Smart growth

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Abstract

In this paper, we establish a multi - level fuzzy evaluation model to evaluate whether the city meets the principle of smart growth. We establish a fuzzy comprehensive evaluation system to measure the success rate of urban smart growth. We select four aspects as the metrics, which are population, space, consumption and economy. Through the analytic hierarchy process, we know that economic growth accounts for 40% in the development of cities. And population factor accounts for 25%. Space factor accounts for 20%. Consumption factor accounts for 15%. Next,we choose the cities which are Geneva and Canberra to research. By searching the information, we get the development plans of the two cities. Then we use the four metrics to evaluate the plan of Geneva and the plan of Canberra. We find that both the Geneva's plans and Canberra's plans have some aspects that do not meet the principles of smart growth. The traffic in Geneva has been worsening in the recent years and Canberra's environment is poor. All in all, our model has a wide application, and it fits the actual. We can use it to evaluate the plan of smart growth .

Keywords

Smart growth; Fuzzy comprehensive evaluation system; Entropy method.

1. Introduction

1.1 Background

Many communities are implementing smart growth initiatives in an effort to consider long range, sustainable planning goals. "Smart growth is about helping every town and city become a more economically prosperous, socially equitable, and environmentally sustainable place to live." Smart growth focuses on building cities that embrace the E's of sustainability—Economically prosperous, socially Equitable, and Environmentally Sustainable. This task is more important than ever because the world is rapidly urbanizing. It is projected that by 2050, 66 percent of the world's population will be urban—this will result in a projected 2.5 billion people being added to the urban population. Consequently, urban planning has become increasingly important and necessary to ensure that people have access to equitable and sustainable homes, resources and jobs.

Smart growth is an urban planning theory that originated in 1990's as a means to curb continued urban sprawl and reduce the loss of farmland surrounding urban centers. There are ten principles for smart growth .

1. Mix land uses
2. Take advantage of compact building design
3. Create a range of housing opportunities and choices
4. Create walkable neighborhoods
5. Foster distinctive, attractive communities with a strong sense of place
6. Preserve open space, farmland, natural beauty, and critical environmental areas
7. Strengthen and direct development towards existing communities
8. Provide a variety of transportation choices
9. Make development decisions predictable, fair, and cost effective

10. Encourage community and stakeholder collaboration in development decisions

These broad principles must be tailored to a community's unique needs to be effective. Thus, any measure of success must incorporate the demographics, growth needs, and geographical conditions of a city as well as the goal to adhere to the three E's.

1.2 Problem Analysis

Firstly, combing with the given ten principles, we set up a model with reasonable assumptions to evaluate the smart growth of the cities. Referring to bibliography, the science of comprehensive evaluation system and some discoveries on smart growth are applied to the modeling. What' more, we take fuzzy comprehensive evaluation model into account to describe the connections among consumption, transport, economic, population and so on. Having considered all the above aspects, we finally established a evaluation system..

Secondly, through our comprehensive evaluation system, we evaluate the development of the two cities in Canberra, Geneva. The results obtained from model can explain similarities and differences of urban development. According to these points, we have drawn up plans for the future development of the two cities. And we also find that excellent geographical position of the two cities plans an important role in their economic growth.

Finally, the subject asked us to classify each indicators. We formulate a chart by de-entropy method. According to the projections of future population data, we decide to deal with it through transport, housing supply and land-use.

Having considered about all the requirements above, our goal is to construct a comprehensive evaluation system to evaluate the cities and gain further analysis and answers for the problem.

2. Symbols

Symbols	Descriptions
$G1$	population
$G2$	space
$G3$	consumption
$G4$	economy
$x1$	the number of traffic trips
$x2$	the number of traffic trips
$x3$	the ratio of investment in transportation facilities to fiscal expenditure
$x4$	land diversity index
$x5$	the average density of land use
$x6$	average land use value
$x7$	pollution discharge
$x8$	noise pollution index
$x9$	residents' Satisfaction
$x10$	the proportion of men to women
$x11$	birth rate and death rate
$x12$	Immigration rate and emigration rate

3. General Assumptions

The size of the city will not increase indefinitely, and the data that we search is relatively stable.

The development of traffic everywhere is the same in the city.

The geomorphic features of the city are consistent.

In the analysis, we assume that the proportion of men and women in each city is the same.

The situation of energy consumption in the city is basically the same.

4. Systems and Metric

We select several recognized garden cities as reference samples to build the model and these cities meet the requirements of smart growth.

We have made a flow chart of urban development, just as follows:

We select four dimensions as the norms of the evaluation, which together affect the city's smart growth. These four dimensions are shown below:

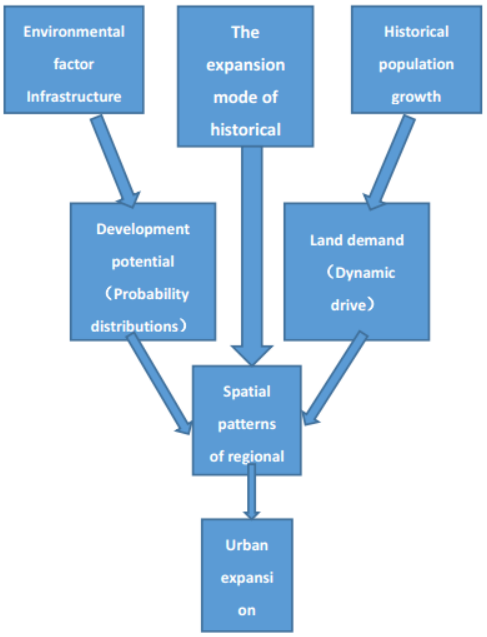

Figure 1

The dimension of population growth

The dimension of spatial growth

The dimension of consumption growth

The dimension of economic growth

For the population growth dimension, we mainly count the population of some garden cities. Through the model, we observed that population change is the main cause of urban changes. Decrease in population can lead to a reduction in the size of the city. On the contrary, the rise in population can lead to an increase in the size of the city. Moreover, the increase in population must be related to the expansion of urban area, otherwise it will reduce the well-being of residents.

For the dimension of spatial growth, we mainly calculated the corresponding increasing trend of urban area.

For the consumption growth dimension, the expansion of population and resources can inevitably lead to an increase in consumption, this dimension plays a negative role in the city's smart growth. Therefore, we use the approach that reciprocal is converted to a positive index. The dimension

indicates that achieving smart growth should be a corresponding increase in the degree of resource conservation.

In order to determine four dimensions influence on the evaluation system, we use cluster analysis to help us solve the problem. In systems analysis or evaluation, we often study the similarity between variables. According to the similarity of variables we can aggregate them into several classes, and then find the main factors affecting the system.

4.1 Variable similarity measure

In the clustering analysis of variables, we must first determine the similarity variables. Commonly used variable similarity measure has two kinds. One is the correlation coefficient, the other is the angle cosine.

1.Correlation coefficient:

$$r_{jk} = \frac{\sum_{i=1}^{n}(x_{ij} - \overline{x_j})(x_{ik} - \overline{x_k})}{[\sum_{i=1}^{n}(x_{ij} - \overline{x_j})^2 \sum_{i=1}^{n}(x_{ik} - \overline{x_k})^2]^{\frac{1}{2}}}$$

Where: The value of $x\,j$ is that $(x_{1j}, x_{2j}, \cdots x_{nj})^T \in R^n (j = 1, 2, \cdots, m)$

Then the sample correlation coefficient of two variables x_j and x_k can be used as their similarity measure.

2. Angle cosine

$$r_{jk} = \frac{\sum_{i=1}^{n} x_{ij} x_{ik}}{[\sum_{i=1}^{n} x_{ij}^{\ 2} \sum_{i=1}^{n} x_{ik}^{\ 2}]^{\frac{1}{2}}}$$

Where:

$$|r_{jk}| \le 1$$

4.2 Variable clustering method

$$r_{jk} = r_{kj}$$

In the variable clustering problem, commonly used methods are the longest distance method and the shortest distance method.

the longest distance method:

We need to define the distance between the two types of variables. The definition is shown below;

$$R(G_1, G_2) = \max_{\substack{x_j \in G_1 \\ x_k \in G_2}} \{d_{jk}\}$$

Where: $d_{jk} = 1 - |r_{jk}|$ or $d_{jk}^{\ 2} = 1 - r_{jk}^{\ 2}$

In this case, $R(G_1, G_2)$ is related to the similarity measure between the two variables with the highest similarity.

the shortest distance method :

We need to define the distance between the two types of variables. The definition is shown below;

$$R(G_1,G_2)=\min_{\substack{x_j\in G_1\\ x_k\in G_2}}\{d_{jk}\}$$

Where: $d_{jk}=1-\left|r_{jk}\right|$ or $d_{jk}^{\ 2}=1-r_{jk}^{\ 2}$

In this case, $R(G_1,G_2)$ is related to the similarity measure between the two variables with the highest similarity.

Using MATLAB, we can find that the weight of economic dimension is the largest, more than 40%, followed by the population dimension, weight of which more than 25%. The contribution of space dimension and consumption dimension to the evaluation of integrated entropy is low, and the weights are not more than 20% or 15%. According to the data of Suzhou, China, we draw the relevant images.

The image is shown below；

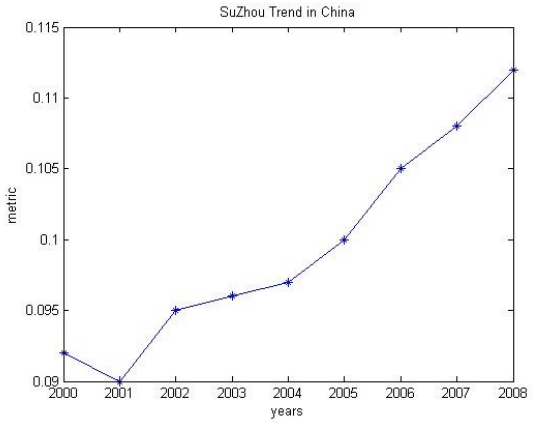

Figure 2

However, for the four dimensions, it is not easy to measure, so we made the problem simpler. We can use the method of scoring weight, through the high and low scores, to determine whether a city to achieve smart growth.

Table 1

First grade assessment indicator	Second grade assessment indicator	Evaluation			
		A	B	C	D
Consumption	Pollution index	0.1	0.2	0.3	0.4
	Noise pollution index	0.1	0.2	0.3	0.4
	Traffic trip index	0.2	0.3	0.3	0.2
Population	Male to female ratio	0.4	0.4	0.05	0.05
	Aging index	0.4	0.4	0.05	0.05
GDP	Per Capita GDP Index	0.3	0.4	0.2	0.1
	Urban GDP growth index	0.3	0.4	0.2	0.1
Land - use	Land diversity index	0.3	0.4	0.2	0.1
	Average land value	0.4	0.3	0.2	0.1
	Land - use density	0.4	0.3	0.2	0.1

5. Research and Evaluation

According to the requirement, we select Geneva and Canberra as a sample. The former is in Europe, the latter is in Oceania. We search the relevant website. Their plans are as follows ;

5.1 Geneva

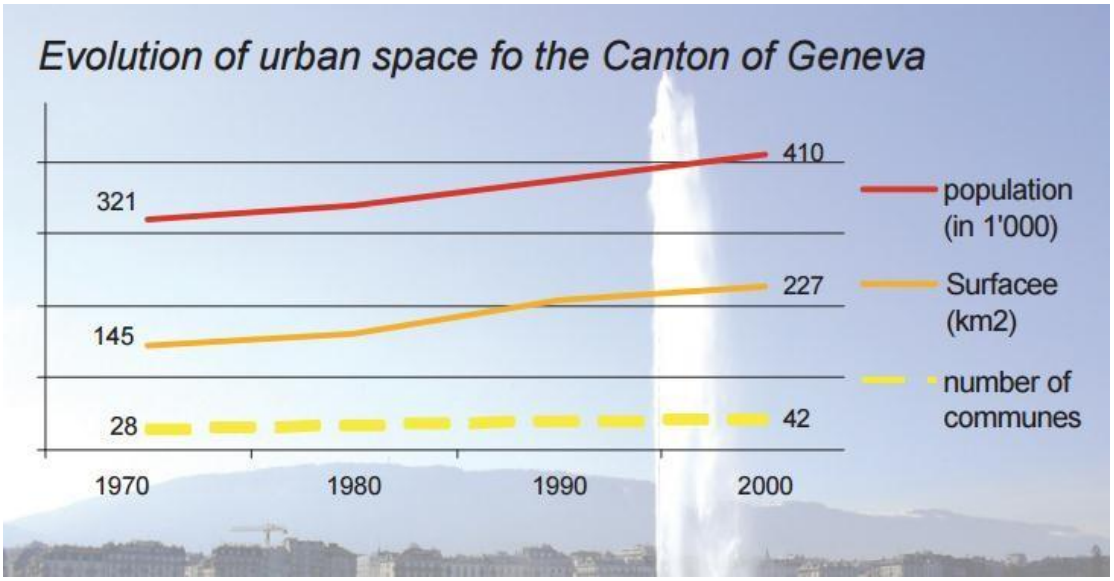

Figure 3

In 2001, Geneva registered its highest recent growth rate of over 2%, while the increases in 2002 and 2003 were 1.3% and 1.6% respectively. For suburban development, put pressure on the agricultural lands and natural environment. In Geneva, these problems are accentuated by the cross-border nature of the urban agglomeration. The Canton has adopted a policy of territorial development favoring "urbanization towards the interior", or “inward urbanization”. It is fighting against the dispersal of the built zone and trying to preserve as much of the agricultural zone as possible. Geneva's goal is to gradually increase the density of the urban center and the suburbs and promote continuous urban space, while allowing some degree of development in outlying villages. This policy has made it possible to limit harm to the countryside – but contributes to the unmet demand for accommodation. The Canton classified limited parts of the agricultural zone that are contiguous with the built zone, but even this has not sufficed. As a result of the housing shortage, real estate prices are high and rising.

Despite its efforts to promote inward urbanization, the government finds that over the last ten years the population has been increasing more in the suburbs than in the center. Consequently, traffic problems are worsening, with major congestion at peak hours in the morning and evening on both major and minor access roads.

5.2 Canberra

The key principles underpinning the Canberra spatial plan are shown below;

Contain growth within 15 kilometers of the city center to reduce sprawl and protect biodiversity.

Increase the number of homes within 7.5 kilometers of the city center to provide a wider range of housing close to employment and services.

Locate new residential areas close to town centers and transport routes.

Locate employment close to residential areas and transport routes.

Provide good travel connections to minimize journey times and trip length.

Protect areas of high conservation value from the impact of development.

Protect and enhance important assets.

Be a responsible partner in the region.

5.3 Key aspects of the Canberra spatial plan are:

More housing in central areas, mostly in Civic, along Northbourne Avenue, Constitution Avenue, in Barton, Kingston and around town centers, while retaining the character and amenity of residential neighborhoods.

Growing communities in Gungahlin, development in Molonglo Valley in the short term, and if needed in Kowen Plateau later.

Civic and the central area a focus for culture, business, ideas, people and important events.

Jobs growth in Civic and town centers, with clustered activities along three employment corridors: Belconnen to Queanbeyan; Gungahlin to Tuggeranong; and Majura Valley to Jerrabomberra Valley.

Wildlife corridors linked to each other and the region to allow wildlife movement.

Transport links between town centers and Civic, and links from Molonglo Valley and Kowen Plateau to employment corridors, but through traffic directed away from the city center.

A bushfire abatement zone established and managed to protect the city from risk of major bushfire.

Rural setting to frame the urban area and provide non-urban land for agricultural purposes.

Landscape setting to create the green backdrop to the urban and rural areas.

Water catchments protected from development that would adversely affect water quality.

6. Conclusion

We can find that both cities take smart growth as an important part in the future plans. According to our metric, Geneva's final score is 3, Canberra's final score is 2.4.We think that the main reason is Geneva's GDP is much higher than Canberra. And Geneva is an international city, it has more communication with other countries.

On the other hand, there are still some problems in both cities. Geneva's plan don't take the use of land into account, so the traffic in Geneva have been worsening in recent years .This don't meet the smart growth's principle. When it comes to Canberra, we think it should place more emphasize to the economic, because GDP takes up a great proportion in our metrics. Canberra has been a garden city,not only does it protect its environment, but also it need to develop its economic to improve people's life.

References

[1] QiaoJiajun.Application of Impove Entroy Method in Henan Suntainable Development Evaluvation .Resources science. 2004.

[2]Han Shangfu, CaiBangcheng, Lu Genfa. Application of Improved Entroy Method in Evaluation Environmental Presssure Change of Industry of Jiangsu Province.Ecological Environment. 2006

[3]Cheng Zhaorong, Li Xunping, Wang Liang,Ye song.Evaluation on Rengional Carrying Capacity of Resources and Environments Based on Entropy Model. Journal of Yibin University. 2013.

[4]Wu Yuming, Zhang Yan.Analyzing Coupled Regional Economic Growth and Environment Conversation in China. Resources science. 2008.

[5]Zhu Li Evolutional analysis of social , Environmental and Economic development of GuangZhou by using entropy thory. Ecology and Environment. 2008.

[6]Yue Li, Gao Xincai ,Zhang Qinzhi.Evaluation of regional circular economy development based on entropy method. Soft science. 2011

[7]Sallis JF, Linton LS, Kraft MK, Cutter CL, Kerr J, Weitzl J, Wilson A, Spoon C, Harrison ID, Cervero R, Patrick K, Schmid TL, Pratt M. The active living research program: six years of grantmaking. Am J Prev Med 2009; 36: S10–S21.

[8]Kaczynski AT, Henderson KA. Parks and recreation settings and active living: a review of associations with physical activity function and intensity. J Phys Act Healt h 2008; 5: 619–632.

[9]Casagrande SS, Whitt-Glover MC, Lancaster KJ, Odoms-Young AM, Gary TL. Built environment and health behaviors among African Americans: a systematic revie w. Am J Prev Med 2009; 36: 174–181.p