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Prediction and Control of Construction Waste in Nanchong City based on System Dynamics

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Abstract

In order to effectively and dynamically predict the production of construction waste and achieve the goal of controlling and reducing construction waste, this paper analyzes the influencing factors of construction waste production based on System Dynamics (SD) theory, and creates an SD model with Nanchong City as an example , using the VENSIM software to conduct simulations to predict the production of construction waste in the duration. And the simulation analysis of the impact of five policies on the total amount of construction waste management and control, the results show that different policies have a certain inhibitory effect on the total amount of construction waste management and control. However, the strongest output control is to strengthen the green ecological development concept to guide the policy efforts, and to provide certain ideas for the management and control of construction waste.

Keywords

Construction Waste; System Dynamics; Predict and Control.

1. Introduction

As an important pillar industry in China, the construction industry plays a pivotal role in my country's national economic growth and social and economic development. With the rapid development of urbanization and industrialization in my country, many cities in China are undergoing spatial expansion. The demolition and reconstruction of old urban areas and the land development of new urban areas, and the continuous improvement of urbanization level, also generate a large amount of waste. According to the "2018 Annual Development Report of Construction Waste Disposal Industry", my country's construction waste has a large amount of storage, rapid growth, extensive treatment methods, and backward treatment methods, environment and affect city appearance[1]. Therefore, construction waste has become a major obstacle to the construction of ecological civilization and sustainable development of cities, and it is particularly important to predict and control the output of construction waste.

At present, the research on construction waste mainly focuses on production forecast, policy analysis, on-site control, and information management. Wang Guiqin[2] and others realized the prediction of construction waste output by creating a grey model. Zhang Hongyu[3] used the empirical coefficient method and the indirect prediction method to predict the amount of construction waste from different sources, and took Chaoyang District as an example to clarify the direction of construction waste management and control with the aid of the ARIMA model. Wang Yuguo[4] and others used scenario analysis method and nuclear density analysis to predict the output of construction waste and analyze the spatial and temporal characteristics, and provided the idea of the design of construction waste resource disposal scheme. Wang Ning[5] and others introduced BIM & GIS technology for real-time monitoring in the management and control of construction waste, so as to realize the information management and control of construction waste.

It can be seen from the above studies that most of the previous studies on construction waste discussed and proposed solutions for a single system or a single party, while there were fewer studies on dynamic prediction from the overall system analysis of influencing factors and feedback relationships. Therefore, based on the system dynamics model, this paper predicts the output of construction waste from the perspective of the overall system, and conducts simulation analysis according to different policies, and puts forward relevant suggestions for the management and control of construction waste.

2. System Dynamics Methods and Procedures

Considering that the production of construction waste is a dynamic process[6], this project plans to use the System Dynamics theory to analyze the factors affecting the production of construction waste, create a SD model of construction waste, and use the VENSIM software to analyze the factors affecting the production of construction waste. Simulation, to verify the validity of the SD model by comparing the predicted value with the actual value, to predict the construction waste production for the duration. As shown in Figure 1.

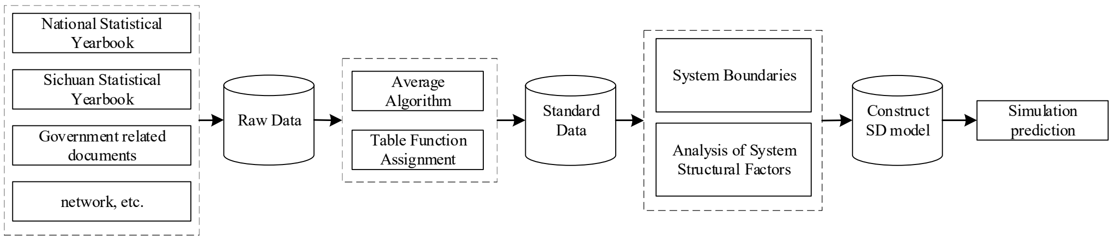

Figure 1. Flow chart of forecasting construction waste production based on system dynamics

2.1 System Boundaries

This paper establishes a system dynamics model for construction waste in Nanchong City. The time boundary of the model is set from 2010 to 2025, the base year is 2010, and the step size is set to 1 year. In 2010-2020, simulation and testing were carried out based on historical data to test the validity of the model. Construction waste production forecast for 2021-2025. The historical data comes from relevant materials such as "Sichuan Statistical Yearbook" and "National Statistical Yearbook". The parameter data comes from relevant literature and government policy documents. For the parameter data that cannot be obtained, the table function assignment method and the arithmetic mean method are used.

2.2 Subsystem Construction

By consulting relevant literature and fully combining the actual status of Nanchong City, the influencing factors affecting the output of construction waste are mainly concentrated in the discharge of construction waste itself, the economic status of Nanchong City, the population of Nanchong City, the ecological status of Nanchong City, and the policies of the Nanchong City government. 5 aspects. Therefore, this paper establishes five subsystems of construction waste, economy, population, ecology, and policy, and establishes the causal relationship diagram of each subsystem, as shown in Figure 2. There are 4 feedback loops in the figure, including 2 positive feedback loops and 2 negative feedback loops. Among them, the positive feedback loop means that the change of a variable in the loop will strengthen its original deviation trend under the influence of other variables. Negative feedback loop means that the change of a variable in the loop will weaken its original deviation trend under the influence of other variables. Economic and population data will affect the scale of buildings, thereby affecting the production of construction waste, and the production of construction waste will affect urban ecology and urban economy. Urban ecology and construction waste will affect urban population. In addition, construction waste The output is regulated through social policy.

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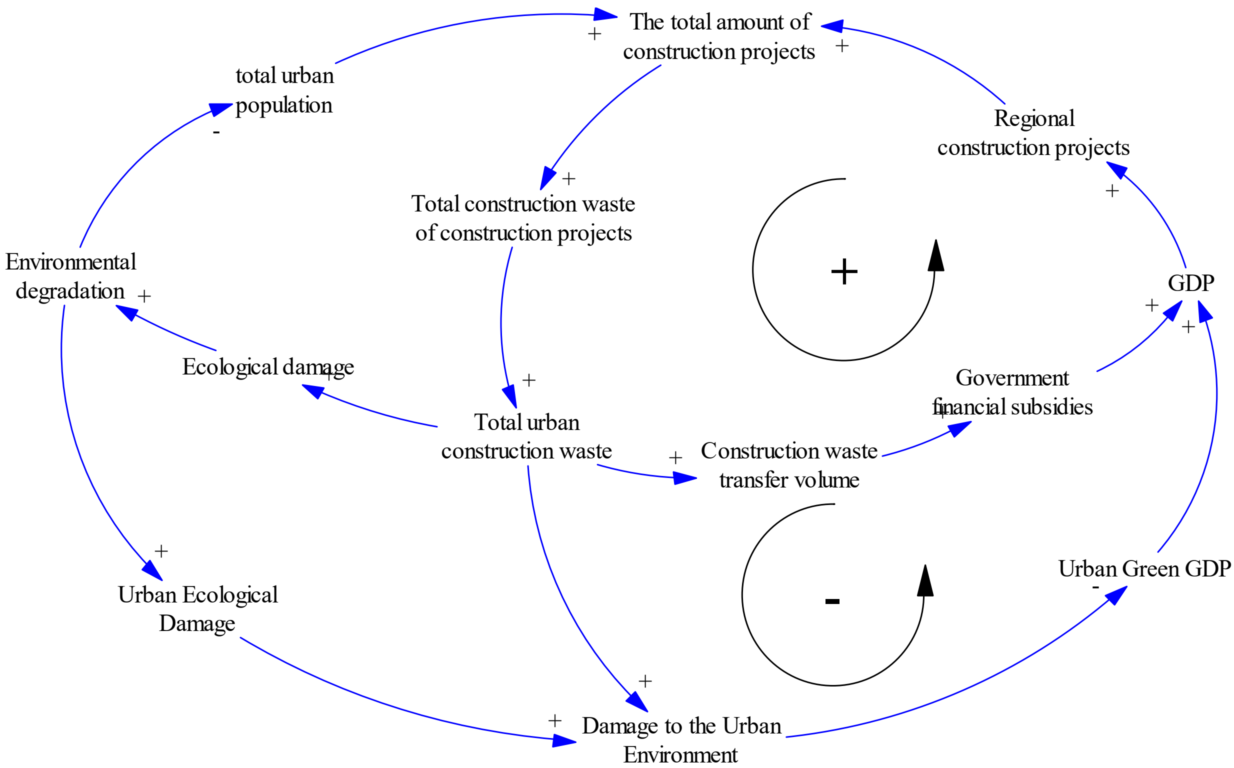

Figure 2. The causal cycle diagram of construction waste

2.2.1 Construction Waste Subsystem

The construction waste subsystem considers the factors affecting the output of construction waste from its own perspective. Therefore, this paper considers the whole life cycle of the construction project from the perspective, which mainly includes three aspects: First, the construction waste generated during the construction process, It is related to the total annual construction area of Nanchong City. The second is the construction waste generated in the decoration process, which is related to the total area of Nanchong City's annual decoration. The third is the construction waste generated during the demolition process, which is also related to the total demolition area in Nanchong City every year. Therefore, this paper needs to check the relevant literature and policy opinions to determine the key indicators such as the waste production coefficient of new construction, the waste production coefficient of decoration area, and the waste production coefficient of demolition.

2.2.2 Economic Subsystem

In the economic subsystem, there are few variables that exist alone in the system, only green GDP. It is related to the gross domestic product of the region, the higher the GDP, the higher the gross regional product, the increase in the total amount of construction projects, and the increase in the output of construction waste.

2.2.3 Population Subsystem

The amount of population will affect the production of construction waste, therefore, this paper also includes the population into the factors affecting the production of construction waste. In the population subsystem, this paper considers that the total population consists of resident population and floating population. Among them, permanent population = INTEG (change in permanent population, 628.5), of which 628.5 is the number of permanent residents in Nanchong in 2011. The floating population is determined by the rate of change of the floating population. In the population subsystem, the greater the population, the more likely the production of construction waste.

2.2.4 Ecosystem

The ecological subsystem mainly considers the impact of construction waste production on the ecology and the environment. Therefore, the ecological subsystem mainly considers the damage of

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construction waste to the air, water and soil quality. The greater the output of construction waste, the greater the damage to the ecology and the greater the environmental loss, so that people are less likely to choose this area when choosing a living environment and employment, resulting in a decrease in the total population of the area, which in turn come to affect the generation of waste.

2.2.5 Social Subsystem

In the social subsystem, the landfill loss of construction waste and the cost of waste removal and transportation are mainly considered. The greater the landfill loss of construction waste, the reduction of land resources available to the government, thereby affecting the government's land income in the region and reducing the region's GDP. However, the increase in construction waste production and the increase in government clearance fees for waste will also affect the region's GDP.

Through the above description of each subsystem, and the establishment of relevant parameter variables for each subsystem, the flow stock map is obtained. As shown in Figure 3.

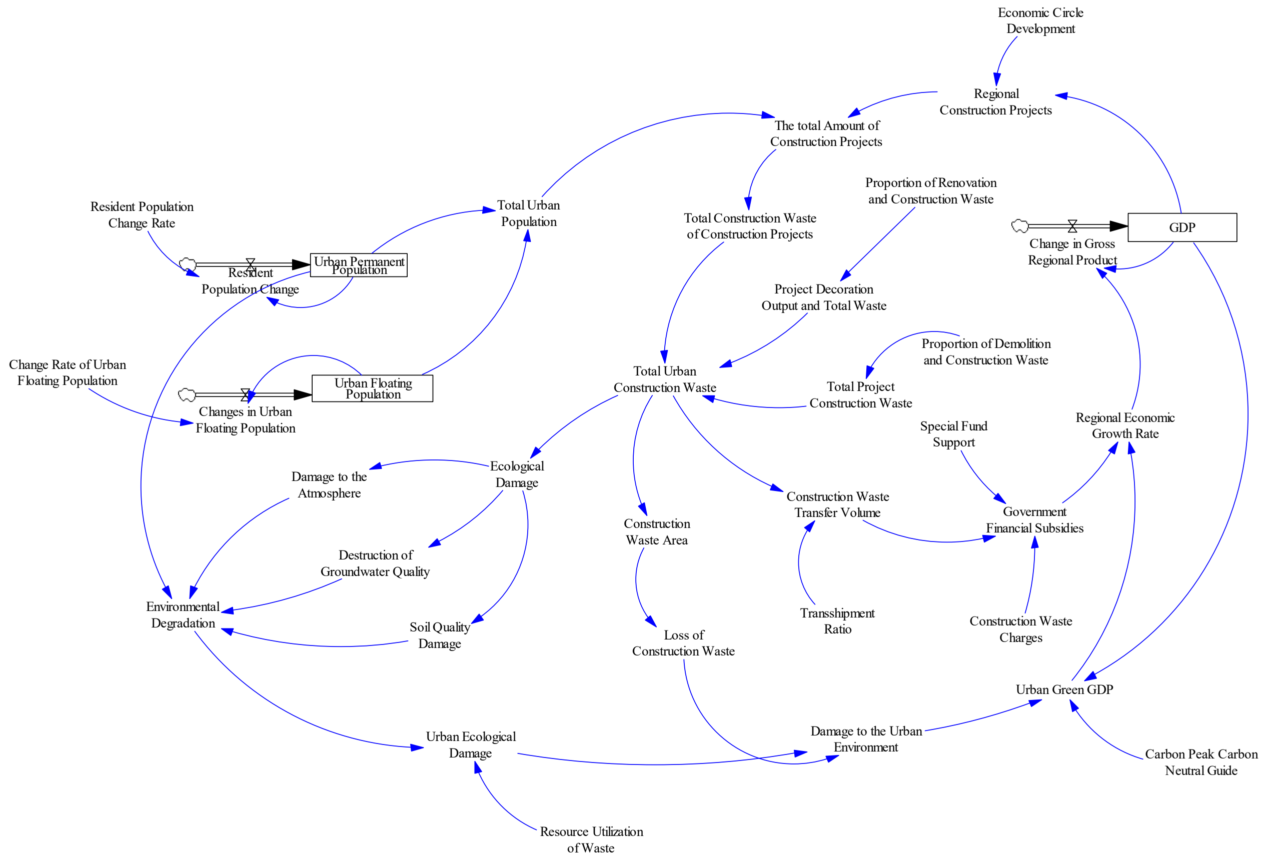

Figure 3. Flow and stock map of construction waste in Nanchong City

2.3 System Validity Check

After the system dynamics model is established, it is necessary to test its validity to judge whether the model can more accurately reflect the reality of the research object. This paper uses the historical test method to test the validity of the model. The historical data of Nanchong City from 2011 to 2020 is brought into the model, and the regional GDP is used as the test variable to test the validity of the model, as shown in the table. According to the table, it can be found that the relative error of the system does not exceed 5%, which is within the allowable range of error. It shows that the simulation results of the model are reliable, can better reflect the real situation of the system, and can be used for subsequent simulations.

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Table 1. 2011-2020 regional GDP real value and simulation value comparison

Years	Actual Value	Analog Value	Error Rate
2011	981.48	982.61	0.12%
2012	1083.02	1092.34	0.86%
2013	1283.71	1292.16	0.66%
2014	1391.7	1432.22	2.91%
2015	1463.4	1487.80	1.67%
2016	1592.97	1595.75	0.17%
2017	1838.25	1922.42	4.58%
2018	2115.73	2119.91	0.20%
2019	2322.22	2411.22	3.83%
2020	2401.08	2514.35	4.72%

3. Construction Waste Policy Simulation and Control

3.1 Policy Simulation Scenario Analysis

At present, construction waste in Nanchong City mainly comes from construction waste, while less construction waste is generated in the decoration and demolition stages. At present, Nanchong City is in a critical historical stage of accelerating the process of urbanization. The expansion of the new city generates a huge amount of construction waste every year. Most of the construction waste is simply landfilled without any treatment, which not only wastes land resources, but also wastes reusable construction waste, which has a certain negative impact on the ecological environment. Therefore, this paper lists the impact scenarios of policies on the output of construction waste, and achieves the goal of controlling construction waste by simulating and analyzing the impact scenarios of construction waste production. The scenarios are shown in Table 2.

Table 2. Simulation scheme of construction waste policy in Nanchong

Serial Number	Scheme Name	Program Features	Model Tuning
Current	original scenario	he various factors in the system are developing according to the current situation	The original data of the system remains unchanged
Scenario 1	Strengthen fiscal policy	Special fund to support improvement	The corresponding policy indices in the model are increased by 20% each
Scenario 2	Strengthen tax policy	Construction waste charges increase	
Scenario 3	Strengthen technology policy	Enhanced utilization of waste resources	
Scenario 4	Strengthening demand guidance policies	Carbon peak carbon neutrality boost	
Scenario 5	Strengthen the green ecological development concept to guide the policy efforts	Economic circle improvement	

3.2 Comparative Analysis of Policy Effects

Different policy scenarios are simulated by VENSIM software, and the following results are obtained. The results are shown in Figure 4. When various policies are strengthened, the corresponding construction waste output changes. It can be found that the strengthening of various policies has a certain inhibitory effect on the output of construction waste, which also reflects the current construction waste in Nanchong City. There is still a lot of room for improvement in the control of things. At the same time, in order to further examine and compare the control of construction waste production under different policy scenarios, the above five types of policies are compared with the original scenarios. Curves 1-6 correspond to the original scenario, scenario 5, scenario 4, scenario 3, scenario 2 and scenario 1.

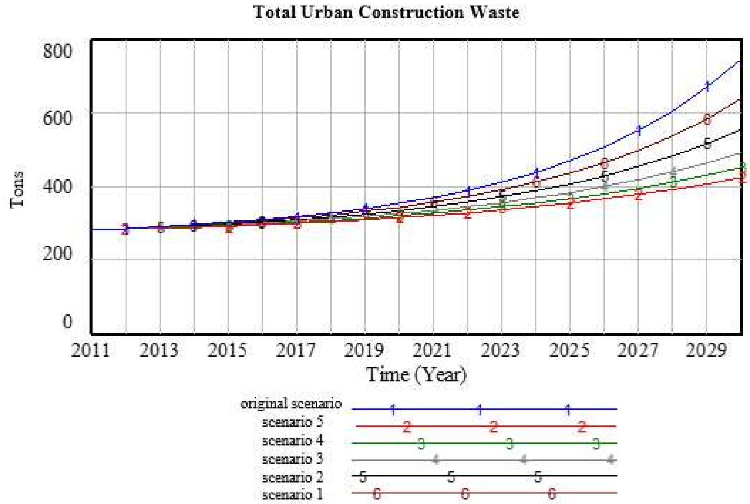

Figure 4. Comparison of the total amount of construction waste under different political scenarios

It can be seen from Figure 4 that the fiscal policy that strengthens the support of special funds has a weaker control on the output of construction waste. The main reason is that although the government has launched corresponding special funds to conduct research on the resource utilization and total amount control of construction waste, However, most of the research is in the theoretical stage, and less of the results are transformed and applied in practice.

Strengthening the concept of green ecological development and guiding policies has the strongest control over the output of construction waste. The main reason for this analysis is that it is difficult to pay more attention to the total amount of construction waste due to people's insufficient awareness of environmental protection. At this time, the government took the lead in launching the guiding policy to strengthen the concept of green ecological development, and it is of great significance to reduce the discharge of construction waste and control the total amount of construction waste. Therefore, Nanchong City has been built by the government into the "Second City of Chengdu and Chongqing", and will be divided into the "Chengdu-Chongqing Economic Circle" in 2021. With the strong support of the Sichuan Provincial Government and the Nanchong Municipal Government, the ecological environment will be strengthened Environmental awareness, reducing the total discharge of building waste.

In addition to the above-mentioned policies, strengthening the strength of demand guidance policy, strengthening the strength of technology policy, and strengthening the strength of tax policy also have a certain promoting effect, but through the simulation results, it is found that their promoting effect is relatively small. The main reasons are: there is a certain gap between the interest rate of construction waste recycling and the ideal effect, the slogan of carbon peaking and carbon neutrality has been put forward for a short time, and its effect is still in the initial stage. The amount involves multiple government departments, and the communication cost in the implementation process is relatively high.

4. Conclusion and Suggestion

This paper simulates and predicts the total output of construction waste in Nanchong City, and analyzes the impact of different policy scenarios and changes in implementation on the total output of construction waste in Nanchong City by setting up different policy scenarios. The research results show that different policies have a certain inhibitory effect on the total output of construction waste, and have a positive promotion effect on the resource utilization of construction waste. Among them, strengthening the green ecological development concept to guide the policy to control the output of construction waste is the strongest, in contrast, the effect of fiscal and taxation policies is relatively weak.

Based on the above conclusions, this paper puts forward the following suggestions on the management and control of construction waste in Nanchong City, in order to further improve the social and economic benefits of construction waste in resource utilization.

(1) Implement multiple policies to speed up the control of construction waste production

From the above analysis, it can be seen that different policies have a certain inhibitory effect on the output of construction waste, and have a certain promotion effect on the resource utilization of construction waste. A single policy guidance may not achieve "1+1>2". Only by implementing multiple policies and promoting each other can comprehensively control the total output of construction waste in Nanchong City.

(2) Innovative inter-departmental coordination and linkage

Through the above analysis, it can be found that during the implementation of some policies, due to the lack of corresponding implementation rules, the time cost of negotiating and communicating with relevant departments is high, and the implementation is difficult. In this regard, relevant departments can innovate administrative approval and work procedures according to the actual situation, improve data sharing between departments, unblock information channels, improve the efficiency of response and processing of related matters, and effectively solve the problem of difficult policy implementation due to communication costs.

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