Research on the Construction of "Resilient City" in the Post-epidemic Period from the Perspective of System Dynamics

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Abstract. The outbreak of the epidemic and the long-term shutdown led to various problems in urban construction and industrial chain. In this paper, Vensim PLE software is used to form the basic flow rate tree model for the image construction of "resilient city", and the second-order and third-order analysis and simulation analysis are carried out. The results show that the model constructed in this paper can well reflect the relationship between various governance means and the construction of "resilient city". Moreover, the government's governance of public opinion and the improvement of its prevention and control capacity after an emergency play an important role in post-disaster construction. The study provides some suggestions for future response to public health emergencies and urban image reconstruction.

Keywords: system dynamics · resilient cities · governance means · image building

1 Introduction

The term "Resilience" comes from engineering and refers to the return of a material to its original shape after it has been deformed. In 1973, Holing, a Canadian ecologist, first applied the idea of resilience to ecology [1]. In the later stage, it was integrated into the social field and integrated with the urban development state, aiming to improve the ability of the city to repair itself after being traumatized. "Resilient city" is a hot topic in the process of urban development [2]. Urban development is bound to face a variety of challenges, among which emergency is one of the important factors that have an impact on urban construction [3]. It also refers to the ability of cities or urban systems to digest and absorb external disturbances while maintaining the original main features, structure and key functions [4]. Resilience construction aims to enhance the sustainable development of a city when it is subjected to external interference and ensure that its own development mechanism will not be damaged [5]. The enhancement of urban resilience is conducive to the rapid recovery and development of cities after emergencies [6]. The study of urban resilience plays an important role in the sustainable development and construction of cities [7].

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Scholars are deepening their research on "resilient city", and diversified evaluation models and improvement strategies for urban Resilience emerge one after another, such as the Resilience Baseline model (BRIC) and ARUP's City Resilience Framework proposed by ARUP Company and Rockefeller Foundation [8]. Zhang studied the relationship between urban economic development and resilience and the law of development process [9]. Cheng discussed the relationship between urban environmental conditions and resilience [10]. The attributes of toughness can be summarized as early warning, timeliness, stability and innovation [11]. The design of early warning and judgment mechanism is very important for the management department to start relevant plans in time and put forward feasible measures to control the situation after the city encounters emergencies [12]. Stability and innovation mean that cities have the ability to work steadily and orderly in the command level and execution level in the face of crisis, and actively innovate to seek for more development space while alleviating the severity of the situation [13]. The sudden outbreak during 2020 is a disaster for people all over the world. As the epidemic became more and more serious, the incident continued to ferment, and the epidemic spread around the world in the later period. Urban construction was challenged by the impact of the epidemic and the pressure of public opinion. It was more conducive to urban development to build a "resilient city".

2 Establish a Tree Model of the Flow Rate of the Image Construction of "Resilient City"

2.1 Determine the Flow Level and Flow Rate System

On the basis of studying the whole system and according to the principle of system dynamics, the factors influencing the image construction of "resilient city" are divided into resistance psychology, network public opinion, prevention and control measures, resilience building and urban characteristics. And the flow rate of five flow bit is designed as follows [where Li(t) (I = 1, 2… 5)] represents the flow bit variable, Rj(t) (j = 1, 2… 5) represents the flow rate variable).

Psychological resistance subsystem: L1(t), R1(t) psychological resistance and its changes.
Network public opinion subsystem: L2(t), R2(t) Network public opinion and its change quantity.
Prevention and control measures subsystem: L3(t), R3(t) prevention and control measures and their changes.
Ductile modeling subsystem: L4(t), R4(t) ductile modeling and its variation.
Urban characteristics subsystem: L5(t), R5(t) Urban characteristics and their changes.
Thus, the flow bit flow rate system of the whole system is obtained: {[L1(t), R1(t)], [L2(t), R2(t)], [L3(t), R3(t)], [L4(t), R4(t)], [L5(t), R5(t)]}.

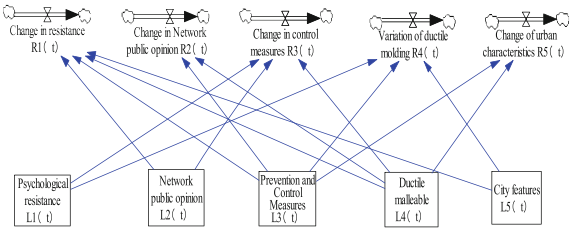

Fig. 1. Two-part diagram

2.2 Establishment of Two-Part Diagram and Establishment of Flow Rate Basic Entry Tree Model

On the basis of qualitative analysis of the internal relations between all flow potential and flow rate variables in the system, a two-part qualitative analysis diagram of flow rate control by flow potential variable is obtained according to the modeling idea of flow rate variable control by the system dynamics flow potential variable (Fig. 1).

- In this system, the network public opinion, the improvement of prevention and control measures, and the change of urban characteristics can all reduce the people's resistance to epidemic city. Therefore, resistance Mentality R1(t) is jointly controlled by network public opinion L2(t), prevention and control measures L3(t) and urban characteristics L5(t).
- In this system, the improvement of prevention and control measures and the resilience of the government can promote the increase of positive network public opinion. Positive network public opinion change R2(t) is jointly controlled by prevention and control measures L3(t) and resilience shaping L4(t).
- In this system, resistance psychology, network public opinion and resilience can all improve the change of prevention and control measures. Therefore, the change R3(t) of prevention and control measures is jointly controlled by resistance L1(t), network public opinion L2(t) and resilience shaping L4(t).
- In this system, resistance, prevention and control measures and increasing urban characteristics can all promote the building of urban resilience. Therefore, resilience building R4(t) is jointly controlled by psychological resistance L1(t), prevention and control measures L3(t) and urban characteristics L5(t).
- In this system, prevention and control measures and resilience building can promote the increase of urban characteristics. Therefore, urban characteristics R5(t) is jointly controlled by resilience shaping L4(t) and prevention and control measures L3(t).

2.3 Establish the Basic Flow Rate into the Tree Model

According to the basic tree modeling method of flow rate in system dynamics, the path of flow rate variable controlled by convective variable was analyzed with the aid of intermediate auxiliary variable, and the basic tree model of flow rate in each subsystem was obtained (Figs. 2, 3, 4, 5 and 6).

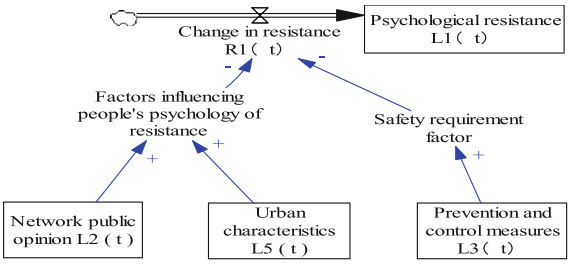

Fig. 2. Resistance psychological change flow rate R1(t) Basic entry tree model T1(t)

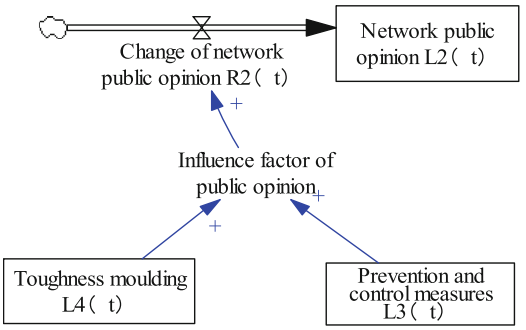

Fig. 3. Network public opinion change volume flow rate R2(t) Basic input tree model T2(t)

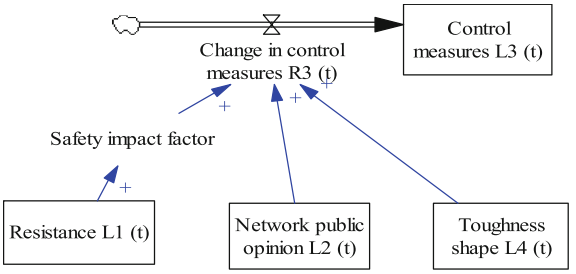

Fig. 4. Change in control measures flow rate R3(t) Basic tree-entry model T3(t)

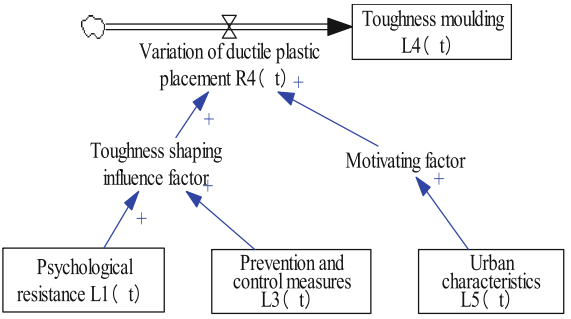

Fig. 5. Ductile molding Variation flow rate R4(t) Basic tree model T4(t)

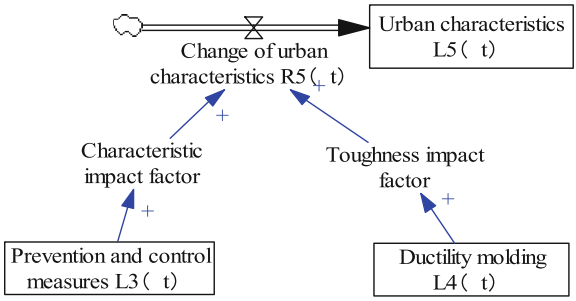

Fig. 6. Urban characteristic variation flow rate R5(t) Basic tree model T5(t)

3 Generation and Construction Countermeasures of Minimal Fundamental Mode Analysis

To analyze the image construction of "resilient city" after the epidemic, the minimal basic model of the system can be analyzed and studied, which can reflect the basic structure of the whole system. The internal relations of the system can be found by using minimal fundamental mode analysis, and the feasible construction measures can be obtained. The following is a classification study of minimal models.

3.1 Calculation and Analysis of Second Order Minimal Fundamental Mode

The first step is to find the minimum fundamental mode.

For each tree Ti(t), find the first minimal fundamental mode. T1(t), T2(t),… The tail of T5(t) does not contain L1(t), L2(t) corresponding to the basic tree, L5(t) flow bit, so there is no first-order minimum fundamental mode for self-embedding operation.

The second step is to find the second - order minimum fundamental mode.

- T1(t): T1(t) enters into the end of the tree, including L2(t) and L3(t) and L5(t). But T2(t) does not contain L1(t), T5(t) does not contain L1(t), and there is and only G13 = T1(t) → UT3(t), second-order minimal fundamental mode 1: G13 = T1(t) → UT2(t). The flow diagram structure of second-order minimal fundamental mode G13(t) is shown as in Fig. 7.

In the second order minimal fundamental mode G13(t), it is composed of two subsystems: resistance mentality and prevention and control measures. Citizens have a strong resistance to epidemic city, so the government is bound to step up efforts in prevention and control measures. Constantly improve, reduce the risk coefficient to the minimum, urban toughness enhanced, otherwise weak.

- T2(t): T3(t) into the end of the tree, including L3(t) and L4(t). While T4(t) does not include L2(t) in the end of the tree, T3(t) does not include L2(t) in the end of the tree, there is and only G23 = T2(t) → UT3(t), second-order minimal fundamental mode 2: G23 = T2(t) → UT3(t). The flow diagram structure of second-order minimal fundamental mode G23(t) is shown as Fig. 8.

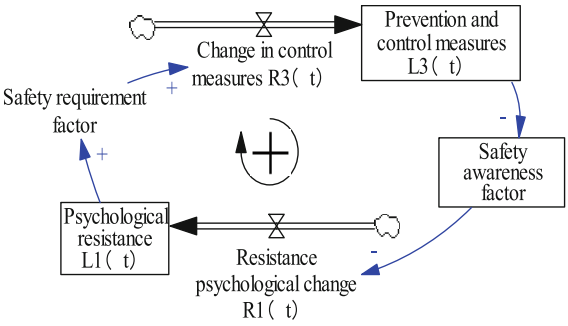

Fig. 7. Second order minimal fundamental mode G13(t)

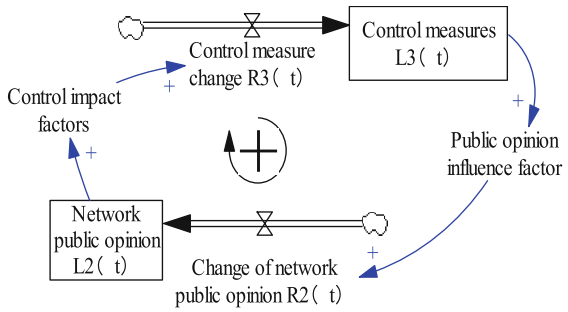

Fig. 8. Second order minimal fundamental mode G23(t)

In the second order minimal fundamental mode G23(t), it consists of two subsystems: network public opinion and prevention and control measures. When netizens express a lot of negative emotions about epidemic city and worry about the remaining risks, the government is bound to increase the number of prevention and control measures in response to netizens' concerns. Try to quell doubts.

- T3(t): T4(t) enters into the end of the tree, including L1(t), L2(t) and L3(t). While T1(t) and T2(t) enter the end of the tree without L3(t), T4(t) enter the end of the tree without L3(t), there are and only G34 = T3(t) → UT4(t), second-order minimal fundamental mode 3: G34 = T3(t) → UT4(t). The flow diagram structure of second-order minimal fundamental mode G34(t) is shown in the Fig. 9.

In the second order minimal fundamental mode G34(t), it consists of two subsystems, namely, ductility modeling and prevention and control measures. The continuous improvement of prevention and control measures represents the gradual recovery of urban construction and enhanced resilience, and vice versa.

- T4(t): T5(t) is included in the end of the tree, including L1(t), L3(t) and L5(t). While T1(t) and T3(t) enter the end of the tree without L5(t), T5(t) enter the end of the tree with L4(t), there are and only G45 = T4(t) → UT5(t), second-order minimum fundamental

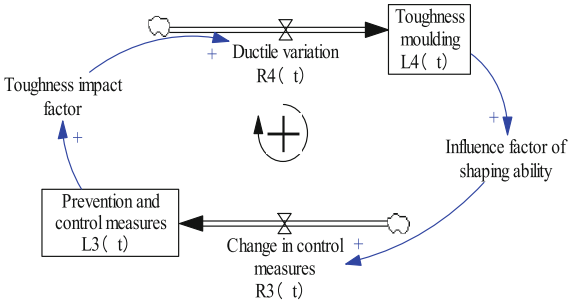

Fig. 9. Second order minimal fundamental mode G34(t)

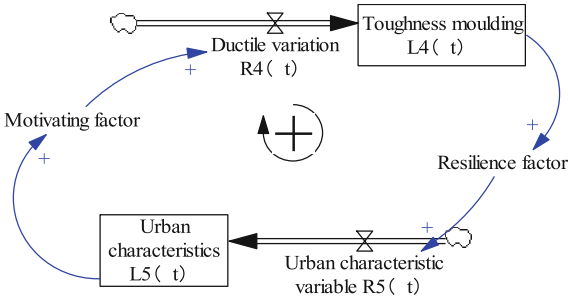

Fig. 10. Second order minimal fundamental mode G45(t)

mode 4: G45 = T4(t) → UT5(t). The flow diagram structure of second-order minimal fundamental mode G45(t) is shown as in Fig. 10.

In the second order minimal fundamental mode G45(t), it is composed of two subsystems, toughness shaping and urban characteristics. The increase of urban characteristics will drive the development of tourism and economic growth, which is more conducive to building resilience. The reverse is not good.

3.2 Calculation and Analysis of Third-Order Minimum Fundamental Mode

$$T1(t) \rightarrow UT3(t) \rightarrow UT5(t)$$

Analysis: The fundamental mode G135(t) constitutes a third-order positive and negative cycle of resistance, prevention and control measures, and changes in urban characteristics. People's strong resistance to the source city will lead to the increase of security demand factors, the amount of urban prevention and control measures will increase accordingly, and at the same time, it will also drive the increase of urban characteristic construction. Continuous improvement in all aspects of construction will reduce the resistance of the masses. The basic mode G135(t) vividly depicts the phenomenon that the three parties promote each other and constantly promote the common development

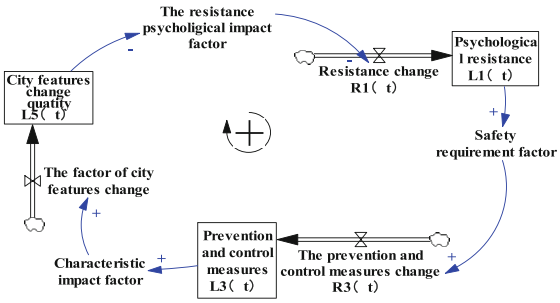

Fig. 11. Fundamental mode G135(t)

of the three parties, including the resistance mentality, prevention and control measures and changes of urban characteristics (Fig. 11).

3.3 System Flow Diagram

It constructs the related system flow diagram, which involves 14 variables. Among them, there are 1 state variable, 1 flow rate variable, 4 auxiliary variables and 8 constants.

Among them, public opinion is an important channel for residents to express their demands. From the analysis and treatment of public opinion, it can be clearly perceived that tourists have a serious resistance to the city of origin. In order to avoid the ferment of public opinion and restore the source of urban economic vitality as soon as possible, the responsibility of the government is to implement effective solutions as soon as possible. Tourists' resistance to the source city is getting stronger and stronger, which will affect the regional economic development more seriously. Public opinion includes positive energy public opinion and negative energy public opinion. Negative public opinion, on the one hand, will aggravate the residents' worries about life, health and safety, on the other hand, it will discourage tourists from other places and affect the economic recovery and development of the city. As a variable of flow rate in the model, the change of resistance psychology is affected by many factors.

Governance effect after a public health emergency official said government public opinion guide to drive the timeliness and spontaneous formation of public opinion to the public, the governance effect of policies formulated according to the development of the event and the actual situation to make adjustment and correction, to achieve the desired government governance effect, therefore, adjust the time as a constant. Resilient cities have their own demand for growth. Resilient cities tend to have more efficient government decision-making, and are better able to control the normal development of public opinion and stabilize the social order in the first place. Actively seek more space suitable for development in difficulties.

The city actively improves the degree of prevention and control measures in the process of confrontation, on the one hand, to fundamentally protect the physical and mental health of residents and tourists, on the other hand, the city itself has a stronger anti-virus system, which is conducive to the improvement of the level of medical prevention and control in the future. In addition, actively developing urban characteristics

and increasing featured projects to attract consumption are important means to restore economic vitality. Whether the specific role can be played depends on the operation of the project itself.

In this model, the original toughness value of the city is set as 100, and the simulation step size is 1.

3.4 Simulation Analysis

Set the simulation time as 100 weeks, and the simulation results are shown in Figs. 12, 13, 14, 15 and 16.

From the simulation results, it can be seen that the government actively takes effective measures to prevent and control the epidemic, improves the early warning mechanism, and protects the health of residents to the greatest extent, and the living environment is comfortable. At the same time, the government actively carries out urban construction, strengthens innovation while recovering economy, makes expectations and plans for the development of foreign cities, and strives to realize them, so that the effect of government governance is in a growing trend.

Various policies have made the prevention and control infrastructure more complete and residents' health guaranteed. In addition, the continuous development of urban characteristics and the continuous completion of some characteristic projects highlight

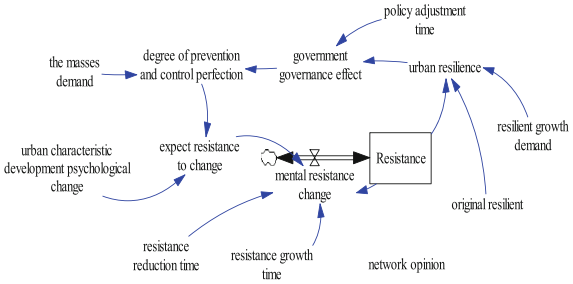

Fig. 12. System flow diagram

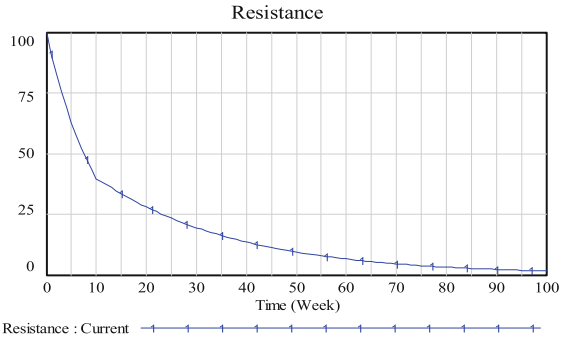

Fig. 13. Model giagram (a)

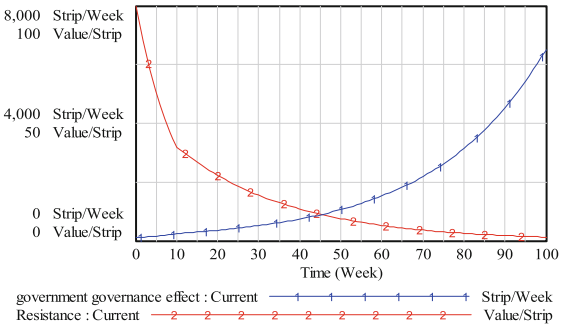

Fig. 14. Model giagram (b)

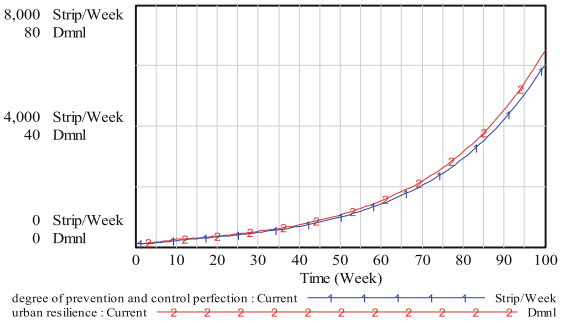

Fig. 15. Model giagram (c)

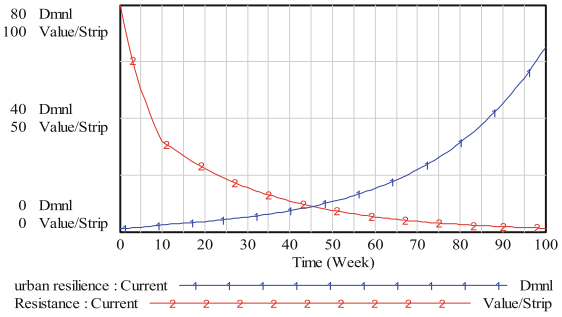

Fig. 16. Model giagram (d)

the city's ability to recover quickly after being impacted. Innovative projects are more attractive, and the resistance of tourists shows a state of decline. Cities that gradually recover their economic vitality steadily improve their resilience. In the first 10 weeks or so, the resistance showed a rapid decline, mainly because most of the tourists were full of confidence in the prevention and control ability of the government. Looking at the relevant official data released, we can conclude that the environment must be safe and stable under this circumstance from the analysis of the governance activities

implemented. In addition, tourists stay at home for a long time due to the epidemic, and characteristic buildings are better able to catch the consumer mentality, and the resistance mentality drops quickly in this stage. However, there were still tourists who continued to wait and see, and as time went on, they noticed more and more positive voices, and the resistance showed a steady decline after 10 weeks.

The level of urban resilience is jointly affected by various aspects. It can be seen from the figure that urban resilience increases with the decrease of resistance and the improvement of prevention and control measures, which is in the same growth trend as the improvement of urban prevention and control measures. Therefore, to build "resilient cities", the government needs to actively coordinate all aspects of work, not only to ensure the life, health and safety of the public and tourists, but also to find ways to enhance the power of tourists' consumption, restore the vitality of economic development, and ensure the market vitality and normal operation through innovation.

4 Construction Countermeasures

In order to deal with public emergencies, it is necessary to improve planning and deployment capacity to policy implementation. It can be seen from the positive and negative relationship of the schema that only by increasing the factors conducive to the construction of "resilient cities" and weakening the adverse factors can post-epidemic cities, which suffered the most after the emergency, be helped to build the image of "resilient cities" and improve the ability of sustainable development. The following recommendations are based on the above analysis:

- Establish a sound official discourse release system to guide the positive development of Internet public opinion from the perspective of the government. Through the network public opinion, establishes the whole view consciousness, strengthens the national unity. "crisis" to promote "understanding" and "unity".
- Ensure the life, health and safety of tourists, build prevention and control mechanism, restrict the flow of scenic spots, and make reservation in advance.
- The government will give more support to post-epidemic cities' business and tourism industries to promote the construction of innovative industries. Driving economic growth. We will increase the number of urban features and make cities more attractive.
- In the face of social resistance to products in the post-epidemic cities, an accurate product monitoring mechanism has been established to ensure that products can be sold after meeting the qualified standards, and the quality standards have been improved, even better than those in other cities.
- Actively promote the construction of "wildlife protection cities", cities that have experienced crises know more about the importance of wildlife protection. To build Wuhan into a positive city benchmark, to promote the idea of wildlife protection, will be more popular.
- A strict urban sanitation monitoring and disinfection mechanism has been established, and special departments have been set up to carry out accurate urban testing. We will establish special third-class medical institutions for the prevention and control of infectious diseases with Traditional Chinese medicine, and improve the long-term

mechanism for the treatment of infectious diseases by combining Traditional Chinese and western medicine.

Take Wuhan, the city of China as an example.

- After the outbreak was effectively controlled, in order to relieve the pressure of various industries, the Wuhan government opened a channel of rent reduction for Grade A office buildings to restore normal order. Reduce pressure on enterprises and help raise funds to resume work and production. For small and micro enterprises that want to enter the market, superior policy support and relief efforts are more conducive to enterprises to take the first step.
- After the resumption of work, a special property management service organization has been set up to control the flow of people in the corridor, regularly sterilize and sterilize, reserve epidemic prevention materials, and regularly and quantitatively distribute them. The most complete prevention and control arrangements should be made for the buildings with the highest density of residents to ensure the life, health and safety of residents in every smallest unit. For the construction industry, the future design will pay more attention to the smooth air link, intelligent prevention and control development that meets the needs of residents in terms of hardware facilities, such as intelligent access control, population density monitoring, real-time patrol, danger warning, etc.
- The Wuhan municipal government has handed over some of the industrial parks to enterprises to reduce the density of population, purify the air quality and promote the common development of the whole suburb. Software development should be enhanced and the online market should be more competitive. During the epidemic period, the profits of the e-commerce industry accounted for a large proportion of the overall profits of the city. In this situation, the government should continue to expand the competitiveness of competitive industries and drive the overall profits of the city.
- Make use of Wuhan University, East Lake, Hankou River Beach, Chuhe Han Street, Yellow Crane Tower and other iconic scenic spots to increase the popularity of tourism.
- For the unemployed during the epidemic period, Wuhan will relax the application period of unemployment insurance for qualified people, ensure the full amount of unemployment insurance payment, and strive to promote consumption and actively improve the vitality of market consumption. The government and the people in their daily efforts to revitalize the economy with concrete actions will be more conducive to the construction of “resilient cities” and better development.

5 Conclusion

After a public emergency, the steady growth of the city over the years has taken a toll and the image of the epidemic city has undergone a transformation from normal to profound, which straight to curved development process. From another perspective, building a “resilient cities” is more conducive to rapid recovery and sustainable development in the later period. The transformation from straight line to curve indicates that the development of a city will not change completely according to the expectation. It will encounter

fluctuations in the middle, but it will not stop, so as to accumulate experience and achieve better development. In the follow-up development and urban construction, the city pays attention to detail construction and link design.

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