Exploration of Sustainable and Livable City Construction: a Case Study of Chengdu

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Abstract: In order to solve the problems raised by SDG11, this paper focuses on the new concept of urban construction and analyzes Chengdu's construction progress and existing problems. We constructs a new evaluation index system and mathematical model. Different from previous studies, we started from the perspective of citizens, incorporated new development concepts, and innovatively constructed a more reasonable analysis model. Through research, we find that the road area, the number of traffic stations and the AQI index load are relatively high, reflecting the greater impact of TOD construction on urban livability. It can be seen that the development of TOD in medium and large cities can improve the level of sustainable development and livability of cities.

1. Introduction

The urbanization of today's human society is increasing day by day. According to United Nations data, since 2007, more than 3.5 billion people worldwide have been living in urban areas; It is estimated that in 2030, more than 60% of the world's population will live in urban areas. This phenomenon is called "rapid urbanization" , which is also prominent in China in recent years. Since the 1980s, China's urbanization has entered a stage of rapid development: a large number of rural people have poured into cities - rapid urbanization has become an important feature of China's current social and economic development. China's urbanization rate increased from 17.4% at the beginning of reform and opening up to 59.58% in 2018. Emerging urban agglomerations have formed everywhere, such as Chengdu-Chongqing urban agglomeration, Yangtze River Delta urban agglomeration, etc.

At the same time, the excessively rapid urbanization has led to an overburden of infrastructure and services in urban areas, aggravated urban pollution and reduced residents' well-being. As the contradiction between human and land is increasing, people pay a high price for the disorderly development and irrational growth of cities, including economic, social, environmental and other aspects. In some third world countries, rapid urbanization has led to an increase in the number of urban slum dwellers: as of 2018, more than 1 billion people live in slums worldwide, of which nearly 80% belong to third world countries.

This paper focuses on two new concepts of "Park City Construction" and "TOD". Through the investigation, collection and analysis of the relevant data of Chengdu, getting the key factors in the current urban development. It is worth mentioning that on the basis of previous studies, this paper constructs a new evaluation system. For one thing, we consider the development indicators of Park City and Tod, and integrate the new development concept. For another, from the perspective of the general public, our research has higher rationality. After analysis, we find that: Road area, number of bus (or MRT) stops, AQI index, GDP and other indicators are significantly positively correlated with the livability of the city. Therefore, under the concept of "Park City" and "TOD", the planned city has a high level of livability and sustainable development. The government should promote these two new models of urban construction according to local conditions.

2. Core Concepts and Research Objects

2.1 Sustainable and Livable City

2.1.1 Livable City

The livability and sustainable development of cities are hot topics in the research field of regional economic development, and they are also the focus of urban residents.

In recent years, many European and American countries have included livability as an important indicator in their urban planning and development goals [1], focusing on coordinated development; China has put the "people-oriented" coordinated development thinking in the "Twelfth Five-Year Plan" Important position [2]. The "Economist", National University of Singapore, and China Urban Competitiveness Research Association have also issued "Livable Cities List" many times.

2.1.2 Sustainable City

The concept of "sustainable cities" has been proposed in a number of international conferences. As early as 1991, UN-Habitat and the United Nations Environment Programme (UNEP) put forward the Sustainable Cities Programme (SCP); the Urban21 Conference, held in 2000, proposed that sustainable cities are urban development models that do not burden future generations, and is sustainable improvement and development in ecological, cultural, social, and economic terms [3]; and in September 2015, the United Nations Sustainable Development Summit proposed 17 Sustainable Development Goals (SDGs), including "Sustainable Cities and Communities" (Goal 11). This paper holds that sustainable city is a city development mode that can satisfy the multi-level needs of residents and can be improved or maintained in ecological environment and social development without negative impact on future generations.

2.2 Urban Development Guided by Public Transport(Tod)

TOD originated in the United States and is the abbreviation of Transit-Oriented-Development. It is an ideal model for sustainable urban development. By coordinating the relationship between land use and transportation development, it carries out comprehensive land development around major public transportation (including subways, buses, etc.) stations [4]. It not only can reduce environmental pollution, but also enhance the efficiency of public transportation. It can lay the foundation for the development of a vibrant, high-quality city.

The development of the TOD model can build a low-cost, high-efficiency, and sustainable urban form.On the one hand, real estate developers develop high-density residential, commercial and office land while developing public facilities such as entertainment and sports, which improves the accessibility of land , achieving mixed land use to improve residents' travel efficiency. Changes in urban land use and spatial structure will change accordingly, which will affect the choice of residents' travel modes.
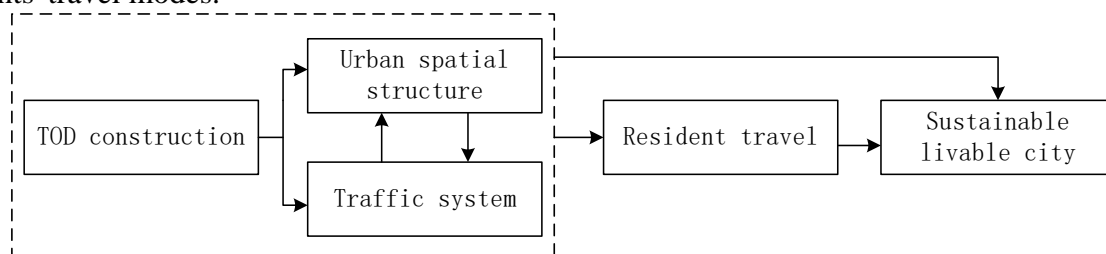

Fig.1 Mechanism of Tod Construction

In recent years, Chengdu, Nanjing and other places in China have also proposed to build TOD.

2.3 The Land of Abundance: Introduction of Chengdu City

Chengdu is located in the western part of the Sichuan Basin, with a geographical location ranging from 102°54′ E to 104°53′ E, 30°05′ N to 31°26′ N. Chengdu is the capital of Sichuan Province, the core city of the Chengdu-Chongqing urban agglomeration, and an important national

central city in western China. It is also the economic, cultural, political center and comprehensive transportation hub of southwest China, which gains the reputation of "the country of abundance".

3. Methods and Data

3.1 Evaluation Index System

In the research of livable city construction, Zhang[5] divided the evaluation index system of livable city into 2 first-class indicators, including subjective and objective indicators, including 10 second-class indicators such as safety, health and convenience, and 52 third-class indicators; Wang(2010) divided the evaluation system of livability of urban human settlements into 4 first-class indicators (such as the livability of natural environment and economic environment) and 30 second-class indicators; Zhan et al. [6] made an objective analysis on the livability of Beijing, which was divided into 6 first level indicators such as urban safety and living convenience and 17 second level indicators; Chen et al.[7] divided the urban livability evaluation system into 5 first-level indicators, 18 second-level indicators and 120 third-level indicators.

On the basis of previous studies, this article sets out a new evaluation system from the perspective of citizens, combined with the "Proposals of the CPC Central Committee on Formulating the Thirteenth Five-Year Plan for National Economic and Social Development". Compared with the previous perspective based on social elites or new citizens, there is a significant difference.

The livable "Park City" of Chengdu under TOD mode is a systematic concept, which requires a comprehensive evaluation of the livable degree of Chengdu. Referring to the TOD and the livable city indicators above, we combined the model with the construction of "Park City" in Chengdu. The indicators are selected from three dimensions - economy, society and environment. The evaluation index system of this paper includes the following 5 first-level indicators: Economy, Society, Ecology, Traffic System and Urban Spatial Structure, with 43 second-level indicators.[8]

3.2 Methodology

After the preliminary establishment of the evaluation system, the representative indicators are selected as the final elements of the evaluation system of Chengdu "Park City" by R-type cluster analysis. Kmo and Bartlet's spherical test are used to test the correlation of the selected indicators. Finally, factor analysis and stepwise regression analysis are used as evaluation models.

3.2.1 Factor Analysis

In order to strengthen the scientificity and objectivity of the evaluation and avoid many subjective factors when determining the weight of the factors.The factor analysis method is selected to analyze the results of R-type cluster analysis in the previous step, and the dimension reduction of the data is carried out at the same time of establishing the evaluation model, so as to reduce the difficulty of data processing. Based on the use of extreme value method to standardize the data, eliminate the dimensional effect of variables, so that each variable has the same expressive force. Kmo and Bartlett's spherical test correlation are used to test whether each variable is independent.[9]

3.2.2 Stepwise Regression Model

In order to more accurately determine the main indicators affecting the park city of Chengdu, the stepwise regression model in regression analysis is used to incorporate all the significant factors of many dependent variables into the regression model to make the final model as simple as possible. Remove the variables that are not significant after testing from the regression equation, then introduce new variables into the regression equation, and repeat the above steps until no variables can be selected into the regression equation..

3.3 Data Processing

Through factor analysis of the index, the KMO constant reached 0.613, and the significance of

Bartlett's sphericity test was 0.000, less than 0.001, which shows that the selected indicators is suitable for factor analysis. From the perspective of the variance contribution rate, when the common factor number is selected as 7, the cumulative variance contribution rate has reached 79.870%, and after the 7 common factors are extracted, the change in the characteristic value curve of the gravel map (Figure 4) is also reduced, so choose 7 common factors. The factor rotation is carried out using the maximum variance method. The main contribution indicators of each factor after rotation are as follows (Table 1), and the index that significantly affects the ranking of Chengdu park cities is selected through the stepwise regression model (Table 2).

Table.2 Main Contribution Indicators of Each Common Factor

Common factors	Main contribution indicators
F2	Comprehensive land price, number of Museums
F6	Number of health institutions and domestic sewage treatment rate
F7	Harmless treatment rate of domestic waste and proportion of added value of tertiary industry in GDP
F1	Road area, number of traffic stations, construction investment of municipal public facilities
F3	Number of health institutions, AQI index
F4	Industrial dust removal and green coverage
F5	Industrial wastewater discharge and road area

Table.3 Indicators That Significantly Affect the Livability of Park Cities in Chengdu

Index	Standard coefficient	T	Sig
Road area	0.292	10.02	0
Number of traffic stations	0.21	10.049	0
AQI index	0.134	9.595	0
GDP	0.229	6.817	0
Green coverage rate	0.099	6.467	0
Construction investment of municipal public facilities	0.116	3.63	0.001
Industrial wastewater discharge	-0.037	-2.501	0.018
Average wage of employees	0.085	3.581	0.001
Comprehensive land price	-0.04	-2.461	0.02
Harmless treatment rate of domestic waste	0.031	2.443	0.021

3.4 Result Analysis

It can be seen from table 3 that the road area, the number of traffic stations and AQI index load are relatively high, which reflects that the completion and development of TOD has a great impact on the livability of the city. [10]In order to further understand the boosting factors of TOD model to build Chengdu Park City, the correlation between TOD related indicators and park city is analyzed.

Based on the influence mechanism between TOD and sustainable development, and referring to the indicators established in the above research, this study selects the corresponding index system from the two dimensions of transportation system and urban spatial structure to explore the correlation between TOD development and livable city, including the total subway passenger traffic volume, the number of rail transit lines, the subway passenger traffic volume, the daily passenger flow of bus passenger station, the number of traffic stations and green space coverage rate, per capita Road area, bicycle and pedestrian travel ratio, public transport travel ratio nine evaluation indicators, using tableau to analyze the correlation between TOD and urban livability, and get the following correlation heat map.

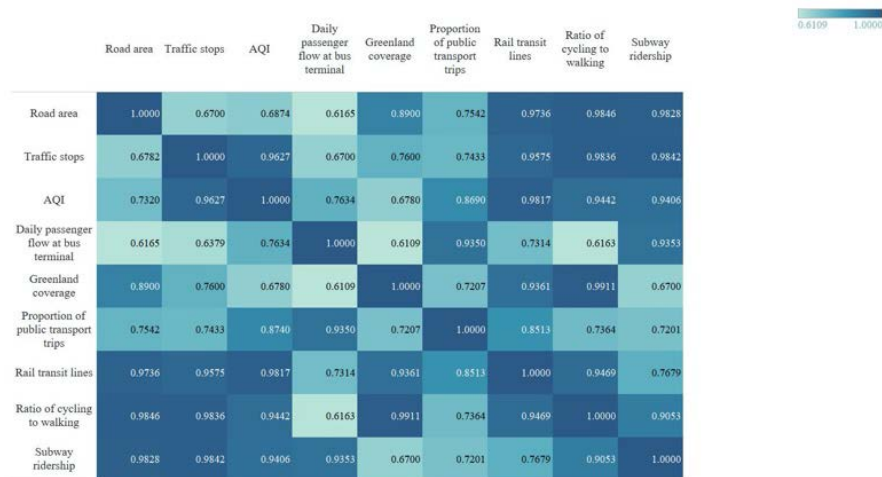|	Road area	Traffic stops	AQI	Daily passenger flow at bus terminal	Greenland coverage	Proportion of public transport trips	Rail transit lines	Ratio of cycling to walking	Subway ridership
Road area	1.0000	0.6700	0.6874	0.6165	0.8900	0.7542	0.9736	0.9846	0.9828
Traffic stops	0.6782	1.0000	0.9627	0.6700	0.7600	0.7433	0.9575	0.9836	0.9842
AQI	0.7320	0.9627	1.0000	0.7634	0.6780	0.8690	0.9817	0.9442	0.9406
Daily passenger flow at bus terminal	0.6165	0.6379	0.7634	1.0000	0.6109	0.9350	0.7314	0.6163	0.9353
Greenland coverage	0.8900	0.7600	0.6780	0.6109	1.0000	0.7207	0.9361	0.9911	0.6700
Proportion of public transport trips	0.7542	0.7433	0.8740	0.9350	0.7207	1.0000	0.8513	0.7364	0.7201
Rail transit lines	0.9736	0.9575	0.9817	0.7314	0.9361	0.8513	1.0000	0.9469	0.7679
Ratio of cycling to walking	0.9846	0.9836	0.9442	0.6163	0.9911	0.7364	0.9469	1.0000	0.9053
Subway ridership	0.9828	0.9842	0.9406	0.9353	0.6700	0.7201	0.7679	0.9053	1.0000

Fig.2 Figure Tod and Urban Livability Correlation Heat Map

As can be seen from the above figure, TOD has a strong correlation with park city construction, and TOD construction can promote park city construction. In particular, subway mileage, road area, bicycle and walking travel ratio, etc., can significantly improve the level of construction of livable cities. In the next stage, the municipal government should continue to roll out TOD projects, pay attention to infrastructure construction and environmental protection to form a new pattern of harmonious urban development.

4. Conclusions and Policy Implications

The disorder of mixed land is the primary crux of Chengdu's current urban spatial system. A reasonable land use mix should be to organically combine different land use functions into urban spaces in a certain proportion.

The over-simplification of land use functions in some urban areas is also the main problem of urban land use in Chengdu. Land use diversity design with public transportation stations as the core can effectively increase the proportion of residents using public transportation, especially the mixture between residential land and non-residential land, which can be more effective than the mixture between non-residential land. It can Promote the growth of public transportation sharing rate. Setting up public transportation stations in the community according to the functional positioning of the site, and configuring a corresponding proportion of commercial office or pure office core areas and residential areas can surely meet the various shopping and commuting entertainment needs or pure commuting needs of residents in the community. In addition, in order to reflect the relationship of equality and tolerance between people in the eco-city concept, in the detailed planning of residential land, residential clusters of various types, prices and densities should be combined so that the design of residential areas can be on the basis of maximizing the housing needs of low- and middle-income people. It also provides high-income people with a living environment with a certain spatial quality, so that the TOD community can attract different types of residents.

The form of mixed land use is not single, and can generally be divided into two forms: plane mixing and vertical mixing. When planning, the government should maximize the scale effect brought by the high concentration of population to the operation of public transportation. In order to alleviate the negative impact of too many high-rise complexes on the quality of urban space, it is necessary to consider the gradual transition of mid-high-rise and multi-storey public buildings and residences in the surrounding areas of traffic stations to meet the needs of different classes of residents for life and housing.

Through TOD development, especially the development of new districts and new towns, the government strengthens the connection with the industrial function zone. It is conducive to building a city cluster with a "commercial center-residential center-production center" circled with a track

station as the core. At the same time, we can change the single centralized urban structure, and form a multi-center urban spatial layout to relieve the population and functions of the central urban area, promote the multi-centralization of the urban structure, and effectively curb the disorderly spread of the city.

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