspond to different credits as shown in Figure 4.31. Both industrial water and agricultural water are included in the evaluation.
<table>
<thead>
<tr>
<th>Types</th>
<th>Reclaimed Water Use Ratio</th>
<th>Credit Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>≥ 20%</td>
<td>Certified</td>
</tr>
<tr>
<td>2</td>
<td>≥ 30%</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>≥ 40%</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 4.31: Proposed Credit Requirement for Reclaimed Water Utilization.

- Building Passive Design

Strategies to improve daylighting would successfully provide illuminance at accepted levels (Fig. 4.32). 95% of the area was within the acceptable levels against 21% of the
original model that follows the LEED Daylight requirements. The remaining 5% was below threshold and it is concentrated at the edges and corners of indoor space. The highest level measured was 1236 lux and the lowest is 185 lux. This phenomenon proves that the south-facing opening would receive more direct and effective daylight than other sides. The local standards will be recommended to assign different credits according to the daylight illuminance range, as shown in the figure below. Relevant data comes from Revit.

<table>
<thead>
<tr>
<th>Types</th>
<th>Daylight Illuminance Range</th>
<th>Credit Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50% - 70%</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>≧ 70%</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 4.32b: Proposed Credit Requirement for Daylight Control Improvement.

Figure 4.33: Ventilation Analysis-a, Dry Bulb Temperature vs. Proposed Indoor Temperature

In view of the close relations between natural ventilation and indoor temperature, this local standard will evaluate the ventilation conditions based on the optimization of indoor temperature. As shown in Figure 4.33, the yellow areas between dry bulb and proposed indoor temperatures reflex the temperature adjustment range of natural
ventilation which is located between the blue line and orange line on the diagram. In addition, in consideration of the humid climate in this region, the new standards also focus on the extent of variation. The green areas under air humidity lines represent the alteration amplitude of indoor space. (Figure 4.34)

![Indoor Humidity Comparison Diagram](image)

Figure 4.34: Ventilation Analysis-b, Indoor Air Humidity Optimum Proposal.

It is suggested to provide scores in accordance with the average temperature and humidity gaps of the whole year in the local sustainable development process. Details are presented as following and sources of relevant data come from ASHRAE 55-2010 Adaptive Comfort Model.

<table>
<thead>
<tr>
<th>Types</th>
<th>Temperature/Humidity Optimization Amplitude</th>
<th>Credit Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$T &lt; 3^\circ C / H &lt; 10%$</td>
<td>Certified</td>
</tr>
<tr>
<td>2</td>
<td>$T \geq 3^\circ C / H &lt; 10%$</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>$T &lt; 3^\circ C / H \geq 20%$</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>$T \geq 3^\circ C / H \geq 20%$</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 4.35: Proposed Credit Requirement for Natural Ventilation Development.
Chapter 5

Conclusion

Based on the above-mentioned parts, this concludes the study contents of Chinese rural sustainable standards.

Firstly, improving operability of sustainable standards in the evaluation process is very important to rural areas. Due to the lagged behind economic situation and cultural conditions in villages, providing a clear reference object and related explanation is more beneficial to better evaluate and work with local situations. For example, LEED standards of farmland protection depends mainly on the related laws & regulations. However, these benchmarks are hard to practice in Chinese rural areas under the changing political environment. In view of this, selecting clear and stable road scale as the benchmarks can reduce the operational problems in the evaluation process, and thus increasing the sustainable constructions in rural areas.

Besides benchmarks, the second idea is focusing on visible effects and actual economic benefit of sustainable standards. Due to the different development stages and economic levels of rural areas, most of local people lack the basic knowledge and understanding of sustainable concepts. In view of this situation, providing definite advantages for sustainable construction in local standards have contributed to the promotion of public identification in Chinese villages, especially the price advantages.
For example, providing detail calculation and specific suggestions for local energy sustainable evaluation can efficiently improve the sustainable efficiency in Heilongjiang rural areas, rather than the standard contents in LEED & LBC which are including much written narratives. In this case, the new energy standard aims to increase public recognition and obtain good performances in Chinese villages through the detailed introductions of sustainable realistic benefits.

The last conclusion of this study is selecting suitable evaluation emphasis based on different regional feature. As mentioned above, the Chinese rural areas are hard to achieve a comprehensive sustainable constructions based on existing resources and economic. So, in this case, focusing on several sustainable aspects with regional conditions is better than a complete evaluation in Chinese rural areas. Taking Heilongjiang case for example. Because of Heilongjiang’s rich agricultural resources and crop production, so farmland protection need to become one of the main evaluation objects of local sustainable standard. On the contrary, Jiangsu’s sustainable standards focus on the conservation of water resources and wastewater management based on its regional conditions. This method not only response to regional features, but also achieve the benefits from sustainable constructions. The same goes for energy aspect, the new standard was targeted at local government as the evaluation objects, but the independent agents in other tools, furthermore, enhancing evaluation working-efficiency based on the strong supports of fund and policy for governments.

5.1 Future Considerations

- Develop a cooperative relationship with local governments in the process of standard establishment for strong supports of fund and policy, this can significantly increase the evaluation work efficiency and identify quantifiable guidelines. For example, the aspects of resources conservation can provide targeted protective measures and expected results to clarify the prefect construction plan.
- Study local lifestyle and historical background and taking into full account the two sides of the influence of person factor in rural sustainable practices. Every standard design should be based on the respect of regional human environments and social features in order to be implemented to the root of the Chinese rural areas. Additionally, the specific works of sustainable construction and evaluation must always embody the dignity of humanity.

- Establish the mutual harmonious relationship between rural society and ecological environments and establishing a long-term assessment and optimization systems.

- Conform to the rules of historical culture and market economy to overcome the barriers from reality and strengthen iteration ability of sustainable standards.
Bibliography


[22]. “China Map of Temperature Zones,” last modified 9 June, 2006, Available: http://www.baike.com/gwiki/%E4%B8%AD%E5%9B%BD%E6%B8%A9%E5%BA%A6%E5%B8%A6


[25]. “Chinese Zoning Distribution,” last modified 1 December, 2016, Available: https://zh.wikipedia.org/wiki/%E4%B8%AD%E5%9C%8B%E5%82%B3%E7%B5%B1%E5%9C%B0%E7%90%86%E5%A4%A7%E5%8D%80


[45]. “Baidu - Reclaimed Water Baike,” last modified 30 July, 2014, Available: http://baike.baidu.com/item/%E5%86%8D%E7%94%9F%E6%B0%B4/6266489?fromtitle=%E4%B8%AD%E6%B0%B4&fromid=2440150#6_1.


Table A.1: Weather Data Summary - Tonghe, Heilongjiang. Climate Consultant 6.0.
Table A.2: Weather Data Summary - Tonghe, Heilongjiang. Climate Consultant 6.0.
Agricultural land conservation

Required

Intent
To preserve irreplaceable agricultural resources by protecting prime and unique soils on farmland and forestland from development.

Requirements
Locate the project on a site that is not within a state or locally designated agricultural preservation district (or local equivalent for projects outside the U.S.), unless any changes made to the site conform to the requirements for development within the district (as used in this requirement, “district” does not equate to land-use zoning).

Meet the requirements of one of the following five options.

Option 1. Infill sites
Locate the project on an infill site

OR

Option 2. Sites Served by Transit
Comply with Smart Location and Linkages prerequisite Smart Location, Option 3, Transit Corridor.

OR

Option 3. Development rights receiving area
Locate the project within a designated receiving area for development rights under a publicly administered farmland protection program that provides for the transfer of development rights from lands designated for conservation to lands designated for development.

OR

Option 4. Sites without affected soils
Locate the project’s development footprint such that it does not disturb prime farmland, unique farmland, or farmland of statewide or local importance as defined by the U.S. Code of Federal Regulations, Title 7, Volume 6, Parts 400 to 699, Section 657.5 and identified in a state Natural Resources Conservation Service soil survey (or local equivalent for projects outside the U.S.).

OR

Option 5. Sites with affected soils
If development footprint affects land with prime farmland, unique farmland, or farmland of statewide or local importance as as defined by the U.S. Code of Federal Regulations, Title 7, Volume 6, Parts 400 to 699, Section 657.5 and identified in a state Natural Resources Conservation Service soil survey (or local equivalent for projects outside the U.S.), mitigate the loss through the purchase or donation of easements providing permanent protection from development on land with comparable soils in accordance with the ratios based on densities per acre of buildable land listed in Tables 1 and 2.

Table A.3: LEED v4 - Neighborhood Development - Agricultural Land Conservation.
Table A.4: LEED v4 - Neighborhood Development - Renewable Energy Production.

Table A.5: LEED v4 - Neighborhood Development - Solar Orientation.

Table A.7: Living Building Challenge Vision 3.1 - Health+Happiness Petal.
### WEATHER DATA SUMMARY

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**LOCATION:**
- **Latitude:** 32.03°N
- **Longitude:** 118.8°E
- **Data Source:** Climate Consultant 6.0
- **Time Zone from Greenwich:** 23 h
- **Elevation:** 20 ft

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Table A.8: Weather Data Summary - Nanjing, Jiangsu, CHN
Table A.9: LEED v4 - Neighborhood Development - Wetlands and Water Body Conservation.
Table A.10: LEED v4 - Neighborhood Development - Wastewater Management.
**LEED ND: Plan v4 - LEED v4**

**District heating and cooling**

Possible 2 points

<table>
<thead>
<tr>
<th>Language</th>
<th>Guide</th>
<th>Resources</th>
<th>Addenda</th>
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**Intent**

To encourage the development of energy-efficient neighborhoods by employing district heating and cooling strategies that reduce energy use and energy-related environmental harms.

**Requirements**

Incorporate a district heating and/or cooling system for space conditioning and/or water heating of new buildings (at least two buildings total) such that at least 80% of the project's annual heating and/or cooling consumption is provided by the district plant. Single-family residential buildings and existing buildings of any type may be excluded from the calculation.

Each system component that is addressed by ANSI/ASHRAE/IESNA Standard 90.1–2010 must have an overall efficiency performance at least 10% better than that specified by the standard’s mandatory requirements. Additionally, annual district pumping energy consumption that exceeds 2.5% of the annual thermal energy output of the heating and cooling plant must be offset by increases in the component's efficiency beyond the 10% improvement. If a combined heat and power (CHP) system is used to comply with the credit requirements, show equivalence by demonstrating that energy consumption savings from the CHP plant at least equal the energy savings that would result from using a conventional district energy system with components that are 10% better than ANSI/ASHRAE/IESNA Standard 90.1–2010. When determining equivalency, take into account the pumping energy as described above.

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Table A.11: LEED v4 - Neighborhood Development - District Heating and Cooling.
Table A.12: Living Building Challenge Vision 3.1 - Water Petal.