Analysis of the relationship between Urban Residential Ecological Footprint and Construction of Urban Ecological Security Pattern

1 Introduction

1.1 Urban ecological security pattern and comprehensive planning of residential land

On the one hand the development of urbanization and the increase of population promote the boom of housing industry; on the other hand they also put huge pressure on ecological environment, threatening the stability of urban ecological security pattern. As the spatial structure of urban ecological system, construction of urban ecological security pattern does not only require the amount of total urban ecological footprint is within the local ecological carrying capacity and different zones should cooperate with each other in terms of the amount of ecological footprint; but also emphasizes the importance of safe urban ecological spatial format. From the point of comprehensive urban planning, urban ecological security pattern is the potential spatial model for the complicated urban ecological system in the process of urban sprawl.

However，present study mainly focuses on the evaluation of ecological security and the selection of influential factors, ignoring the necessity of qualitatively and quantitatively analysis of urban ecological spatial characteristics at a comprehensive level of urban spatial structure. Besides that, studies of ecological planning of residential land centralizes on the layout of parcels, designing of architecture and landscape, failing to deeply research the influence which quantitative standards of ecological spatial scale and regional position have on residential land from a general view.

1.2 Analysis of case background

As an important city for strategically development of central region in China, the urbanization rate in Wuhan was nearly 60% in 2009. The built area was almost 500 hm^2. Among them, residential land had taken up about 22%, 111.15 hm^2. According to principle of landscape ecology, when the percentage of certain kind of land accelerates 20%, it would have stronger development potential and ecological stability, becoming core part in urban ecological security pattern. Thus, the analysis of the footprint of housing footprint in Wuhan could represent the level of stability of urban ecological security pattern.

2 Quantitatively analysis the relationship between residential ecological footprint and ecological security pattern

2.1 The conception of urban residential ecological footprint

The conception of urban residential ecological footprint was first mentioned by the Canadian ecological economist William Rees, etc, in 1992, as a way to weigh the capability of urban sustainable development, it means under certain economical, social and natural environment, in order to maintain certain number of people, certain amount of productive land and water area is needed(1). In accordance with <Athens Chapter>, residence is one of the four important functions of modern cities. Living environment, as a compound ecological system includes society, economy and nature which are supported by city itself. Thereby, we could take the ecological footprint generated by living activities, like the land and water area which is used to provide urban residents with daily material and energy and clear up relative rubbish, as the quantitative ecological characteristics of urban residential space and use the conception to describe urban ecological security pattern from the view of urban comprehensive land planning and space design.

2.2 Urban residential ecological footprint and urban ecological carrying capacity

Ecological carrying capacity indicates the self- maintain and self- adaptation capability of ecological system, the intensity of social and economic activities supported by natural resources and sub-environmental system, the amount of people with certain living standards(2). Using DPRSC-AHP dynamic model could imitates the ecological process and evaluates the weight of influential factors related to urban housing ecological footprint, choosing key elements for the construction of urban ecological security pattern.

2.2.1 DPRSC model for the urban residential ecological footprint

DPRSC model (Drive- Press-State-Response-Control) could generally represent how the urban ecological system reacts to dynamic influence from outer and inner environment. From the point of urban ecological security, it emphasizes human has dominated effect on urban environment, analsizing the ecological network derived from the transaction and communication of energy, material, information, society trend (3)

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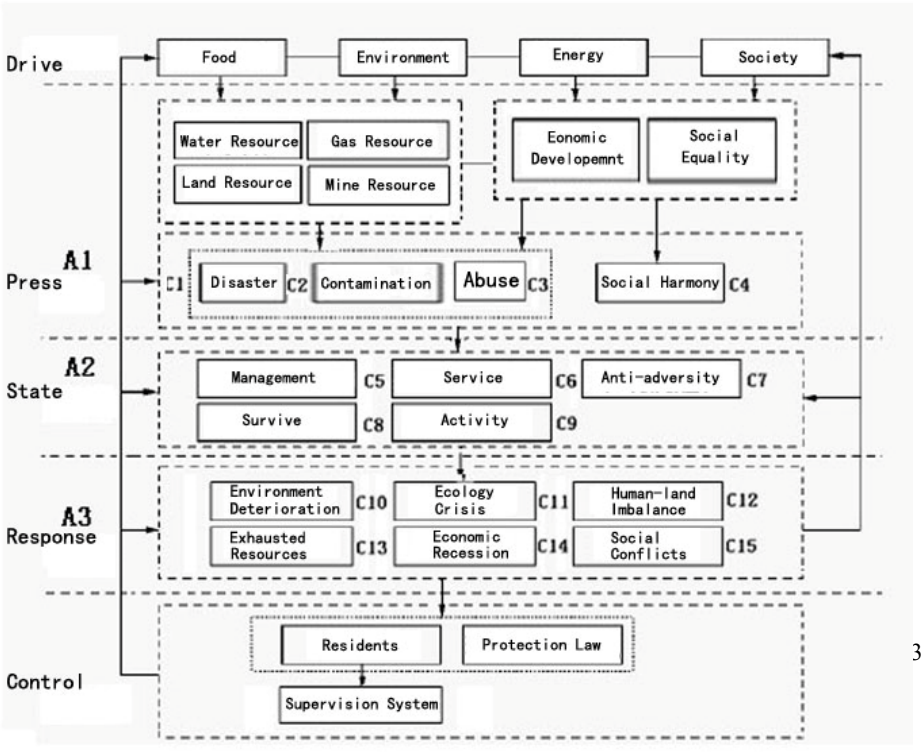
Pricture(1) is the dynamic reaction process of DPRSC model for urban residential ecological footprint, reflecting the motivation for residential ecological footprint consists of the material and energy which are needed by maintaining architecture and daily live; the drive is the transaction process of society and science, in order to cope with what is required by motivation level; the state refers to how self-organized urban housing system reacts to pressure; the response means after self-adaptation, transaction of material and

The DPSRC Model for Urban Residential Ecological Footprint



energy trend, the housing system would have a comprehensive influence on the neighborhood. The last, but not the least is the control stage, which integrates the measure of the above four.

2.2.2 AHP analysis for the ecological carrying capacity

Based on DPRSC model, through AHP analysis(T.L．Satty), with the assistance of DPS2000 software and excel, we can quantitatively and qualitatively analyze how different factors effect the grey system of ecological carrying capacity, selecting order of their influential weight and find out the most important elements.

(1)Building analysis hierarchy

Treating quantitatively analysis of weight of residential ecological footprint as research purpose, through judging the study objects of residential ecological security pattern and complex system (Residents- Material- Energy- Environment- Economy- Society), it can take the guide level stage as independent variable factor (A1,A2,A3) and the index stage as the group of relative variable factors(c1,c2…c15),according to AHP and its method.

The AHP Analysis Model for Urban Residential Ecological Footprint

Guide Level	Index	Weight	Wi
A1	C1	0.0855	0.2222
	C2	0.2735	0.1911
	C3	0.4103	0.1067
	C4	0.2308	0.0600
A2	C5	0.0662	0.0139
	C6	0.2781	0.0584
	C7	0.1656	0.0348
	C8	0.1854	0.0390
	C9	0.2384	0.0500
A3	C10	0.2639	0.1399
	C11	0.0854	0.0453
	C12	0.1235	0.0654
	C13	0.2396	0.1270
	C14	0.1746	0.0925
	C15	0.0686	0.0364

(2)Calculation of evaluation index weight

Combining advises from experts, the percentage of guide line stage is: Press(A1): State(A2): Response(A3)=0.26：0.21：0.53. Then use YAAHP software to computing the group of former statistics, get a result the random coherence of the estimation matrix is 0.0034. Except that, it also gets A1(0.0062), A2(0.0056),A3(0.0098), all below 0.01, so the estimation matrix has coherence.

(3)Selection of important factors

Table (1) is the correct weight of residential ecological footprint, according to computing, the average weight of the 15 ecological factors is 0.2323, standard difference is

0.080381<0.1, so the most influential factors are C2(Contamination), C3(Abuse of resources), C4(Social harmony), C6(System service), C9(System productivity), C10(Environmental destroy), C13(Exhausted resources).

2.3 Layout of urban space and residential ecological footprint

2.3.1 Urban residential ecological footprint and comprehensive land use planning

Based on the function and characters of urban land, different functional matrixes account for different percentages [4]. From the point of comprehensive land use planning, the matrixes in built environment are the base and background to each other at the level of geographic structure and the square of land is related to the corresponded percentage of ecological footprint[5].

The Amount of Ecological Footprint for Different Kind of Functional Land in Wuhan

Kind	Scale(hm2)	Percentage	Ecological Footprint (10000hm2)	hm2
Housing	111.15	0.22	6.42	28%
Public Service	75.24	0.15	0.46	2%
Industry	80.61	0.16	11.24	49%
Storage	18.25	0.05	0.92	4%
Transportation	26.06	0.05	0.46	2%
Road and Square	92.68	0.18	1.38	8%
Infrastructure	16.25	0.03	0.69	4%
Green Land	69.24	0.15	0	
Specific	5.54	0.01	1.38	3%
Total	495.02		22.94.	100%

As table (2) shows, the percentage of residential ecological footprint in Wuhan is 28%, much lower than the industry land(49%), which accounts for 15% of whole land. It indicates the ecological footprint, as a quantitatively index to weigh the urban ecological carrying capacity has non-linear relationship with its square. Thus different kinds of matrixes are different in terms of unit area. But, from a general view, the square of residential area exceeds 20% of total urban built area; it is the core matrix of urban ecological support system. Besides that, based on integrated data analysis of historical statistics in Wuhan, for residential land, the square of land and amount of ecological footprint has certain linear relationship. Because of that, it proves the possibility of adjusting the scale of residential land could assist in controlling its ecological footprint, smoothing the pressure on urban

ecological carrying capacity, constructing safe ecological security pattern.

2.3.2 Urban spatial design and residential ecological footprint

As important part of urban ecological security pattern, through ecological corridor, urban housing matrix forms spatial topology network system. In order to clear identify the spatial relationship, this essay views ecological footprint as invisible spatial character of the land matrix and introduces new spatial indexes, residential ecological footprint appeal level and control degree, aiming at quantitatively and qualitatively describe the influence of scale, form, spatial joint depth and distance between of residential matrix on the spread of ecological footprint based on the developing process of urban space.

(1) Urban residential ecological footprint appeal level Wij

Urban residential ecological footprint appeal level could represent the spatial relationship and ecological connection level between residential matrixes based on ecological corridor, which is greatly related to the length and width of spatial corridor. Qualitatively and quantitatively weighing the spatial attraction among the material, information, society trend, similar to the law of gravity, can identify the dual relationship, especially the attraction rate of both ecology and space between the same functional matrixes.

$$Wij=G\times Ai\times Aj/(Lij\times Dij) \quad (1)$$

(*W*- appeal level；*A*-the amount of ecological footprint；*i,j*-numbers of matrix；*L*-length of corridor，*D*- width of corridor, *G*-constant)

(2) Urban residential ecological footprint control degree Ki

Urban residential ecological footprint control degree means based on certain ecological appeal level, the residential matrix has strong influence on the other matrix which is directly related to it in aspect of geography. It has strong relationship with the scale of land, percentage of ecological footprint and accumulated ecological corridor. Similar to space syntax, this conception is used to quantitatively evaluate how single residential matrix affects the neighborhood and its position in the urban ecological network.

$$Ki=Si\times Ai/(\sum Wn*Ln) \quad (2)$$

(*K*- control degree；*A*- the amount of ecological footprint；*i,j*- numbers of matrix；*L*- length of corridor；*S*-scale of matrix；*n*-number)

3 The meaning of residential ecological footprint for constructing urban ecological security pattern

3.1 Control the process of urban ecology

Construction of urban ecological security pattern requires the whole amount of urban ecological footprint is within the capability of urban ecological carrying. As a complicated open system which can not support itself, in order to gain stable development, cities needs to spread their ecological footprint to suburban area, so they can get more ecological capacity. Seeing these, use the quantification of urban residential ecological footprint to identify the boundary of ecological capacity and influential weight is beneficial for the integration of urban economic, social and ecological interests and supervision of the state of ecological security pattern. Thus, when ecological capacity exceeds certain amount, we could establish ecological reaction mechanism, effectively achieving the goal of adjusting the urban ecological process and maintaining a general balance of ecology through controlling key factors.

3.2 Optimize the layout of urban space

Construction of urban ecological security pattern emphasizes the form of urban space. In terms of comprehensive land planning, the spatial connection and control level are linearly related, and so is the amount of ecological footprint with the scale of land. When it refers to urban design of space, the ecological footprint among residential matrix is directly proportional to their amount product and inverse proportional to the scale of ecological corridor between them. What is more, the ecological position of residential matrix is decided by its scale, the product amount of ecological footprint and the accumulated surrounding ecological footprint appeal level, Thus, through computing and selecting the connectional index related to ecological footprint, making full use of natural resources, adjusting the intensity of development and improving the ecological efficiency, it is more effective to construct urban ecological security pattern.

3.3 Cooperate with the development of land

Construction of urban ecological security pattern needs different functional matrix to harmonize with each other and especially in terms of ecological foot print, based on the function and character of land, their percentage varied a lot. Take the whole city as study case, the scale of housing land is more than 20% of the built area in Wuhan, so it is the main core matrix. Because of these, the planner needs to make the surrounding matrix adjust for the residential ones which take the leading place and supervise the transaction of ecological footprint among them, secure the stability of urban ecological security pattern.

3.4 Promote the sustainable development of cities

Construction of urban ecological security pattern aims at realizing the sustainable development of cities. As evaluation index of urban ecological carrying capacity, the dual characteristics of residential footprint are both spatial and ecological, influenced by resources, economy, population, etc, and changes with time. Thus, through the quantification and qualification of ecological footprint, it is convenient for us to understand its ecological position in the urban ecological security pattern, value the ecological risk of the development of real estates, and choose the scheme which has higher sustainable development expectation. It can not only meet the requirement of urbanization, constructing more, but also alleviate the negative influence caused by the spread of urban area, achieving the goal of contributing to save resources and becoming environmental- friendly.

4 Conclusions

(1)The application of DPSRC-AHP model and mathematic computing could be used to describe the process of generation of residential ecological footprint and construction the evaluation system of index which closely related to it as well.

(2) According to the rank of the importance of different influential factors, it can not only select the key elements among them, but also make the results more clear and directly.

(3) To describe and evaluate the urban ecological security pattern from the view of ecological carrying capacity and spatial structure can effectively represent how they influence each other and use the comprehensive results of evaluation to guide urban planning and design.

(4) As the amount of residential ecological footprint and the scale of residential land are linearly related, greatly affecting the other functional land around them, so the urban planning needs try to harmonize the whole land.

(5) Through decide the boundary of residential ecological appeal level and control degree, the equation (1),(2) could be used to quantitatively and qualitatively calculate the comparatively safe distance between matrix, the scale of land and the form of ecological corridor, making it possible to direct the design of ecological safe space.

(6) Due to the complication of collecting and computing data, there are unsure elements involved with grey system, so the analysis is limited to some extent.

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