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Element Components and Mechanism of Low-carbon Rural Communities Based on Mixed-use Development Take the Yangtze River Delta as an Example

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Abstract: Based on the evolution of developed villages in the Yangtze River Delta region, this study attempts to analyze the mixed-use paradigm of rural low-carbon community construction through the comparison of low-carbon operational modes. It mainly takes the overlapped relationship of live-work space as the objects of study and the carbon balance as the investigation point, to analyze the elements and evolution mechanism of low-carbon community system. Case-based empirical research and demonstration is carried out for further guidance of low-carbon transformation and green habitation construction in developed rural communities in the Yangtze River Delta region.

Key words: Low-carbon communities, mixed function, Yangtze river delta, habitation

INTRODUCTION

The Yangtze River Delta region has conducted rural community construction initially in China with the distinct characteristics and effectiveness. In terms of economic model, “rural collective economy” and “individual people-oriented economy” both belong to industrial transformation on the basis of “rural communities”. Taking “Zhejiang phenomenon” as a typical example, regional distinctiveness has gradually formed by the mixed function with the development of economic social background such as “Wenzhou mode” and “Yiwu experience”, the mixed function communities of which are dependent on the popularized characteristic paradigms such as “professional market community” and “industrial villages of families” with distinct characteristics. (Zhu, 2011) Meanwhile, the phenomenon of many demands, fast development and great dissipation of rural settlement construction has become the primary cause for high-carbon energy dependence and waste emission for developed villages. Therefore, the exploration of mixed-use paradigm of rural low carbonization and the construction of low-carbon rural communities with various mixed functions could provide reference for practical construction and promote the sustainable development of rural areas.

INVESTIGATION ON LOW-CARBON COMMUNITIES IN THE YANGTZE RIVER DELTA

- Special morphology of mode different from other areas by the developed villages of the Yangtze River Delta region lies in their high live-work mixture and coordination of individuals and networks. In recent years, urbanization is with rapid expansion, leading to the high compound of industrial agglomeration and habitation growth in geographic space. The integrated live-work rural communities gradually appear to form the rural habitation way with the characteristics of people-oriented economy. Therefore, the integration of “communities” with mixed function becomes the core of rural communities, so as to form the “carbon emission” pressure with various needs
- Rapid expansion of rural development and construction. Taking the “thousands of villages for demonstration and tens of villages for renovation” in Zhejiang province and the top ten projects of new rural construction in Jiangsu province as examples, wrong ways are taken in rural construction of “urbanization” and “moving type”. Defined indexes are pursued blindly with the lack of regional carbon capacity judgment and agrarian protection due to destructive development of forest resources and the

usage property of lands is changed arbitrarily to break the self-carbon balance of rural communities

- There are various habitation mixture types as the symbolic modes such as rural industry, market, tourism and art in developed areas of the Yangtze River Delta, which are long-term in lack of specific transportation, facilities and service system. The construction standard of different types of rural communities is “mechanically applied” with blind facility construction and non-formation of central service system, resulting in low effectiveness and dissipation in actual use and the strengthening of high-carbonization development

COMPARISON OF THE CONSTRUCTION PATTERNS OF LOW-CARBON COMMUNITIES

There are four perspectives contained in the study on “low-carbon community” in the West, namely, low-carbon economic system, sustainable construction mode, green behavior and system. Kuo and Chen (2009) consider that four elements shall be included in the low-carbon community construction, that is, technical function, organizational function, institutional function and cultural function. “Low-carbon community” is in consistency with modern constructional theories such as “smart growth” and “compact city” with the specific performance of diversified empirical features:

- Space mixing and intensive orientation, represented by the high-density layout mode of Beddington, the U.K
- Green circulated technology orientation, represented by the Sun and wind Community of Beder, Danmark
- Public facility intensive orientation, represented by “Non-car Community” of Vauban District, Germany. Currently, pilot low-carbon construction of domestic communities is still concentrated in big cities such as the low-carbon community of Changxin in Beijing, the ecologic demonstration area of Chongming Island in

Shanghai and the green low-carbon community of Taiyangxingcheng in Changsha, the low-carbon strategies of which are basically similar to foreign concepts to focus on layout, facilities, traveling and mechanism, so that the comparison result of development approaches and types in developed low-carbon communities at home and abroad can be shown in Table 1

In summary, “low-carbon community” is still in the diversified, experimental and exploratory period of the domestic and foreign construction field without the formation of construction indexes, technologies and institutional systems of “low-carbon community” that can be widely promoted (Meng, 2012). There is a lack of operable demonstrative support especially by rural low-carbon community researches in developed areas of the Yangtze River Delta. Therefore, a development approach in line with the rural features and loading abilities shall be explored for the low-carbon construction in rural communities.

ELEMENTS FOR RURAL LOW-CARBON COMMUNITIES WITH MIXED FUNCTION

“Rural community” is a basic carrier to achieve low-carbon strategies in villages. Bill Dunster, an architect from the “zero energy consumption plant” of the U.K., believes that the core of low carbon communities is to improve the living quality of people and reduce the insufficient resource consumption effectively. Rural low-carbon communities refer to the rural settlement carriers for production, living, construction and operation by “carbon emission reduction”, which contains not only hard environment such as physical space, but also soft environment such as system culture. The study takes the mesoscale “rural area” as the object to solve the phenomenon of “villages with green buildings and without low carbon emission” in rural construction of developed areas in the Yangtze River Delta. The construction,

Table 1: Comparison of constructional types of low-carbon communities

Area	Community name	Development features	Operational mode	Constructional features
England	Beddington	Smart growth	Ecologically friendly means of transportation; Implementation of feedbacks;	With high-density construction layout; mixed land use; with energy-saving compound glass; circulated use of water
Danmark	Beder	Green technology	Transportation with green energy; Public low-carbon consciousness improvement	Development and utilization of solar energy and wind energy, clean energy advocated; centralized heating
Germany	Vauban	Compaction	Private car sharing; walking and bicycle first; public involvement	With mixed use of land; study-oriented planning
Shanghai, China	Chongming Island	Peri-urbanization	Mainly for featured vacation tour; with convenient transportation	Graded development and utilization of land; environment improvement and greening
Changsha, China	City of Taiyangxing	Green neighbourhood	Oriented by green living; Construction of demonstrative educational base	Habitation environment optimization; greenbelt vegetation and its “carbon sink” protection

guidance and control of rural low-carbon communities mainly involves four core aspects, that is, the functional element, spatial type, economic structure and contextual element.

Functional elements of rural low-carbon communities:

The internal function composition of rural low-carbon communities includes production, operation, living, transportation and assistance. There are great differences in the national conditions and industrial modes of rural communities in the Yangtze River Delta. The prosperity of people-oriented economy has driven the development of settlement with mixed function. The internal function composition of rural communities is oriented by making a living with the emphasis on integration of “work” and “live”, which attaches greater importance to the effectiveness of production. Therefore, the high carbonization of production and operation is considered as the major obstacle for the construction of low-carbon communities.

Spatial paradigms of rural low-carbon communities:

The spatial type of rural low-carbon communities basically includes the living unit, industrial group, open space and transportation network. Due to the rapid development of urbanization, land resource in the Yangtze River Delta region is more limited with more focus on the rationality of spatial utilization. The extensive growth of the industrial function could lead to the homogenization of the form of the living unit, resulting in slow development of rural community interface and living quality along with high energy consumption. The transportation network is taken as the basis of internal partitions and bond of connections among neighborhoods. The tidal transportation way of travel can be seen as a result of the separation of live-work space.

Economic structure of rural low-carbon communities:

Economic structure mainly includes business distribution, industrial type, energy structure and production technology of communities. The industrial framework of rural communities is constituted by the economic environment basically and the basic energy consumption structure is determined by the industrial type which will further influence the carbon emission intensity. It is generally considered an important means to realize low-carbon development for rural communities by optimizing its live-work structure. Meanwhile, the development of low-carbon technology and improvement of energy use efficiency are also crucial. Since the high carbon development with “high emission and low energy effectiveness” for rural communities in the Yangtze River Delta is unsustainable, low carbonization and high-effectiveness growth from the perspective of economic structure which takes “low-carbon community” as the goal for development shall be conducted urgently.

Contextual element of rural low-carbon communities:

The regional contextual element constituted by the living manners, habits and communication ways of villagers is playing a significant role in the low carbonization of rural communities, which provides an overall behavior standard for villagers and restricts their living manners and social production to certain degree. People living in different habitation types of communities would create the recognition and sense of belonging to their own region, thus maintaining their mutual communication.

Based on the integration of the above four aspects, the elements of low-carbon rural communities can be summarized as shown in Fig. 1.

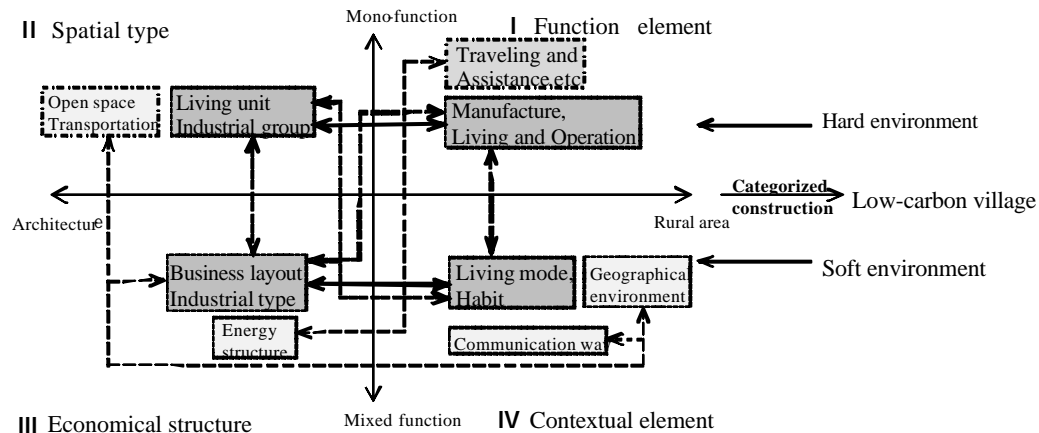


Fig. 1: Elements of low-carbon rural communities

ORIENTATION MECHANISM OF RURAL LOW-CARBON COMMUNITY

Appropriate development mechanism shall be applied to the construction of rural low-carbon communities with mixed function in accordance with their mixed business composition. On the one hand, rectification to wrong “high carbonization” construction of new “economy-oriented” villages in the Yangtze River Delta shall be conducted on the basis of “low-carbon construction”, so as to achieve the low-carbon control mechanism in rural communities with quantified and operable standard system; On the other hand, low-carbon performance integration of the function, space, facilities and systems of rural communities of various types in different regions of the Yangtze River Delta shall be implemented by taking “low-carbon community” as the goal.






Classification control of community formation: The focus and main approaches of planning may vary in achieving the “low-carbon goal” by different types of communities (Gu, 2013). The habitation mode with live-work integration is closely related to the people-oriented economic development, especially in the Yangtze River Delta where the development, transformation and renewal of live-work integrated communities is popular. According to the ecological theory of “ecosystem homeostasis maintenance by diversity”, the planning shall avoid large areas of signal functional zones with the construction

of adequate compact spatial form of communities (Gu, 2009). Lands for living, production and operation, outdoor activities and cultural entertainment shall be with unified planning, classified control and major understanding of mixed function space, so as to form a relatively complete ecological system, reduce the commuting time, ease the traffic pressure, increase production and living communication within rural communities and encourage low-carbonized production and living mode by villagers. For example, the original scattered living mode in traditional rural communities shall be changed for the purpose of low carbonization, thus improving the land utilization intensity and guiding the rational allocation and utilization of land market. The comparison of correlation among different live-work mixed communities is shown in Table 2.

General settings of work-live unit:

- In consideration of the actual environment and geographical factor, the group type of building layout shall be concerned in terms of mixed function with different tendencies and various general changeable spatial construction systems shall be developed. According to the economic conditions, the unit standardization technology of house building shall be selected, which is considered as an important strategy for the realization of low-carbon communities. The standardization of the single form is based on various types of plane

Table 2: Comparison of the correlation among different live-work mixed types of communities (□live-work unit ■unmixed unit)

Mixed-use type	Traditional communities	Industrial communities	Market communities	Tourism communities	Artistic communities
Community samples	Lima Village in Huai'an	Luqiao Industrial Village	Qingyanliu Village in Yiwu	AntingTown (Chen, 2010)	Waitongwu Village in Hangzhou
Spatial texture					
Regional conditions	Sound public facilities	Developed commercial market	Convenient rail transit	Close to China Academy of Art	
Rich carbon sink resources					
Land property	Agriculture/living	Industry/living	Commerce/living/logistics	Tourism/living	Studio/living
Carbon emission factor	1. Scattered living mode 2. Agricultural cultivation	1. Industrial energy planning 2. Commuting pressure	1. Logistic construction 2. Energy utilization	1. Waste disposal 2. Transportation travelling	1. Architectural form 2. Infrastructure
Mechanisms for improvement	1. Improve land utilization 2. Protect carbon sink 3. Provide subsidy for existing houses	1. Apply with efficient production technology 2. Introduce index of security distance	1. Logistic integration 2. Elastic electric power transportation planning	1. Low-carbon design for housed with mixed function 2. Circular economy	1. Low-carbon design for housed with mixed function 2. Construct compact spatial form

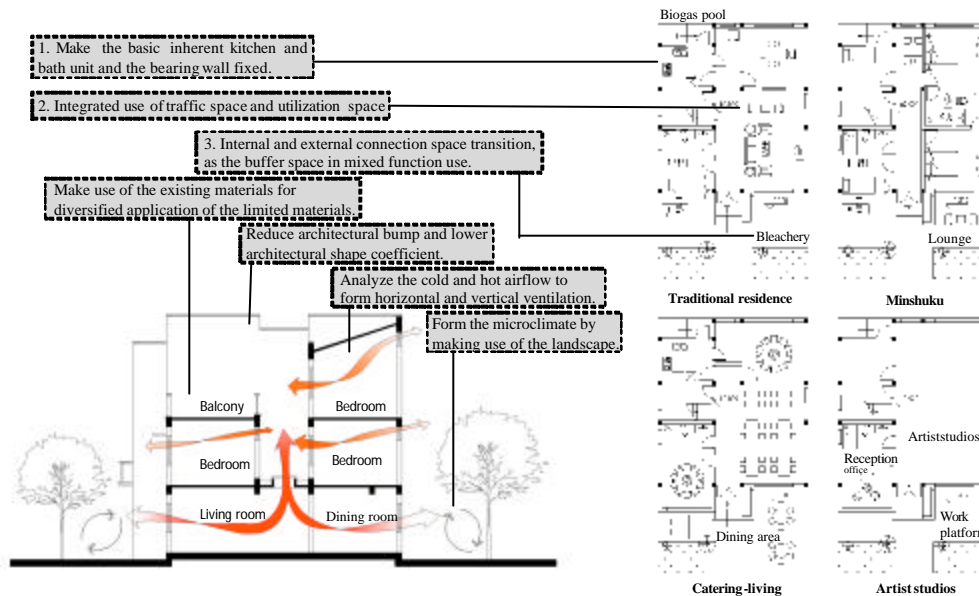


Fig. 2: Low-carbon construction and plane elastic design of the single form

function and profile space, in order to develop the standardized unit that can satisfy the actual function and reach the low-carbon objective

- As time goes by, people’s demand on live-work space changes as well. Expect for space inappropriate for transformation such as kitchens and bathrooms, the space of other rooms can be changed by moving the division walls to adapt to different actual needs. Spatial use interconnection is available especially for the live-work function of village tourism and artistic communities. In order to improve the spatial utilization, elastic design can be further conducted for a single building. The general layout and low-carbon process of single design are shown in Fig. 2

Elastic integration of public facilities: Based on the site selection and layout, live-work capacity and spatial form of rural communities, the energy, water, traveling and waste disposal system shall be regulated and optimized. According to prominent dynamic features such as industrial agglomeration and population immigration in rural communities of the Yangtze River Delta region, rural conservation type of municipal facilities and public service system with flexible capacity and regulation shall be developed for certain types of rural communities. ① Rest nodes and tourism nodal points shall be set in rural tourism communities. Reception work shall be done in peak seasons on holidays. Maintenance and construction of infrastructure and service system shall be conducted in off seasons. ② Current industrial layout

shall be optimized in rural industrial communities and high energy consumption industries shall be with scientific planning and integration. Repeated pipeline paving shall be decreased with major consideration of the traffic network layout for final achievement of resource agglomeration and sharing as well as labor division.

Spontaneous organization for low-carbon development:

The demands, perception and decision-making of behavioral agents like villagers could play an important role in the evolution of rural communities (Qiao, 2011). The automatic decision-making of villagers is the key point for the construction of rural low-carbon communities as the foundation of turning the will of community managers to that of villagers. During the practical development, NGO introduction shall be conducted and core families shall be taken as the basic units to encourage the low-carbon life style of villages through live-work conditions, concepts and activities. On the one hand, establishment of behavior rules for carbon reduction communities as well as demonstration and promotion of low-carbon construction shall be carried out for organization of rural communities; On the other hand, quantitative assessment of “low-carbon performance” shall be formulated and allowance system shall be established in terms of management in rural communities, so as to build the connection mechanism between villagers and community management by NGO and promote the transition from “autonomy by villagers” to

“autonomy by communities” under the guidance of people-oriented economic society. The construction of Waitongwu artistic community in Hangzhou is guided by the community with automatic selection by villagers to introduce the art studio of China Academy of Art.

Comprehensive evaluation of low-carbon synergy: Five elements of nature, industry, life, management and awareness of rural communities can be integrated with GIS technology. The “rural area” is taken as the carrier to establish identifiable unit system of rural communities. By setting indexes such as the layout compactness of units, live-work balance degree, landscape security degree, spatial compound degree, work-live proximity and mixed function index (Doxiadis, 1968), “low-carbon unit” construction evaluation of the series and group property of rural communities can be constructed. Core units shall be selected on the basis of different live-work mixed modes. According to the conclusion made by the evaluation system, the current actual issues shall be settled. For example, indexes such as the live-work balance degree and landscape security degree in Luqiao industrial community are relatively insufficient, so existing land and landscape space shall mainly be focused and optimized.

Compensation balance of low-carbon performance: Appropriate industrial type shall be introduced into different rural communities with the adoption of smart growth type of mixed function communities for construction to solve a single type of internal contradiction. Comprehensive solutions for wastes, energy and wastewater treatment shall be created. Coordination shall be conducted in the low-carbon community construction process through effective carbon compensation mechanism and carbon balance transfer and settlement mechanism among regions shall be built, so as to coordinate the live-work balance among different regions. Taking Anting tourism community as a typical example, due to its higher waste disposal and energy consumption of tourism than that by local residents (Kuo and Chen, 2009), the tourism concept of carbon compensation is introduced to neutralize the carbon emission of tourism, so as to conduct systematic integration from various aspects.

CONCLUSION

As China is a big agricultural country with relatively low overall level of urbanization, there is more development potential for carbon sink increase and carbon source decrease in villages. Based on the construction of mixed rural paradigm in the Yangtze River

Delta region, four aspects including function element, spatial type, economic environment and contextual element are analyzed to make the corresponding strategies. Systematic integration of exosystem level for low-carbon planning systems, technological approaches and architectural modes is carried out by taking “community unit” as the media platform, so as to further summarize the key point for constructing rural low-carbon communities. However, mutual integration with issues such as industrial transition, villagers’ involvement and new rural construction shall be conducted for practical application. In addition, “rural adaptability” is taken as the goal for low carbon to build the differentiated low-carbon construction standard in accordance with the function, space, facility and system of different types of rural communities.

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