# The Urban Land Ecosystem Health Evaluation in Chengdu City

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## Abstract

This article declares the connotation of the Urban Land Ecosystem Health by ecological economics theory and method based on the study of ecosystem health. Besides, this paper constructs the evaluation system composed of "Vigor-Organization-Resilience-Ecosystem service function-Lifestyle" to analyse the urban land ecosystem healthy status in Chengdu city, and the evaluation results are calculated by parametric synthesis method. The results indicate that the system has been generally getting healthier from 2001 to 2009, ending up with a relative stable state in recent years, which is attributed to a series of policies. Thus, it is necessary for the government to take measures to spur the city vigor release, resilience and service enhancement, and a positive attitude towards the urban land ecosystem healthy protection should be established among the public.

**Keywords:** urban land ecosystem, health, evaluation, Chengdu

## 1. Introduction

Modern economic development has brought us better life of high quality with convenient lifestyle. However, humans' increasing demand for city resources makes the urban load capacity now close to saturation. We're suffering stresses such as environment containment, energy shortage, traffic congestion and restriction of raising living standard. As one of the most important resources for urban construction, land has become the bottleneck of regional development. Not only the construction land use change and its spatial pattern adjustment, but also the food safety threat resulting from a consistent amount of farm land transforming into a construction one, would play an important role in the social and economic region development. As a result, building a harmony and healthy urban land ecosystem is the internal demand for a sustainable land use, as well as the basic of keeping city prosperous. Therefore, this paper aims to evaluate the urban land ecosystem health in Chengdu city based on its urban development planning and function orientation, so as to supply a reasonable political suggestion for a sound development.

Up to the present, several researchers have studied health evaluation for different kinds of urban ecosystem . The evaluation system tends to be a richer and more practical one associating with the deeper connotation of the ecosystem as well as basing on the classical land health evaluation system called "pressure-state-response". For instance, Li Weihai chooses "vigor-organization-function-resilience" factors integrating into the "pressure" indicator in PSR system, so as to analyse the health state of ecosystem environment in Guiyang city, and the outcome reveals that the ecological security and service function in this region are declining, the ecological environment health is getting poorer. Guo Xiurui indicates that an urban ecosystem health evaluation should aim at a deeper study on human activities, environment change and their influences and threats on human and ecosystem health, rather than indicator system solely, thus she innovates the index system when analyzing urban ecosystem health by building "vigor-function-organization-ecosystem service function maintenance-public health" system. Ni Zhen adapts "vigor-vitality-resilience-ecosystem maintenance-ecosystem service-creativity" to evaluate realty industry ecosystem health in Chongqing city, and the outcome shows that the previous years are cooler sub-healthy, the latter years are developing into hotter sub-healthy and healthy.

## 2. The Connotation of Urban Land Ecosystem Health

The concept of "land health" could be traced back to the 1940s, when studies on ecosystem health had replaced that and developed into research focus. It was until 1980s that the program regarding land health firstly put forward in Canada, involving a general survey of soil through the whole country. Subsequently, some researchers spread out researches on several specific ecosystems, such as grassland ecosystem, lake basin

ecosystem, and wetland ecosystem. As for the more microcosmic urban land ecosystem, systematical health studies remain almost blank, and relevant theories need to be traced from the branch framework of "global ecosystem – land ecosystem – urban ecosystem – urban land ecosystem" to which this research subject was undertaken.

For example, Chen Meiqiu pointed out that, land health is a state that land remains its normal metabolism, and the system is capable of alleviating the harmful shock from external system by its own resilience, so as to achieve sustainable development through symbiosis, alternation and regeneration between the living body and inorganic environment. Besides, Cai Weimin holds that a healthy land utilize system is a healthy one composed of land utilize system structure, function and efficiency which aims to achieve sustainable development of human society, to spur to a harmonious unity among economy, society and ecology.

Based on the evidence from up to date literature, this paper summarizes that a healthy urban land ecosystem should be characterized by the following: 1 offering enough substance and energy needed by different groups of people; 2 a reasonable urban land structure, sustainable resources utilization and human lifestyle; 3 showing a certain flexibility to alleviate the outer harmful shock and sufficient resilience to keep the system stable. In terms of system efficiency, the service value of which supplies is unlikely to decline as time passing by; regarding the external force, the more natural or less amount a system depends on to keep itself steady, the healthier the system tends to be.

### 3. The Model Construction of Urban Land Ecosystem Health Evaluation in Chengdu City

Urban land ecosystem is a typical artificial system and composed by human willingness through city function realization. Therefore, the stability of system depends on human behaviors to a large extent, otherwise it couldn't be called a urban land ecosystem. In terms of Chengdu city, the landform of which appears to be plains, hills and mountains, it is likely to be replaced by desert ecosystem or forest ecosystem without human activities.

*3.1 General Situation of Study Region*

Chengdu is located in the hinterland of Sichuan Province, playing a role as political, economic and cultural center. It has a square of 12390 km$^2$ with fertile soil, and population of 140.5 million, subtropical monsoon climate, an average temperature of 16$^o$C, rich precipitation, cloudy and humid. The city stands on affluent biology resources and natural landscapes, with a view to modern economy construction, and has developed into the "western heart of China" – the core linkage of science, trade, finance, industry, transportation and communication in west regions through the country. The land resource configuration as well as land use regimes are closely related to the city construction, and especially the high urbanism rate and flourishing city strategies ask for an increasing amount of construction land. In recent years, the farm land remains steady with little decrease with the control of strict farm land policy, while the rise of construction land comes from mainly land consolidation, and a few amount of farm land collection. Besides, the utilize way tends to be more saving and intensive, such as metro and underground parking developing.

*3.2 Methodology*

3.2.1 The Evaluation System Construction

The evaluation system construction is the key element of ecosystem health evaluation. As the urban land ecosystem is a sub-system of urban ecosystem, the former one thereby owning the same characteristics as the urban ecosystem. Thus, we reserve the classical ecosystem evaluation system "vigor-organization-resilience" as a basic. In addition, since a healthy ecosystem should take individuals as the essential and tries to supply all kinds of services to meet city function, we take "ecosystem service function" to the evaluation system. Apart from that, as a humanistic system with a broader connotation, the health state of which is affected by human behaviours at every time, and the non-renewable resources consumed in daily life associated with the system sustainability, thereby the "lifestyle" is considered into the evaluation system. Therefore, this paper adapts "vigor-organization-resilience-ecosystem service function-lifestyle" to analyze the urban land ecosystem health in Chengdu city.

3.2.2 Indicators Selection

Generally, we select indicators by following the principle of data acquisition, regionality, scientific, representative, objectivity and early-warning.

Vigor is the direct expression of system health, which is represented by activity, metabolism and primary productivity. This can be reflected by macro economy development, resident purchasing power and real estate market activity.

Organization stands for the pattern and proportion of elements in the ecosystem, and the structure of which should stimulate to an efficient city function. As a result, we choose population density, science and education expenditure accounts for local finance, construction land area accounts for the urban area, factors contributing a lot to the indicator, to explain ecosystem organization.

Resilience reveals the capacity to keep system stable by restraining outer harmful shock. The way we dispose the discharge of waste water, gas and solid materials as well as the core resource--land, can be the best manifestation.

The ecosystem service function can be reflected by the closely related indicators concerning livelihood, such as medical treatment resource, transport capacity and job opportunities.

Lifestyle reveals the national quality directly, advocation of a low-carbon lifestyle helps the individuals build an awareness of ecosystem protection, which contributing to a sustainable resource utilize. By this way, we can select those absolutely necessary energy demand of citizens in daily life in an effective way, such as running water and household electricity consumption.

3.2.3 Index-weight Given

As various factors contribute differently to the ecosystem, we need to give proper weight to each index. To make sure the weight scientific and reasonable, we use entropy method--an objective method at the first, followed by analytic hierarchy process--a subjective method to revise the outcome according to the practical situation. Subsequently, we get parameter value of each factor in research years through dimensionless method (see Table 1).

3.2.4 Health value calculation

The comprehensive health score can be obtained by the weight sum of the weight and parameter value. The following step divides the score by the sum of maximum and minimum ones, so as to get G value--the urban land ecosystem health value (see Table 2) by the following formula:

$$G = \frac{X_i \times W_i}{[\max(X_i \times W_i) + \min(X_i \times W_i)]} \quad (i=1,2,...,n)$$

(1)

Where, $X_i$ and $W_i$ stand for the parameter value and weight of each corresponding factor respectively; G represents the health value of urban land ecosystem.

According to the way of grading intensity in a land intensive use evaluation, we adapt cluster analysis method to grade the G value into groups with the help of software of SPSS 17.0, the principle of which is is to categorize data into groups basing on their similarity or difference. And the G values are finally divided into three grades as health, inferior healthy and poor health.

Table 1. The urban land ecosystem health evaluation index system and their proportions and values in Chengdu city

| Evaluating indicator | Parameter factor | Weight | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Vigor | GDP growth (Gross domestic product growth) (%) | 0.0423 | 61.91 | 0.00 | 100.00 | 40.48 | 33.33 | 35.71 | 21.43 | 23.81 | 35.71 |
| | CPI (Consumer price index) | 0.0709 | 100.00 | 16.11 | 68.12 | 6.04 | 78.31 | 0.00 | 61.49 | 43.45 | 4.58 |
| | Housing investment accounts for real estate investment (RMB 10 000) | 0.0907 | 100.00 | 93.27 | 92.61 | 49.46 | 22.85 | 6.54 | 7.27 | 3.20 | 0.00 |
| Organiza-tion | Population density (person/km$^2$) | 0.0732 | 4.41 | 0.00 | 12.05 | 20.48 | 21.60 | 43.22 | 58.10 | 91.76 | 100.00 |
| | Science and education expenditure accounts for local finance (RMB 10 000) | 0.0967 | 100.00 | 85.99 | 23.52 | 27.60 | 6.73 | 16.97 | 14.69 | 3.28 | 0.00 |
| | Urban construction land accounts for the whole urban area (%) | 0.1000 | 86.69 | 100.00 | 73.88 | 41.60 | 21.46 | 5.82 | 2.66 | 1.50 | 0.00 |
| Resilience | Area of farmland increase by land consolidation (ha) | 0.1103 | 78.34 | 94.11 | 100.00 | 50.64 | 11.84 | 0.00 | 4.71 | 2.80 | 0.32 |
| | Comprehensive utilization of waste products (RMB 10 000) | 0.1396 | 100.00 | 40.76 | 16.50 | 14.94 | 6.32 | 10.35 | 0.99 | 0.14 | 0.00 |
| Ecosystem service function | Doctor numbers(person) | 0.0693 | 100.00 | 73.06 | 49.26 | 25.82 | 16.47 | 13.55 | 0.00 | 14.02 | 15.52 |
| | Urban road area per capita (m$^2$) | 0.0419 | 100.00 | 72.48 | 58.81 | 55.58 | 81.48 | 62.77 | 65.83 | 3.24 | 0.00 |
| | Registered urban unemployed number (person) | 0.0600 | 13.19 | 0.00 | 38.97 | 11.97 | 69.74 | 75.14 | 22.52 | 27.61 | 100.00 |
| Lifestyle | Urban living consumption of electricity (million kwh) | 0.0595 | 46.16 | 100.00 | 99.35 | 83.858 | 94.36 | 84.57 | 0.00 | 7.13 | 5.04 |
| | Residents water consumption (million tons) | 0.0452 | 0.00 | 16.46 | 27.71 | 100.00 | 91.68 | 99.16 | 28.98 | 67.68 | 77.14 |

Data resources: <China city statistical yearbook>, <China land & resources almanac>, and <Sichuan statistical yearbook>.

Table 2. The evaluation results of urban land ecosystem health and their health grade in Chengdu city

| Year | 2006 | 2008 | 2005 | 2009 | 2004 | 2007 | 2003 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|
| G value | 0.6953 | 0.6414 | 0.6160 | 0.6061 | 0.5965 | 0.5392 | 0.4663 | 0.3100 | 0.3047 |
| Health grade | Health | | | Inferior health | | | | Poor health | |

## 4. The Results of Urban Land Ecosystem Health Evaluation in Chengdu City

### 4.1 Outcomes

The data comes from related yearbooks and statistical sources, thus we can get corresponding parameter by dimensionless method (see Table 1), and calculate the G value for each year with formula 1, finally achieve the health grade (see Table 2).

### 4.2 Discussion

As is shown in Table 2, the average health value of urban land ecosystem in Chengdu is 0.5306, which is higher than that in the year of 2001, 2002 and 2003. The previous two years appear to be unhealthy while the other years are healthy and sub-healthy. The overall parameter values begin to climb sharply from 2002, and that of 2004 to 2009 rise smoothly, reaching the peak in 2006 and then fluctuating slightly. Generally speaking, the trend of urban land ecosystem health state in Chengdu city keeps optimistic.

During the study years, the Chengdu ecosystem suffered "5.12 Wenchuan earthquake" in 2008, the values of vigor indicator, especially relevant economic ones, were obviously impacted, GDP and CPI of that year were lower than that in the past years. However, after the disaster, the citizens' consumption ideas were no longer conservative generally, which spured to a new economy rise to some extent, hence the values of GDP and CPI had gone up again in 2009. Although facing the economy frustration, the government had tried best to keep the urban land ecosystem steady by taking several measures. Thus the value of medical treatment resources, science and education expenditure, disposal of waste discharge and urban road area per capita appeared to be relevantly stable.

The local government had also carried out positive policies to spur the healthy development of urban land ecosystem from the aspect of resilience and lifestyle indicators. For example, the implementation of environment protection regulations involving medical and electrical waste recycling regulation, taxation on pollution contributed to a certain extent of energy-saving and low carbon dioxide emission. Especially when the <Law of the People's Republic of China on Prevention of Environmental Pollution Caused by Solid Waste> came into force in 2005, the production value of waste goods multipurpose use rose greatly. All of those prove that various policy and regulations have come into the wind vane of industry developing, in turn, the rise and fall of parameter values reflect policy effectiveness as a barometer.

### 4.3 Conclusion and Suggestion

Human beings are not capable of dominating the natural law, but we need to comply with that and utilize the law reasonably as the first criterion to guide human behaviours. Besides, as the urban land ecosystem is a humanistic system, the prosperity of which still depends on the people's subjective initiative. As can be seen from the results illustrated above, several evaluation factors are affected by government policies. Therefore, it is wise for us to carry out sound plans not only to sustain the system vigor, but also to optimize its organization at the basis of economy development as well as science and technology innovation. In addition, we need develop a certain man-made ecological reconstruction when necessary, since it is not realistic to depend on the natural ecosystem resilience too much as it tends to be so long a term compared to a person's lifelong time. In summary, more efficient ways to build a healthier and more harmonious urban land ecosystem should be noticed, such as protection and utilization approaches on the natural landscape and resources, the advocation of low carbon dioxide lifestyle.

Researches on ecosystem health have been in a continuous hot discussion, as one branch study of that, urban land ecosystem is a forefront study comparatively. The progress not only needs to follow the general study framework, but also to show a view to the subject's attribute, involving the disciplines such as land economy, ecosystem health and so on. In addition, the adoption of modern geography technology like GIS, RS and GPS would do us a favor to get a easier way to achieve a healthy urban land ecosystem construction.

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