Smart Growth Theories in City Design

Xuanyi Li [a, *]

School of Computer Science and Technology, North China Electric Power University, Baoding 071000, China;

[a]57436746@qq.com

Abstract

With the development of global urbanization, urban planning has been a hot spot of most concern. Since the traditional urban sprawl plan has been gradually unable to meet the development needs of the city, smart growth is proposed in 1990's. In this paper, a series of methods are developed to help to implement smart growth theories into city design. We define a comprehensive index that measures the success rate of urban smart growth - the Smart Growth Index and the development strategy to deal with the spread of cities.Through the AHP (Analytic Hierarchy Process) method, the structure model is established, and the evaluation model of the definition of smart growth success rate and sub-smart growth index has a strong stability and universality. On this basis, the new growth plan was drawn up, the expected indicators and standard values were obtained, the success rate of the plans was evaluated, and the prediction was made using the GM (1,1) forecasting model. The cities in Jinchang and Geneva in the next 30 years did not have A more successful direction and a new plan based on a Smart Growth Index will allow both cities to move towards more success.

Keywords

Smart growth index; smart growth success rate; AHP; structural model.

1. Introduction

1.1 problem background

The world is rapidly urbanizing. It is estimated that by 2050, the urban population will reach 66% of the world's population. The consequences are: the expansion of metropolitan-edge cities, the consequent negative impact on the environment, and the excessive pressure on environmental resources and infrastructure. In today's increasingly globalized and interconnected world, more than half of the world's population (54%) live in urban areas, although there are still significant changes in the level of urbanization in various countries. The coming decades will bring about further profound changes, the size and spatial distribution of the global population. The world population for urbanization and overall economic growth is projected to increase by 2.5 billion by the year 2050, with nearly 90% of urban population concentrated in Asia and Africa. Meanwhile, the proportion of the world's population living in urban areas is expected to increase, reaching 66% by 2050.

1.2 Description of the problem

Define a measure to measure the success of smart growth in the city. It should consider the principles of three E's sustainability and / or 10 smart growth.

Study the growth plans of the currently selected cities. Measure and discuss how each current urban growth plan meets the principle of smart growth. How successful is the current plan based on your measurements?

Develop plans using the Smart Growth Principles These two cities will be in the next few decades. Why You Choose Components for Support and Planning Your plans are based on geographic, projected growth rates, your city and economic opportunities. Use your metrics to evaluate the success of your smart growth plan.

Also redesign your smart growth plan with your metrics, individual plans within the hierarchy, with the lowest possible potential. Compare and contrast the actions between these two cities and their rankings.

Assume that each city will have an additional 50% increase in population by 2050, indicating how (s) your plan supports this level of growth?

2. ideas analysis

This article defines a composite index that measures the success rate of urban smart growth - the Smart Growth Index. Through the establishment of Analytic Hierarchy Process (AHP) structural model, the judgment matrix is generated based on data such as data, expert opinion and system analyst's experience, the weight is calculated and the consistency test is conducted. Then set up a rating system, grading the definition of successful growth rate of smart growth. Furthermore, taking Jinchang City, Gansu Province, China and Geneva, Switzerland as the research object, the model is tested based on the index data and the current growth plans of the two cities. The rationality and sensitivity analysis of the model parameters are carried out. feasibility. A new growth plan was developed for both cities to arrive at the expected indicators and standard values and the success rate of the plan was assessed. Finally, calculate the indicators of smart growth based on the new growth plan. Based on the new evaluation model, the smart growth index for both cities in 2050 is calculated (assuming that the population of each city will increase by 50% in 2050).

3. Smart Growth Index Definition

Based on the "3E" goal of sustainable development and the ten principles of smart growth, a comprehensive indicator that measures the success rate of urban smart growth is defined as the Smart Growth Index.

3.1 index definition

A level of indicators: smart growth index. The secondary indicators are: intensity of urban land use, growth benefit of urban land use and livable urban growth rate. Three indicators include: urban population expansion coefficient, urban output, urban green coverage and so on. Specific as shown in figure 1.

3.2 Formula Definition

As shown in the formula (1) ~(8)

$$\textit{City Population Expansion Index} = \frac{\text{Urban land growth rate}}{\text{Urban population growth rate}} \tag{1}$$

$$\textit{City Economic Growth Index} = \frac{\text{Urban land growth rate}}{\text{Urban economic growth rate}} \tag{2}$$

$$\textit{Urban population density} = \frac{\text{Urban non-agricultural population}}{\text{Urban land}} \tag{3}$$

$$\textit{Urban output} = \frac{\text{Urban area GDP}}{\text{Urban land}} \tag{4}$$

$$\textit{Urban GDP per capita} = \frac{\text{Urban area GDP}}{\text{Urban population}} \tag{5}$$

$$\textit{City traffic convenience factor} = \frac{\text{Urban traffic road length}}{\text{Urban population}} \tag{6}$$

$$\textit{Urban green space per capita} = \frac{\text{Urban green coverage area}}{\text{Urban population}} \tag{7}$$

$$\textit{Degree of urban pollution} = \frac{\text{Urban industrial land}}{\text{Urban land}} \tag{8}$$

4. The model is established

4.1 Assumptions

Make five assumptions:

Assuming the listed indicators are in line with the specific structural requirements of AHP;

Suppose that we only consider the eight third-level indicators mentioned, regardless of other conditions;

It is assumed that all the analysis factors in the model are comprehensive;

Suppose in a short period of time, the structure of factors at all levels will not change;

It is reasonable to assume the importance of the evaluation index.

4.2 Modeling

Build AHP structural model according to the index. The model is a hierarchical structure with three different layers (O, C, A), as shown in Figure 1.

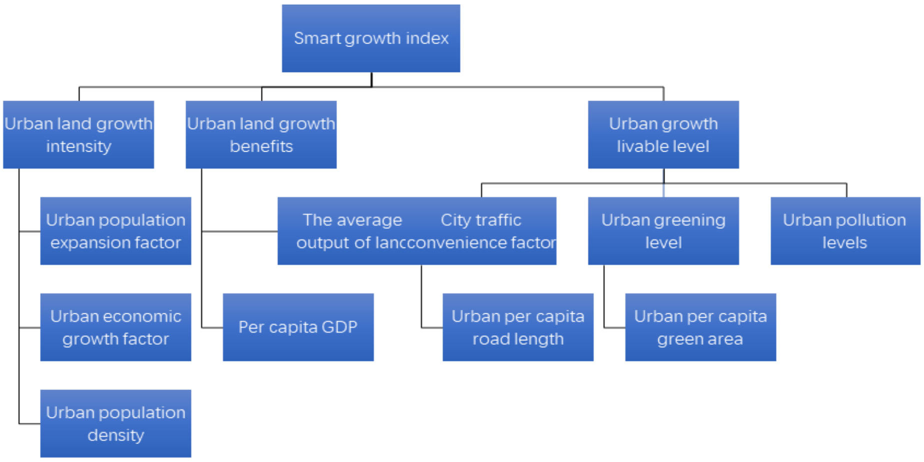

Figure1

4.3 Weight and consistency test

According to data, expert opinion, system analyst's experience and other indicators, it will generate a judgment matrix, calculate the weight and conduct consistency test.

As shown in the formula (9) ~(11)

$$CI = \frac{\lambda_{\max} - n}{n-1} \tag{9}$$

$$RI = \frac{\sum_{i=1}^{m} C_i}{m} \tag{10}$$

$$CR = \frac{CI}{RI} \tag{11}$$

Smart growth factor(O) ,Urban land growth intensity(C1),Urban land growth benefits(C2) and Urban growth livable level(C3) Judgment matrix

Tab.1 Judgment matrix

O	C2	C3	ω	λ	CI	RI	CR
C1	1/3	1/5	0.1095	3.0037	0.0018		0.0032
C2	1	1/2	0.309				
C3	2	1	0.5816				

Urban land growth intensity(C1),Urban population expansion factor(A1),Urban economic growth factor(A2) and Urban population density(A3) Judgment matrix

Tab.2 Judgment matrix

C1	A1	A2	A3	ω	λ	CI	RI	CR
A1	1	1/5	1/3	0.1095	3.0037	0.0018		0.0032
A2	5	1	2	0.5816				
A3	3	1/2	1	0.309				

Urban land growth benefits(C2),The average output of land(A4),Per capita GDP(A5) Judgment matrix

Tab.3 Judgment matrix

C2	A4	A5	ω	λ	CI	RI	CR
A4	1	1	0.5	0	0		0
A5	1	1	0.5				

Urban growth livable level(C3),city traffic(A6),city greening(A7) and Urban pollution(A8)

Tab.4 Judgment matrix

C3	A6	A7	A8	ω	λ	CI	RI	CR
A6	2	1/3	1	0.1692	3.0183	0.0091		0.0158
A7	3	1	2	0.3874				
A8	1	1/2	1	0.4434				

4.4 evaluation system

Access to information, analysis of data to determine the upper and lower limits of the indicators. Positive and negative indicators define the standard value of the formula shown in Table 7.

The upper and lower limits are dimensioned, resulting in a set of standard values, followed by weighted summation, as shown in Table 5.

Tab.5

NO	Index	Weight	Lower limit	Standard value	Capped
A1	Urban population expansion factor	0.012	0	0.8-(X-L)/(U-L)*0.2	30
A2	Urban economic expansion coefficient	0.0338	0	0.8-(X-L)/(U-L)*0.2	20
A3	Urban population density	0.0637	0	0.6-(X-L)/(U-L)*0.4	25000
A4	City output of land	0.1545	0	0.6-(X-L)/(U-L)*0.4	1500
A5	Urban per capita GDP	0.1545	300	0.6-(X-L)/(U-L)*0.4	130000
A6	Urban per capita road length	0.0984	0	0.6-(X-L)/(U-L)*0.4	2
A7	Urban green coverage	0.2253	0%	0.6-(X-L)/(U-L)*0.4	100%
A8	Urban pollution levels	0.2576	0	0.6-(X-L)/(U-L)*0.4	0.1

Tab.6

NO	Index	Weight	Capped	Lower limit
A1	Urban population expansion factor	0.012	0.8	0.6
A2	Urban economic expansion coefficient	0.0338	0.8	0.4
A3	Urban population density	0.0637	1	0.6
A4	City output of land	0.1545	1	0.6
A5	Urban per capita GDP	0.1545	1	0.6
A6	Urban per capita road length	0.0984	1	0.6
A7	Urban green coverage	0.2253	1	0.6
A8	Urban pollution levels	0.2576	1	0.6

According to the approximation of the ideal point algorithm, formula (12), as shown in Figure 2, to define the three levels of the success rate of smart growth:

$$y_i = \sum_{i=1}^{m} Wj(X_{ij} - X_j^*)^2 \qquad i=1,2,3\ldots n \qquad (12)$$

Tab.7

NO	Ideal point offset range	Success rate
1	0~0.0172	very successful
2	0.0172~0.0687	Very successful
3	0.0687~0.1545	Unsuccessful

5. Model test

Research was conducted on the two cities of Jinchang, Gansu, China and Geneva, Switzerland, and the indicator data were collected as shown in Figure 8

Tab.8

NO	Index	Jinchang	Geneva	Remarks
A1	Urban population expansion factor	10.3	0	
A2	Urban economic expansion coefficient	9.3	0	
A3	Urban population density	51.7	9160	People per square kilometer
A4	City output of land	2.53	950	*10^6 Dollars per square kilometer
A5	Urban per capita GDP	4709.5	75406	Dollars per person
A6	Urban per capita road length	1.317	1.519	0km*10^(-3) per person
A7	Urban green coverage	32.30%	45.40%	
A8	Urban pollution levels	0.05	0.0153	

According to the definition of smart growth index, exponential weight distribution and evaluation system, using the algorithm approaching the ideal point, we estimate the success rate of smart growth in the two cities, as shown in Figure 9.

Tab.9

Close to the ideal point	Index	Weight	standard value	
			Jinchang	Geneva
	A1	0.012	0.7313	0.8
	A2	0.0338	0.707	0.8
	A3	0.0637	0.6008	0.7466
	A4	0.1545	0.6007	0.8533
	A5	0.1545	0.6136	0.8316
	A6	0.0984	0.8634	0.9038
	A7	0.2253	0.7292	0.7816
	A8	0.2576	0.8	0.6612
Offset			0.0869	0.0531
Success rate			unsuccessful	successful

6. Model application

First research on the analysis of the Jinchang city, collect related geography, national development and reform and other books to get relevant data.

6.1 Jinchang City

6.1.1 City information

Geography of the Jinchang city: The Jinchang city with a total area of 8896 square kilometers, 623800 acre of garden land, with 6.694 million acre of grass land, 177100 acre of the urban, rural villages, towns, factories and other land and 85500 acre of traffic land, 7.9743 million acre of unused land.

the economy of the Jinchang city: Its GDP totaled 22.45 billion.The first, twice, third industry structure ratio was 5.2:78.4:16.5.The per capita GDP reached 50060 yuan ($7751).

the city general situation of mineral resources: the nickel ore is abundant, the scale is huge, second only to Canada sudbury mine, who has the world's largest, the first in the country.The urban traffic road highway mileage is 1897.405 kilometers.

6.1.2 Based on the original trend of the forecast

Based on the existing parameter, using grey prediction model, the Jingchang city of smart growth index to forecast the development of Jinchang in the next 30 years, as shown in table 10

Tab.10

NO	Jinchang City					
	20 years ago	10 years ago	Currently	After 10 years	After 20 years	After 30 years
A1	9.8	10.7	10.3	9.9	9.54	9.19
A2	8.7	9.1	9.3	9.5	9.7	10
A3	49.2	50.8	51.7	52.6	53.5	54.5
A4	1.96	2.27	2.53	2.82	3.14	3.5
A5	2476.8	3581.3	4709.5	6128.4	8045.3	10561.8
A6	0.98	1.178	1.317	1.47	1.644	1.838
A7	23.20%	28.40%	32.30%	36.67%	41.70%	47.41%
A8	0.0047	0.0055	0.0068	0.0084	0.0103	0.0128

Based on table 10 forecasts, according to the model of standardization of data processing, draw a standard table and the success rate, such as table 11

Tab.11

NO	Jinchang expected sign value				
	Weight	Currently	After 10 years	After 20 years	After 30 years
A1	0.012	0.7313	0.734	0.7364	0.7378
A2	0.0338	0.707	0.705	0.703	0.7
A3	0.0637	0.6008	0.6008	0.6009	0.6009
A4	0.1545	0.6007	0.6007	0.6239	0.6316
A5	0.1545	0.6136	0.618	0.6239	0.6316
A6	0.0984	0.8634	0.894	0.9288	0.9676
A7	0.2253	0.7292	0.7466	0.7668	0.7896
A8	0.2576	0.8	0.6336	0.6412	0.6512
Offset		0.0869	0.1079	0.1029	0.0975
Success rate		unsuccessful	unsuccessful	unsuccessful	unsuccessful

The Jinchang city is located in the inland, sparsely populated, although it has rich mineral resources, but still to be improved urban greening indicators, far from smart growth factor. So according to the adjustment of urban development planning, appealling to improve population need to increase the population density, attracting foreign population, developing the third industry, especially the travel service industry are good choices. To improve urban air quality and livable level, the Jinchang need to increase vegetation coverage.

Based on the adjustment of the new planning, it is concluded that the standard table and the success rate, such as table 12.13

Tab.12

NO	Jinchang City					
	20 years ago	10 years ago	Currently	After 10 years	After 20 years	After 30 years
A1	9.8	10.7	10.3	9.9	9.54	9.19
A2	8.7	9.1	9.3	9.5	9.7	10
A3	49.2	50.8	51.7	94.2	168.6	292.8
A4	1.96	2.27	2.53	274.8	429.3	3626.8
A5	2476.8	3581.3	4709.5	8466	14860	25090
A6	0.98	1.178	1.317	1.47	1.644	1.838
A7	23.20%	28.40%	32.30%	36.67%	41.70%	47.41%
A8	0.0047	0.0055	0.0068	0.01	0.02	0.05

Tab.13

NO	Jinchang expected sign value				
	Weight	Currently	After 10 years	After 20 years	After 30 years
A1	0.012	0.8	0.734	0.7364	0.7378
A2	0.0338	0.8	0.705	0.703	0.7
A3	0.0637	0.7466	0.6015	0.6027	0.6047
A4	0.1545	0.8533	0.6732	0.7145	0.7671
A5	0.1545	0.8316	0.6251	0.6449	0.6765
A6	0.0984	0.9038	0.894	0.9288	0.9676

A7	0.2253	0.7816	0.7467	0.7668	0.7896
A8	0.2576	0.6612	0.64	0.68	0.8
Offset		0.0869	0.09765	0.08166	0.0553
Success rate		unsuccessful	unsuccessful	unsuccessful	successful

Then analyze Geneva, collect related data information of the Geneva

6.2 Geneva

6.2.1 City information

The Geography of Geneva: Geneva is located in north latitude 46°12 6°09 east longitude, in the southwestern corner of lake Geneva into the Rhone river.Its south, east, and west sides all border with France. Thus at the ancient times,it is a mohican. Geneva covers an area of 15.86 square kilometers. Geneva is surrounded by two big mountains, the Alps and the Jura mountains mountains.

The economy of Geneva: The economy is mainly the third industry in Geneva.The city has ancient financial sector, especially the private banking business (about $1 trillion in assets management) and the international trade financing.Many transnational corporations, international headquarters lie in Geneva.In humanitarian tradition ,with its deep and colorful cultural activities including major conference, exhibition, mouth-watering delicacies, the outskirts of the scenery and many tour and sports facilities known by the world.Geneva is the world of watches and clocks, watch industry and banking have become two major spiritual pillar in Geneva. Geneva is also the place of the concentration of main cultural and artistic performance. And international performing arts companies regularly perform in the theatre music and opera.Geneva is the intersection point of the world, more than 200 international important institutions in Geneva.Geneva is the intersection point of the world, more than 200 international important institutions in Geneva.

the city general situation of mineral resources: the public transportation services including bus and tram provided by public transport (TPG) in Geneva.In addition to responsible for the center of the city traffic, the network also extends to the perimeter of the French towns throughout the state.Geneva states with 30% of all electricity demand in the local production, mainly composed of three hydroelectric power station was built on the Rhone river.

6.2.2 Based on the original trend of the forecast

Based on the existing parameter, using grey prediction model, the Geneva city smart growth index to forecast the next 30 years.As is shown in figure 14

Tab.14

NO	Jinchang City						
	20 years ago	10 years ago	Currently	After 10 years	After 20 years	After 30 years	
A1	0.6	0.2	0	0	0	0	
A2	1.2	0.4	0	0	0	0	
A3	7430	8320	9160	10075	11092	12211	
A4	674	839	950	174	1216	1376	
A5	52711	64303	75406	88165	1E+05	1E+05	
A6	1.18%	1.337	1.519	1.723	1.957	2.223	
A7	40.20%	42.70%	45.40%	48.25%	51.30%	54.55%	
A8	0.016	0.015	0.015	0.014	0.014	0.013	

Based on the prediction data in Table 14 and the data normalization according to the above model, the standard value table and the success rate are obtained as shown in Table 15\

Tab.15

NO	Jinchang expected sign value				
	Weight	Currently	After 10 years	After 20 years	After 30 years
A1	0.012	0.8	0.8	0.8	0.8
A2	0.0338	0.8	0.8	0.8	0.8
A3	0.0637	0.7466	0.7612	0.7775	0.7954
A4	0.1545	0.8533	0.8864	0.9243	0.9669
A5	0.1545	0.8316	0.871	0.9178	0.9727
A6	0.0984	0.9038	0.9446	0.9914	1.0446
A7	0.2253	0.7816	0.793	0.8052	0.8182
A8	0.2576	0.6612	0.6568	0.6548	0.6524
Offset		0.0531	0.0485	0.0444	0.0418
Success rate		successful	successful	successful	successful

Based on the adjustment of the new planning, it is concluded that the standard table and the success rate, such as table 16. 17

Table16

NO	Jinchang expected sign value				
	Weight	Currently	After 10 years	After 20 years	After 30 years
A1	0.012	0	0	0	0
A2	0.0338	0	0	0	0
A3	0.0637	9160	10075.2	11091.6	12210.5
A4	0.1545	950	1074	1216	1376
A5	0.1545	75406	88165	103354	121159
A6	0.0984	1.519	1.723	1.957	2.223
A7	0.2253	45.40%	0.4825	0.513	0.5455
A8	0.2576	0.0148	0.0112	0.0534	0.0801

Tab.17

NO	Jinchang expected sign value				
	Weight	Currently	After 10 years	After 20 years	After 30 years
A1	0.012	0.8	0.8	0.8	0.8
A2	0.0338	0.8	0.8	0.8	0.8
A3	0.0637	0.7466	0.7612	0.7775	0.7953
A4	0.1545	0.8533	0.8864	0.9243	0.9669
A5	0.1545	0.8316	0.871	0.9178	0.9727
A6	0.0984	0.9038	0.9446	0.9914	1.0446
A7	0.2253	0.7816	0.793	0.8052	0.8182
A8	0.2576	0.6612	0.6448	0.8136	0.9204

Offset		0.0531	0.0507	0.0226	0.01223
Success rate		successful	successful	successful	very successful

7. Conclusion

7.1 Two cities realize the difficulty degree of every index

7.1.1 For the Jinchang city

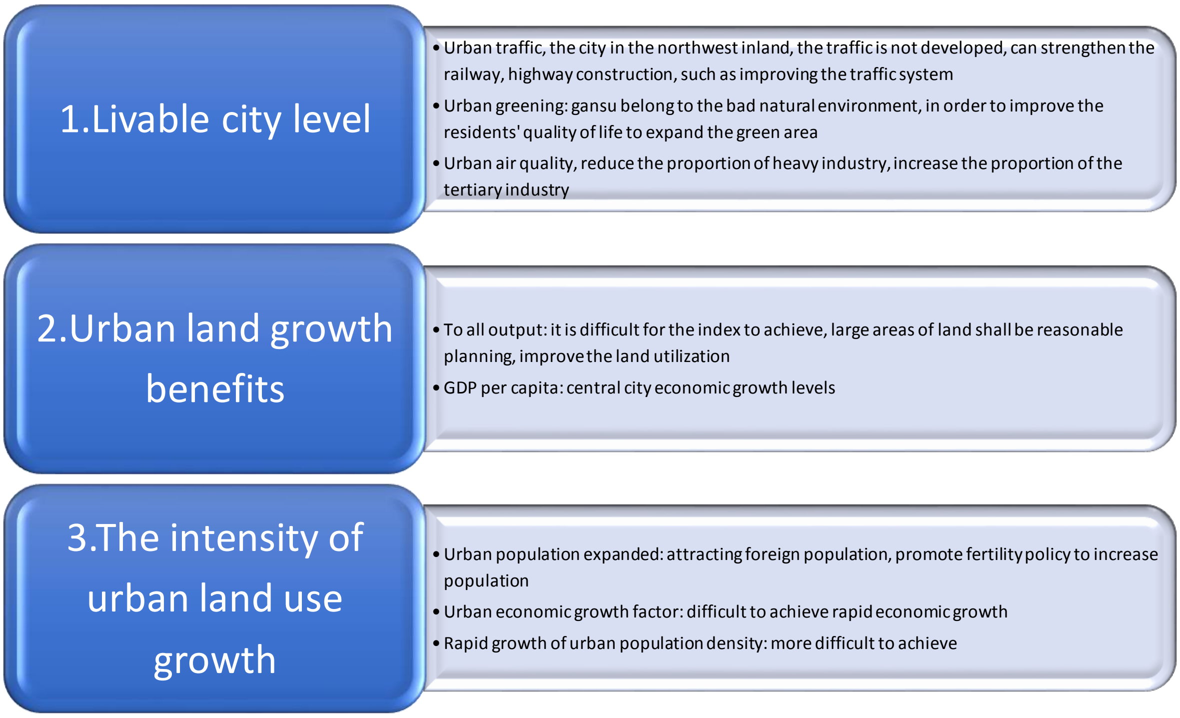

figure 2

7.1.2 For the Geneva

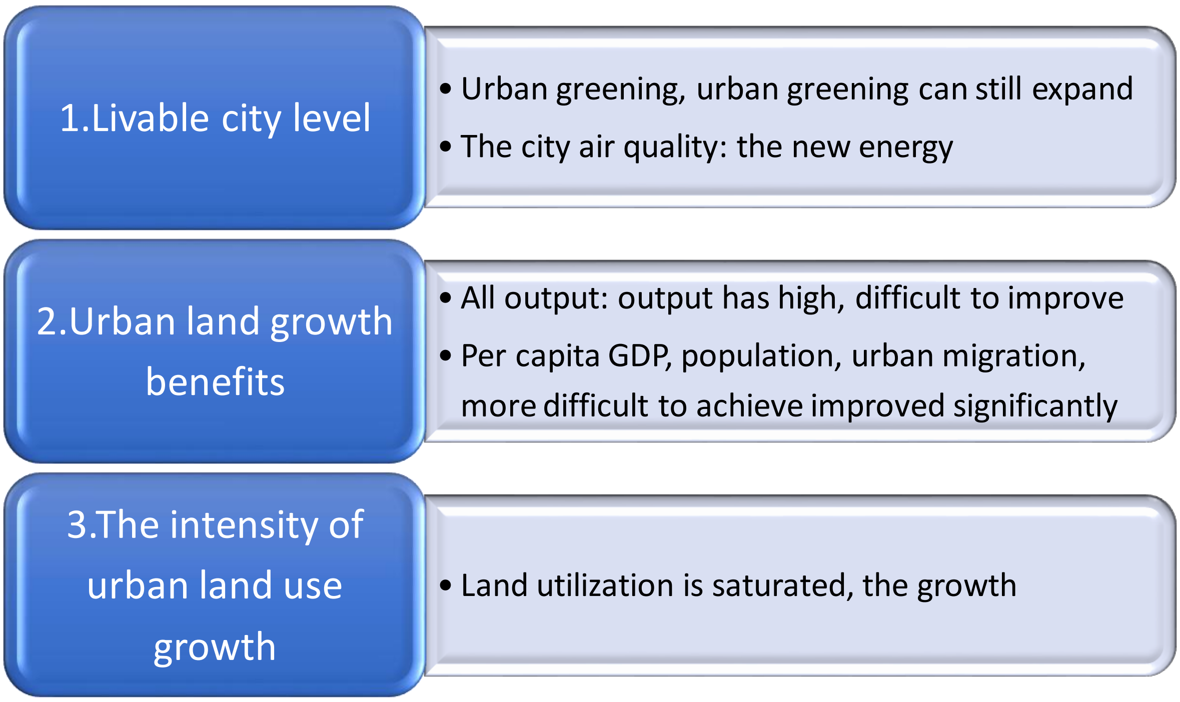

figure 3

7.2 Contrast

Geneva city out of the intersection area, economy and culture developed, due to the current economic indicators are significantly higher than the Jingchang city, it can increase greatly ascend. The indicators of the Jingchang city are relatively low, but its land area is larger, should better use of the advantages of land, realize the significant improvement of city smart growth index.

7.3 The application of the situation of 50% population growth

Data shows that the proposed program can control the sharp growth of almost all of the indicators promoting the development of the city and making city more attractive and competitive.Basis for the Jingchang city of China's gansu province and new growth plans in Geneva, Switzerland. Assuming the two cities to 2050 more than 50% per year,with population growth, smart growth index were 0.0553 (" successful ") and 0.01223 (" very successful "), fully show the paper can play a supporting role in carrying out a plan for the growth of the two cities the scale of the population growth.

8. Model Stability and Sensitivity Analysis

Using the current index information in Geneva, USES the local sensitivity analysis drawing, as shown in figure 4, the eight indexes sensitivity debugging, smart growth index model sensitivity stability results.

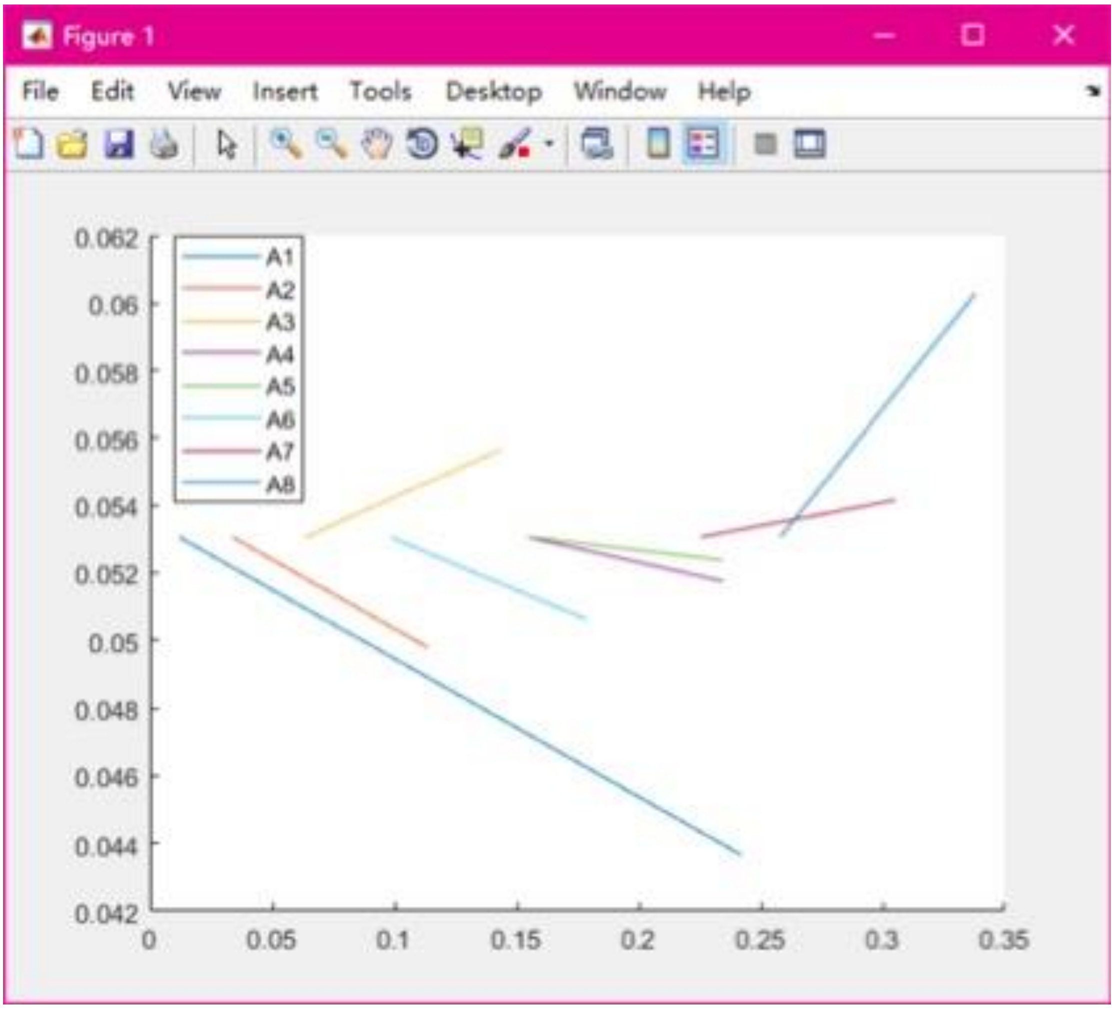

figure 4

9. Model evaluation

9.1 Model advantages

the eight-basic data of model are accessible. By the better control of the eight indicators or coefficient, It is easy to realize the goal of smart growth according to the plan

Using AHP hierarchy analysis, given weight to each index, We can emphasize the importance of environment in light of the actual situation

According to the fitting grey prediction algorithm, simulations can estimate the growth trend in the future

Combined with the characteristics of each city, it is a strong guidance to industrial planning.

9.2 Model shortcomings

The weight of delamination has great subjectivity, so the findings are controversial.

In view of new plan fitting index emphasizing on urban air quality, it is necessary to adjusted weight

If we employ gray prediction analysis, it demands faster economic growth. But the actual execution has certain realistic factors.

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