The evaluation system of the success of a city's smart growth

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Abstract. With the world rapidly urbanizing, the phenomenon of urban sprawl is prominent, and long - term and sustainable urban planning development is of great importance. Smart growth is an urban planning theory with great superiority. This paper studies the evaluation of smart growth on urban development, in order to give a reference on the process of urban development. In the essay, establish an original three-grade evaluation system then take use of directed graph to analyze indexes of system. Finally get the definition of the success of smart growth of a city through impulse process modeling

Introduction

Nowadays, the world is rapidly urbanizing. Urban planning is of great significance. It is worth noting that urban sprawl has become one of the world's concerns. The American planning community has proposed smart growth as a means to curb continued urban sprawl and reduce the loss of farmland surrounding urban centers. So what is smart growth? Smart growth is an urban planning theory aimed to realize the E's of sustainability— economically prosperous, socially Equitable, and Environmentally Sustainable. It benefits for our health and natural environment and make our communities more attractive, economically stronger, and more socially diverse.

It follows that the smart growth theories are great favorable for the development of city. Based on it, in order to effectively ensure fair and sustainable home, resources and the opportunities of job, the leader not only should take the ten principles of the smart growth and the E as measures, but also should consider urban population statistics, growth and unique geographical conditions to adapt to community needs to make decisions.

Smart growth theories are complex, which is meaningful for urban planning. However, there is little research on the model that can implement smart growth theories into city design around the world. Thus, this paper is to build a model to measure the success of smart growth of a city, define a metric, in order to research the smart growth of cities.

The Arrangements of evaluation system model

General assumptions.

- In the impulse-based system simulation prediction process, the only active change factor is the initial given population factor. The other factors such as policy, planning and so on, will not had a big change suddenly in the short term.
- We take 10 years as the demarcation point between short-term and long-term. Forecasts more than 10 years are long-term forecasts and less than 10 years are short-term forecasts.

Symbol Description.

Parameter	Meaning
V_1	Mix land uses
V_2	Take advantage of compact building design
V_3	Create a range of housing opportunities and choices
V_4	Create walkable neighborhoods
V_5	Foster distinctive, attractive communities with a strong sense of place
V_6	Preserve open space, farmland, natural beauty, and critical environmental areas
V_7	Strengthen and direct development towards existing communities
V_8	Provide a variety of transportation choices
V_9	Make development decisions predictable, fair, and cost effective
V_{10}	Encourage community and stakeholder collaboration in development decisions
V_{11}	Population statistics
V_{12}	Traffic demand brought by the urbanization process
V_{13}	Environmental demand brought by the urbanization process
V_{14}	The natural environment conditions
V_{15}	The social environment conditions
E_1	Economically prosperous
E_2	Socially equitable
E_3	Environmentally sustainable

The evaluation system of the success of a city's smart growth

The original three-grade evaluation system.

We establish a three-grade evaluation system. The first level is comprehensive evaluation, which measures the success of smart growth of a city. The second level is the main target level, which takes three E's as three goals in this level. The third level is for indexes, considering the ten principles for smart growth and three E'S and they are the common indexes. The forth level is original level directly reflecting each index. And the figure of hierarchy evaluation as follows.

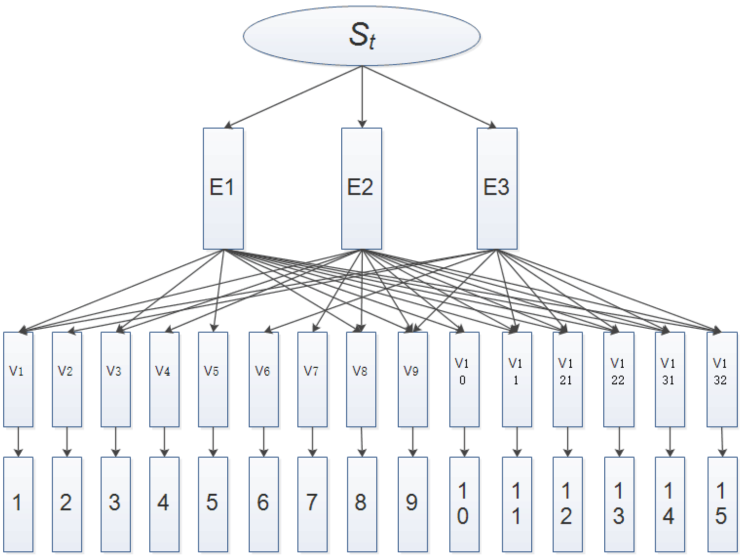

Fig. 1 The three-grade and four-layer evaluation system

The choice and evaluation of indexes.

Based on figure1, we select the 15 original indexes as primary indexes corresponding to target level. For the main target level, according to correlation calculation of slope, we classify 15 primary indexes and identify the formulas for calculation.

Table 1 the formulas and meanings of indexes

Symbols	Formulas and Explanations	Remarks	Categories
V_1	$\frac{1}{\text{Cat}}\sum_{i=1}^{\text{Cat}}\left[1-\frac{s_i}{s_i^{\text{obj}}}\right]^2$	Cat is the quantity of types of land used s_i is the area that one of the particular type of land researched covers s_i^{obj} is the total area of land we reaseached	E1/ E2/ E3
V_2	$\frac{A}{A'}$	A is the area of buildings in the region A' is the area of the minimum circumscribed circle in the region	E3
V_3	$\frac{C}{P}$	C is the area of total housing P is the total population	E1/ E2
V_4	$1-\frac{B'}{B}$	B' is the floor space in the community B is the total area in the community	E2
V_5	$\frac{D'}{D}$	D' is the quantity of the communities owning characters D is the quantity of the total communities of the area	E1
V_6	$\frac{100E'}{E}$	E' is the area of green space E is the total area	E3
V_7	F	F is the quantity of infrastructure's categories within 500m in average	E2
V_8	G	G is the quantity of types of public transportation within 300m in average	E1/ E2
V_9	H	H is the quantity of factors that leader considered (among make development decisions predictable, fair and cost effective)	E1/ E2/ E3
V_{10}	I	I is the quantity of policy related to encouragement about collaboration between community and stakeholder	E1

- To calculate the value among indexes with different dimension, we introduce the concept of membership grade, these indexes are divided into 5 levels, matching to number between 0 and 1. And we take the number as membership grade.
- To quantify the influence among the factors of system, we establish the directed graph to describe the influence. we can obtain the adjacency matrix w_{ij} of directed graph with weight. The directed graph is as E1 for example.

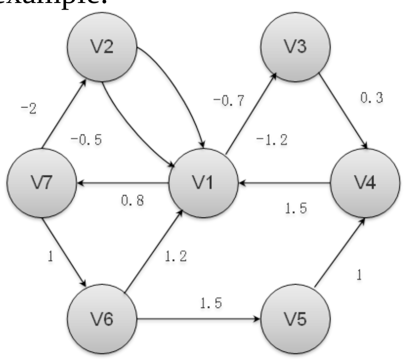

Fig. 2 Directed graph with weight of E1

The definition about smart growth's index of a city.

- **The indexes' weight**

In the level of comprehensive evaluation, the success of smart growth of a city can be determined by the formula

$$s_t = \sum_{i=1}^{3} \alpha_i E_i \qquad (1)$$

$$\sum_{i=1}^{3} \alpha_i = 1 \qquad (2)$$

Where：α_i is the weighting coefficient of three E's, the value of which depends on the starting point the decision-makers consider and the specific requirements of the government's policy.

- **The building of a model based on impulse**

To solve the above problem, we build a model based on impulse. First, we define the parameters

$V_i(t)$: the value of factor $V_i$at the tth year

$P_i(t)$:the impulse of $V_i$during the t years

We assume that the system's factors is N. After that, based on the meaning of w_{ij}, we can get the formulas:

$$V_i(t+1) = V_i(t) + P_i(t+1) \qquad i = 1,2,\ldots,n \quad t = 0,1,2,3,4,5 \qquad (3)$$

$$P_j(t+1) = \sum_{i=1}^{n} w_{ij} P_i(t) \qquad j = 1,2,\ldots,n \quad t = 0,1,2,3,4,5 \qquad (4)$$

If only considering the change of the system on the initial state, we might as well assume that $V(0)$ is equal to $P(0)$.

For a given $V(0)$, then we can calculate the impulse $P(t)$ of system at the tth year according to formula(3)(4). Furthermore, we can obtain the value of $V(t)$, that is predict the change of system and the formula about E_i is as follows:

$$E_i = \sum_{i=1}^{n} \frac{(V_i(5) - V_i(0))}{V_i(0)} \qquad (5)$$

Conclusion

Finally, we can get the definition of the success of smart growth of a city .We assume the expected smart growth of a city is S_e, and in actual, the value is S_t,then we define the success of smart growth of a city as:

$$S_r = \frac{S_t}{S_e} \times 100\% \qquad (6)$$

According to formula(6), we can calculate the success of smart growth of a city based on formula(1)(2)(3)(4)(5) ,in order to research the smart growth of a city. Furthermore, it can give references on making growth plans for a city.

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