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Simulation Analysis of Xi'an Eco-City Construction

Ding Fan

Northwest University of Political Science and Law, Xi'an, 710122, China

Abstract: *Based on reviewing the theoretical research and construction practice of eco-city, this paper analyzes the system constituent elements from five subsystems, including economic subsystem, social subsystem, population subsystem, resource subsystem and environmental subsystem. The SD model of Xi 'an urban ecosystem was established by system dynamics method, the six main variables selected are as follows: GDP, per capita water resources, energy consumption per 10000 yuan of GDP, per capita public green area, number of doctors per 10000 people and GDPSO_2 emissions per ten thousand yuan, different simulation results under different strategies are analyzed. According to the simulation data of ten leading indicators of eco-city construction, the paper calculates the measurement of Xi'an eco-city construction level. It puts forward specific suggestions from economy, resources, environment and security of eco-city construction.*

Keywords: *Xi'an, Eco-city, Simulation analysis*

1. Introduction

1.1. Relevant theoretical research

Eco-city can be called a scientific urban development model in modern society, and its ideological roots are far-reaching [1]. The "Utopia" conceived by Plato, the ancient Greek philosopher, the "ideal city" proposed by Vitruvius, the ancient Roman architect, the simple ecological thought of "the unity of heaven and man" in ancient China, and the "Utopia" described by Moore in England in the 16th century. In 1898, Edward Howard expounded the "garden city theory". In 1971, the word "eco-city" formally appeared in the Research Report of the man and biosphere program of UNESCO. The eco-city theory developed in the 1980s believes that there is an ecological limit in urban development. Since the 1980s, Chinese scholars have begun to study the theory of eco-city.

1.2. Practice of eco-city construction

Since the concept of eco-city was put forward in the 1970s, the exploration of eco-city construction in the world has never stopped. The United States, Brazil, Australia, Germany, New Zealand, Japan, Singapore, South Africa, Denmark, Sweden, Britain, Argentina and other countries have successfully carried out the practice of eco-city construction. The construction types of eco-city include priority planning and regulation, beautifying the environment, pollution first and then treatment, resource recycling, and function transformation. Currently, China has become a country in the world with large-scale eco-city construction led by the government, 80% of cities at or above the prefecture level have put forward the slogan of building ecological cities.

1.3. Xi'an eco-city construction

In 2021, the regional GDP of Xi'an reached 1068.828 billion yuan [2], and the permanent resident population of Xi'an (including Xi'an-Xianyang Co, Ltd.) will be 13.163 million. The area of arable land is 1419.87 Square kilometers, the total production capacity of public water supply is 2.9 million cubic meters per day, the total energy consumption of industries above the designated scale is 5.8477 million tons of standard coal, and the total social electricity consumption is 48.937 billion kWh. The sewage treatment rate reached 96.86%, the forest coverage rate of the whole city reached 48.03%, and the green coverage rate of the built-up area reached 39.57%. In 2021, the income of urban and rural residents will reach 46931 yuan and 17389 yuan, and the per capita consumption expenditure of urban and rural residents will reach 28810 yuan and 14521 yuan. The number of people participating in medical insurance in the city is 10.941 million.

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2. SD Simulation Analysis of Xi'an eco-city construction

2.1. Analysis of Xi'an eco-city construction system

As the eco-city is a complex artificial composite system, its development is determined by its internal subsystems and corresponding components. The study of the construction of Xi'an ecological city, that is, the research on its inter subsystem interaction and coordinated development. According to the interaction relationship of its internal elements, the urban ecosystem is divided into five subsystems [3], namely, the economic subsystem, social subsystem, population subsystem, resource subsystem and environmental subsystem.

2.1.1. Economic subsystem

Economic subsystem is the core of eco-city development and the driving force of social development. Without economic growth, there can be no social development. The main measuring elements of the economic subsystem include economic system, economic scale and economic benefits. The economic structure plays a crucial role in economic development. Adjusting the economic structure mainly means changing the proportion of the three major industries and the consumption structure. Only a reasonable design can lead the economy develop steadily and rapidly. The size of the economy is generally reflected by indicators such as GDP and monetary funds. Indexes such as fixed asset investment and per capita GDP generally reflect economic benefits.

2.1.2. Social subsystem

Social subsystem is an indispensable part of eco-city. Mainly measured through three aspects, including people's quality of life, social development level and social security. Quality of life is generally reflected by people's income. Essential indicators are the per capita disposable income of farmers, and the per capita disposable income of urban residents. The level of social development can be reflected in the aspects of culture and education, employment, medical and health conditions. Fiscal expenditure and social security rate reflect social security.

2.1.3. Population subsystem

Population subsystem is the critical factor affecting the development of eco-city, and is an essential component of eco-city system. The main measuring factors include people quality, population scale and population structure. The population quality is generally reflected by the proportion of people with college education or above and the number of people with higher education. Population size generally refers to the population, including urban population and rural population. Population structure refers to the proportion of men and women in the population and the composition of age.

2.1.4. Resource subsystem

The resource subsystem is a branch of the natural subsystem and the fundamental part of the ecosystem. Its main measuring factors mainly include resource supply capacity and resource utilization level. Usually speaking, the resource supply capacity is to provide energy and material basis for economic development and people's life, generally including the supply of water resources and the storage of land resources. The level of resource utilization is generally reflected by the water consumption per 10000 yuan of GDP.

2.1.5. Environment subsystem

The environmental subsystem is the key construction system of the ecosystem. The premise of realizing the construction of ecological cities is to achieve environmental ecology. Its measuring factors mainly include environmental quality, environmental pollution and environmental protection. Environmental quality and pollution degree are generally reflected by air pollution index, sulfur dioxide emission, chemical oxygen demand (COD) concentration and other indicators. Environmental protection needs scientific and technological innovation and investment in environmental protection funds, which are generally reflected by urban green area and forest coverage.

2.2. SD model of Xi'an eco-city construction

According to the causality diagram of system elements, the system flow diagram of Xi'an urban ecosystem is drawn with system dynamics (SD) simulation software Stella [4] [5]. After adding the quantitative relationship between variables, the system SD model is obtained, as shown in Figure 1.

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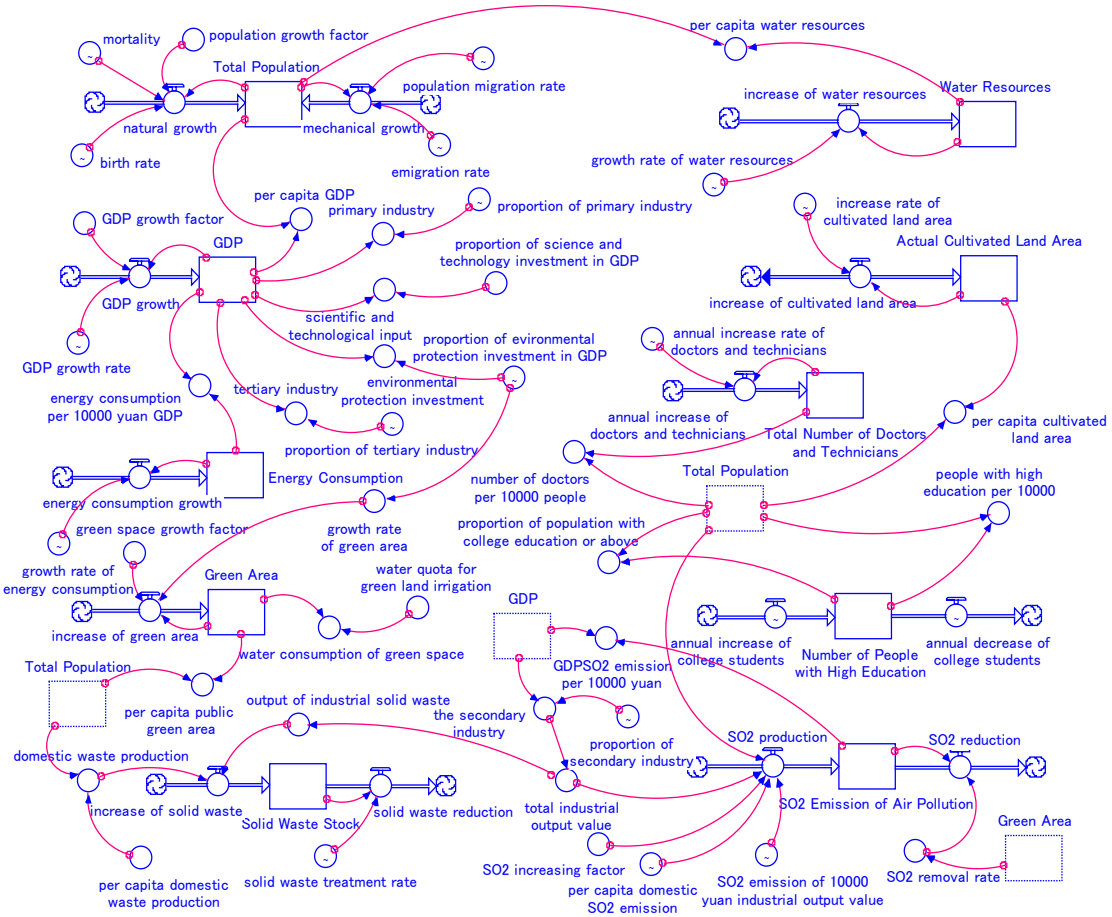

Figure 1: SD model of Xi'an urban ecosystem

The relevant parameters in the model are directly obtained according to statistical data and relevant documents [6] [7] [8], or obtained by econometrics and grey prediction model.

2.3. SD model simulation analysis

Because of the connotation of urban ecosystem and the degree of impact on development goals, this study mainly selects six main variables: GDP, per capita water resources, energy consumption per 10000 yuan of GDP, per capita public green area, number of doctors per 10000 people, and GDPSO2 emission per 10000 yuan to analyze the simulation results under different strategies. GDP, per capita water resources and energy consumption of 10000 yuan GDP are shown in Figure 2. The per capita public green area, the number of doctors per 10000 people and the emission of 10000 yuan GDPSO2 are shown in Figure 3.

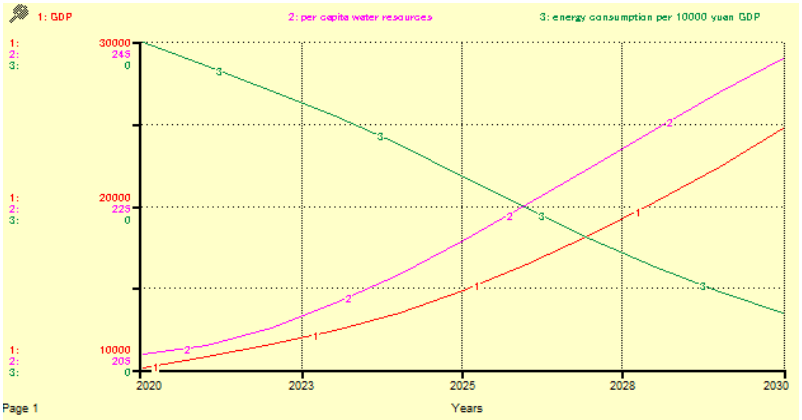

Figure 2: Simulation diagram of GDP, per capita water resources and energy consumption of 10000 yuan GDP

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Figure 3: Simulation diagram of per capita public green area, number of doctors per 10000 people and GDPSO2 emission per 10000 yuan

The above two charts show the development trend of the six major variables. GDP, per capita water resources, per capita public green area, and the number of doctors per 10000 people have all increased to varying degrees. The energy consumption per 10000 yuan of GDP continues to decline, and the emission of 10000 yuan of GDPSO_2 will rise to the peak in 2021 and then decline year by year. By 2030, the GDP will be 2472.408 billion yuan, the per capita water resources will be 243.02 cubic meters, the per capita public green area will be 40.29 square meters, the number of doctors per 10000 people will be 153, the energy consumption per 10000 yuan GDP will be 0.13 tons, the GDPSO2 emission per 10000 yuan will be 0.10 tons.

Through the disturbance analysis of variables, the research results of the influence of relevant variables are as follows: changing the population growth factor, the per capita water resources, per capita water resources and per capita public green area will decrease with the population growth; If the GDP growth factor is changed, the SO2 emission of air pollution, energy consumption per 10000 yuan of GDP and solid waste emission will increase with the increase of GDP. Figure 4 shows the increase of solid waste emission with the increase of GDP. Among them, curve 1 is the solid waste emission before the change of GDP growth factor, and curve 2 is the solid waste emission after the increase of GDP growth factor.

Figure 4: GDP growth and solid waste emission growth

If the increase factor of SO2 is changed, the emission of air pollution SO2 will increase significantly. If the green space growth factor is changed, the per capita public green space area will increase with the increase of green space, while the air pollution SO2 emission will change in the opposite direction, as shown in Figure 5. In particular, curve 1 is the SO2 emission of air pollution before the change of green area growth factor, and curve 2 is the SO2 emission of air pollution after the increase of green area growth factor. To sum up, a conclusion can be drawn, to improve urban air quality, we need to take a multi-pronged approach and work together. In addition to doing an excellent job in pollution reduction and emission reduction in industry and daily life, we should continue to attach great importance to urban greening.

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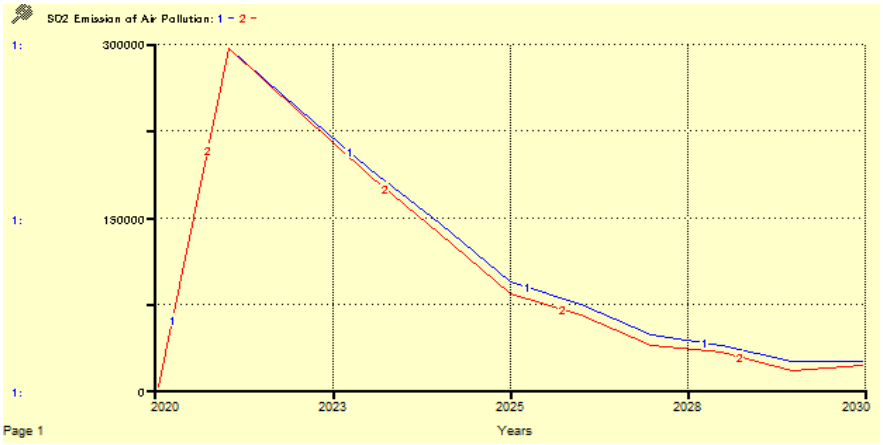

Figure 5: Impact of increasing green space on SO2 emission of air pollution.

Table 1 shows the simulation data of ten main indicators related to eco-city construction. The ten indicators are normalized [9] and added according to the equal weight to obtain the measurement of Xi'an eco-city construction level from 2020 to 2030, as shown in Figure 6. It can be seen that after eight years of hard work, Xi'an's eco-city construction level will be greatly improved and reach the urban construction level of moderately developed countries as a whole.

Table 1: Simulation data of ten main variables

Age	per capita GDP (Ten thousand yuan / person)	Energy consumption per unit of GDP (ton of standard coal / ten thousand yuan)	The proportion of the tertiary industry in GDP (%)	Ten thousand people have a number of teachers and students (People / ten thousand people)	Ten thousand people with higher education number (People / ten thousand people)	Per capita water resources (m^2/ person)	Per capita arable land area (km^2/ person)	Per capita green space area (m^2/ person)	Industrial solid waste treatment rate (%)	proportion of environmental protection costs to GDP (%)
2020	7.74	0.30	0.63	90.83	3099.90	206.75	0.01	27.82	0.85	0.01
2021	8.18	0.29	0.63	94.16	3151.05	207.89	0.01	27.99	0.87	0.02
2022	8.67	0.27	0.63	97.67	3193.94	209.98	0.01	28.68	0.88	0.03
2023	9.20	0.25	0.63	101.35	3228.85	213.02	0.01	29.92	0.89	0.03
2024	9.89	0.24	0.64	105.66	3261.36	216.61	0.01	31.19	0.89	0.03
2025	10.78	0.22	0.64	110.66	3291.55	220.75	0.01	32.50	0.90	0.03
2026	11.78	0.20	0.65	116.82	3318.22	225.13	0.01	33.89	0.91	0.03
2027	12.93	0.18	0.66	124.30	3341.42	229.75	0.01	35.37	0.92	0.03
2028	14.17	0.16	0.67	132.78	3364.14	234.32	0.01	36.93	0.93	0.03
2029	15.51	0.15	0.68	142.42	3386.34	238.83	0.01	38.58	0.96	0.03
2030	16.92	0.13	0.70	152.90	3409.89	243.02	0.01	40.29	0.98	0.03

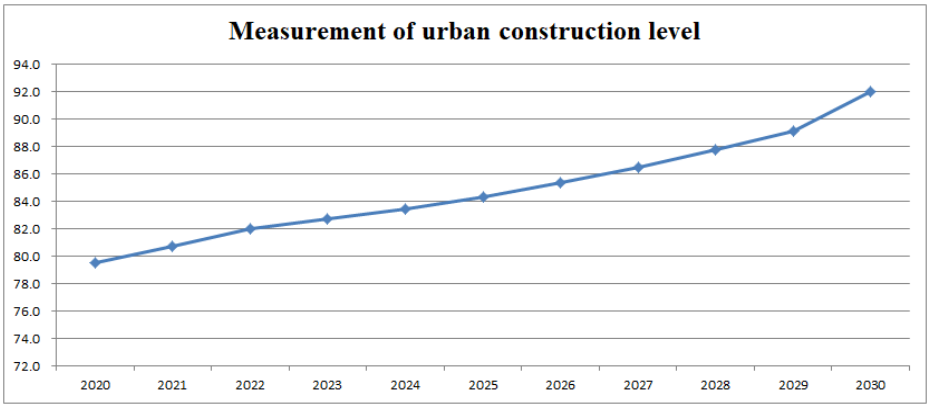

Figure 6: Measurement of Xi'an eco-city construction level

3. Suggestions for simulation analysis

Through simulation analysis, only by scientifically handling the dialectical relationship between population, resources, environment and society and economy can we realize the benign operation of

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nature, ecology, economy and society. Combined with the results of simulation analysis and the actual situation of Xi'an, the following suggestions are put forward [10].

3.1. Economic of eco-city construction

From the simulation analysis, the proportion of industrial structure plays an important role in Xi'an eco-city construction. Therefore, it is necessary to adjust the industrial structure of the whole city and strictly supervise industrial enterprises to realize cleaner production. Develop ecological, green, leisure and sightseeing agriculture, develop and cultivate modern urban ecological service agriculture, facility agriculture and seed source agriculture, and develop into specialization and diversification. Develop eco-tourism, ecological logistics and modern service industries, and actively cultivate environmental protection industries; Develop a low-carbon economic model with low energy consumption, low pollution and low emissions.

3.2. Resources and environment of eco-city construction

Strictly control the discharge of industrial pollutants and strengthen the control of agricultural pollution sources, we will strengthen the management of rivers and lakes, strengthen the connectivity of water systems, and gradually restore the water ecology of rivers and lakes. It is necessary to further improve the land management system and intensify the clearance and disposal of idle land. Strengthen soil pollution control, especially from the source of prevention and control of new soil pollution. Optimize the energy structure, promote clean energy, and strictly control the emission of sulfur dioxide, nitrogen oxides and other pollutants. Urban parks will be built in the center of the city, and the formation of points, lines, surfaces combined with road greening, two points combined to form a three-dimensional urban greening system.

3.3. Supportability of eco-city construction

Improve the systems, laws and regulations on environmental protection to provide legal protection for the construction of ecological cities. We will implement the leadership responsibility system for eco-city construction, and assign specific tasks and responsibilities to individuals. We will improve the expert demonstration system, the social hearing system, and the social publicity system to ensure that decisions are scientific. We will increase the investment of government, industrial and commercial enterprises, bank credit and foreign capital, increase the proportion of scientific and technological investment, and use advanced technology to improve the ecological environment. From urban planning to planning implementation and improvement of environmental protection laws and regulations, we need to listen to the public's opinions and mobilize the public's enthusiasm to participate in the construction of ecological cities.

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