

Evaluation of Urban Human Settlement Environment in Corps Based on the Entropy Method -- A Case Study of Tumushuke City

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Abstract. Human settlement environment has become a new proposition in China's urban development research. Accurate identification and evaluation of the human settlement environment is an important link to stimulating urban vitality, promoting urban construction, and formulating more effective development strategies. In this paper, Tumushuke City is selected as the research object, aiming at the current situation of local human settlements, and 22 indicators are selected from four aspects: ecological environment, economic environment, infrastructure, and social environment, such as the green coverage rate of built-up areas, the number of parks, the per capita green area of parks, the harmless treatment rate of domestic garbage, the total output value above designated size, etc. By using the entropy method, the evaluation scores of various indicators of human settlements in Tumushuke City are obtained. Finally, through the analysis of the evaluation results, corresponding optimization strategies and suggestions are proposed for the indicators with low evaluation values, which provide directions for the construction of the human settlement environment in Tumushuke City.

Keywords: Tumushuke City; Human settlement environment; Evaluation system; Entropy method.

1. Introduction

Academician Wu Liangyong put forward "the science of human settlement environment" for the first time and proposed that the human settlement environment is a complex system composed of five systems: nature, human beings, society, residence, and support. Through sorting out the research results of human settlements, it is found that in the research of human settlements evaluation, scholars at home and abroad evaluated and analyzed human settlements in different cities from various perspectives. For instance, after selecting topography, climate, hydrology, and land cover index and focusing on the basic ecological environment and ecological problems in the study area, Cheng Shujie^[1] et al. constructed the ecological adaptability evaluation index system of arid human settlements in central Ningxia from the perspective of ecological factors. Li Xueming^[2] et al. have comprehensively considered the connotation of sustainable development and the content of the urban human settlement environment and constructed the index system of sustainable development of Dalian's human settlement environment from the level of urban living, urban building, and urban development. Xiong Wei and Xu Yilun^[3] set up the evaluation index system of Nanjing's human settlement environment suitability from two basic factor layers: the basic life circle of people's lives and the urban life circle, taking the public facilities that have a major impact on the urban human settlements as the evaluation factors. Focusing on residents' real-life needs and based on Maslow's hierarchy of needs theory, Bao Jie, Zhang Yu, etc.^[1,2] fully considered the phases and levels of human settlements, and built an evaluation system of urban human settlements quality from four dimensions: basic living needs, public security needs, social communication, and belonging, and self-realization. On the basis of existing research, the present study takes Tumushuke City as the research object and constructs the evaluation index system of the human settlement environment from four aspects: infrastructure, ecological environment, economic environment, and social environment. By calculating the weight of each index by the entropy method, this paper analyzes the construction of human settlements in Tumushuke City, in order to provide direction for the construction of the human settlement environment in Tumushuke City.

2. Overview of the research area

Tumushuke City, with an administrative area of 3,664 square kilometers, is located in the center of Kashgar, Aksu, Kechu, and Hotan, bordered by five Central Asian countries and five national open ports. It is China's opening frontier to Central Asia, West Asia, and South Asia, as well as an important city along the new Asia-Europe continental bridge along the international corridor "China, Kyrgyzstan and Urumqi Railway", which is under construction in Kashgar.

3. System construction and evaluation method

3.1 Collection of raw data

The objective data used in this paper were obtained from standardized statistical data sources, including the China City Statistical Yearbook (2015-2020), Xinjiang Statistical Yearbook (2015-2020), Tumushuke City Production Yearbook of the Third Division of the Xinjiang Production and Construction Corps, Tumushuke City 2020 National Economic and Social Development Statistical Bulletin and the official website of Tumushuke City Government: consisting of the Report on the Work of the Government, the Statistical Information on Economic and Social Development and the Text of the General Urban Land Use Plan of Tumushuke City (2012-2020).

3.2 Construction of evaluation system

Based on the evaluation index system established by previous studies, the objective evaluation index system of the human settlement environment was constructed according to the principles of evaluation index selection, combined with the current situation characteristics of the human settlement environment in Tumushuke City. The objective index system was divided into four levels, namely, four primary indicators of infrastructure, economic environment, social environment, and ecological environment, including a total of 22 secondary indicators (as shown in Table 1).

4. Evaluation methodology

Using the entropy weight method to evaluate is to comprehensively consider the information provided by various factors in the evaluation, determine the weight according to the information entropy reflected by each evaluation index, and obtain a comprehensive evaluation index through corresponding calculation, so as to objectively and comprehensively evaluate the things to be evaluated. The concrete steps^[5] are as follows:

a) Data dimensionless processing:

Because the dimensions of each index are different and cannot be analyzed and compared within the same standard, it is necessary to standardize the subordinate data of all indexes and transform the actual value of each index into an evaluation value that can be placed within the same judgment standard. The formula is as follows:

Positive index processing formula:

$$X_{ij} = \frac{(x_{ij} - \min x_{ij})}{(\max x_{ij} - \min x_{ij})}$$

Negative index processing formula:

$$X_{ij} = \frac{(\max x_{ij} - x_{ij})}{(\max x_{ij} - \min x_{ij})}$$

Among them: x_{ij} is the raw data of the index, X_{ij} is the standardization of the raw data of the corresponding index.

b) In order to make data processing more meaningful, zero and negative values must be eliminated. Therefore, it is necessary to carry out non-negative translation on the dimensionless data, namely, $X_{ij} = X + \alpha$ and the value of α is 0.01.

c) Calculating the contribution of indicators, and constructing the evaluation matrix of the human settlement environment. The formula is as follows:

Table 1 Objective evaluation system of human settlement environment

Primary index	Secondary index	Unit	Index attribute
B1 Ecological environment	C1 Green coverage rate of built-up area	%	Positive
	C2 Number of parks	one	Positive
	C3 Park green area per capita	Square meters/person	Positive
	C4 Harmless disposal rate of domestic garbage	%	Positive
	C5 Average daily sewage treatment capacity	Ten thousand cubic meters/day	Positive
B1 Economic environment	C6 Gross industrial output value of above designated size	Ten thousand yuan	Positive
	C7 Total GDP	Ten thousand yuan	Positive
	C8 Total investment in social fixed assets	Ten thousand yuan	Positive
	C9 Number of employed persons in secondary and tertiary industries	One	Positive
	C10 Road area per capita	(m ² /person)	Positive
B3 Infrastructure	C11 Number of road lighting lamps	Calix	Positive
	C12 Natural gas consumption population	Ten thousand people	Positive
	C13 Gas penetration rate	%	Positive
	C14 Total water supply	Ten thousand cubic meters	Positive
	C15 Water supply penetration rate	%	Positive
	C16 Construction land area	Square kilometer	Positive
	C17 Urbanization rate	%	Positive
B4 Social environment	C18 Number of beds in medical and health institutions per thousand people	Zhang/thousand people	Positive
	C19 Educational input	Ten thousand yuan	Positive
	C20 Number of legal entities in health, social security and social welfare services	One	Positive
	C21 Number of libraries	Seat	Positive
	C22 Number of students in ordinary middle schools	Human	Positive

$$A = \begin{pmatrix} X_{11} & \dots & X_{1m} \\ \vdots & & \vdots \\ X_{n1} & \dots & X_{nm} \end{pmatrix}$$

Calculating the proportion of the i evaluation unit in the j index, and the formula is as follows:

$$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^n X_{ij}} (j=1,2,\dots,m)$$

d) Entropy calculation. The formula for calculating the entropy value of item j index is:

$$e_j = \left(-\frac{1}{\ln m}\right) \sum_{i=1}^m P_{ij} \ln P_{ij} (0 \leq e_j \leq 1)$$

e) Calculating the difference coefficient of the j index, and the formula is:

$$g_i = 1 - e_i$$

Namely, the larger the value of g_i , the more important the indicator.

f) Entropy weight calculation

$$w_j = \frac{g_i}{\sum_{j=1}^m g_i}$$

(3) Calculation results

After dimensionless processing and weight calculation of the statistical data, the evaluation results can be obtained by the formula, and the formula is as follows:

$$F = \sum_{j=1}^m X_{ij} w_j$$

Among them, $X_{ij} w_j$ is the standardized value the processed values, and w_j is the weight value corresponding to the indicator. It should be noted here that the calculation of the weight of the first-level indicators is obtained by the entropy method based on the comprehensive scores of the second-level indicators again. Therefore, the calculation process should be as follows: the standardized values of the indicator factors (i.e., the second-level indicator layer) are multiplied by the weights of their corresponding first-level indicator layers to obtain the scores of the first-level indicator layers, and then the scores of each first-level indicator are multiplied by their corresponding weights in the whole evaluation system to obtain the final comprehensive evaluation value is obtained [6].

5. Evaluation of human settlement environment in Tumushuke City

In this paper, the data of Tumushuke City between 2015 and 2020 were selected in order to analyze the changing trend of human settlement environment quality during the past six years. And the unilateral quality evaluation analysis of the human settlement environment is reflected from the whole to each subsystem.

6. Data standardization processing and index weight calculation

Using Excel and SPSS software, according to the dimensionless data processing formula mentioned above, the data of Tumushuke City from 2015 to 2020 were standardized, and the index weights of the standardized results were calculated by the entropy method. As the weights of the secondary indexes calculated by the above-mentioned auxiliary software are relative, it is necessary to calculate the weight of each secondary index layer relative to the total objective to calculate the weight of each index factor needed for the final evaluation result, and Table 2 is obtained.

7. Calculation result

According to the formula for calculating scores mentioned above, the present study used excel software for the auxiliary calculation to obtain Tables 3 and Table 4.

Table 1 Index weight value table of objective evaluation index system

Primary index	Weight	Secondary index	Weight	Relative weight
B1	0.2423	C1	0.0948	0.3913
		C2	0.0423	0.1745
		C3	0.0629	0.2594
		C4	0.0424	0.1748
		C5	0.0000	0.0000
B2	0.2539	C6	0.0425	0.1676
		C7	0.0941	0.3706
		C8	0.0664	0.2614
		C9	0.0509	0.2004
B3	0.2216	C10	0.0164	0.0738
		C11	0.0224	0.1012
		C12	0.0476	0.2146
		C13	0.0236	0.1067
		C14	0.0437	0.1974
		C15	0.0144	0.0648
		C16	0.0535	0.2415
B4	0.2822	C17	0.0206	0.0728
		C18	0.0190	0.0675
		C19	0.0356	0.1263
		C20	0.0598	0.2119
		C21	0.0851	0.3017
		C22	0.0620	0.2198

Table 3 Grade 1 index level score

	2015	2016	2017	2018	2019	2020
B1	0.2690	0.7845	0.8513	0.5026	0.4069	1.0000
B2	0.0000	0.1260	0.3392	0.4926	0.7883	0.8571
B3	0.1299	0.2625	0.3249	0.5396	0.4288	0.6832
B4	0.0000	0.0601	0.3351	0.4344	0.6180	0.8330

Table 4 Total target score

	2015	2016	2017	2018	2019	2020
	0.0940	0.2972	0.4590	0.4890	0.5681	0.8464

8. Evaluation results analysis

8.1 Overall evaluation

From Figure 1, it can be seen that the overall level of human settlement environment in Tumushuke City shows a steady upward trend between 2015 and 2020. Among them, between 2015 and 2017, the evaluation value of the human settlement environment rose faster; between 2017 and 2019, the rising trend was slower, and the evaluation value only increased by about 0.11 compared with 2017. And after 2019, the comprehensive evaluation value of the human settlement environment increased rapidly again, which shows that the overall human settlement environment of Tumushuke City is in a benign development stage in recent years.

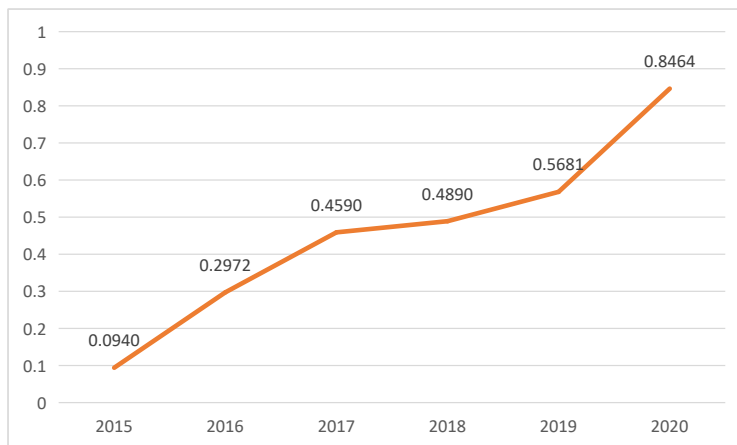


Figure 1 2015-2020 Change process chart of comprehensive evaluation value of human settlement environment

8.2 Subsystem evaluation

As can be seen from Figure 2, the evaluation values of the four subsystems show an increasing trend over the six-year time frame. Specifically, the growth rate of the ecological environment subsystem is 0.7310; the growth rate of the economic environment subsystem is 0.8571; the growth rate of the infrastructure subsystem is 0.5533, and the growth rate of the social environment subsystem is 0.8330. It can be found that the growth rate of the economic environment is the largest and the growth rate of the infrastructure subsystem is the smallest. Except for the ecological environment subsystem, the development of the other three subsystems is relatively consistent. According to the evaluation system established according to the current situation of Tumushuke City, this paper analyzes the corresponding situation of every single index's evaluation value change chart when it is implemented in the real development situation of Tumushuke City.

Ecological environment: From 2015 to 2020, Tumushuke City adhered to the people-centered development idea, and implemented the concept of green ecology, livable industry, and tourism in the construction of an ecological city, a vibrant city, and a happy city. This city also promoted the comprehensive management, systematic management, and source management of grass and sand in the landscape forest, fields, and lakes, conscientiously implemented the “One-three-five Plan”, constantly improved the green outline of the city, as well as improved the city through river management, mountain landscape and “network convergence”. As can be seen from Figure 3, the green coverage rate of built-up area (C₁) increased from 2015 to 2016. This is because Tumushuke City paid attention to greening construction in the previous two years, and continuously increased the greening investment, totaling 220 million yuan. The effect of “greening, adding scenery and color” in the city was obvious, and 358,000 trees and 2.8 million shrubs were planted throughout the year, with an additional greening area of 419 mu; The evaluation values of C₂ (number of parks) and C₃ (park green area per capita) are relatively consistent. From 2015 to 2016, the number of parks in Tumushuke City increased obviously, but from 2016 to 2019, it tended to be flat. This is due to the decision of Tumushuke City Municipal People’s Government to create a “national garden city” in 2014 and to start the creation work comprehensively. The total area of park green space reached more than 2,600 mu in 2016, but with the gradual increase in population, the value of park green space per capita showed a decreasing trend from 2017 to 2019. The evaluation trend of C₄ (harmless treatment rate of domestic garbage) is not obvious. It increased from 2015 to 2016, and basically remained the same from 2016 to 2020. The average daily sewage treatment capacity (C₅) will be stable from 2015 to 2020.

Economic environment: From 2015 to 2020, Tumushuke City’s economic development level rose steadily, which was due to the rising trend of various individual indicators. As can be seen from Figure 4, the growth trend of gross industrial output value of above designated size (C₆) scale is the most stable among the economic environment indicators. This is because Tumushuke City’s industrial

development adheres to the working idea of “one district, two parks, two transformations and strong support”, relying on the cultivation and growth of leading enterprises, and carries out the annual activities of quality and benefits management of industrial enterprises in-depth, so as to promote the sound and rapid development of industrial economy in the city. C_7 (total GDP), which showed a slow upward trend from 2015 to 2018, increased rapidly from 2018 to 2019. Tumushuke City, the third division of the Corps, was identified as one of the key cities for industrial development in southern Xinjiang Province. Tumushuke City firmly seized this policy opportunity to promote the integration of production and city, focusing on building the whole industrial chain of textile and garments. It made use of agricultural characteristic resources, extended the industrial chain, and vigorously developed intensive processing of agricultural and sideline products, and total production. Affected by the epidemic from 2019 to 2020, the trend slowed down. The evaluation value of C_8 (total investment in social fixed assets) remained basically unchanged from 2015 to 2016 and increased from 2016 to 2018, which was due to the rapid development of various industries in Tumushuke City during these two years. It decreased from 2018 to 2020. The number of employed persons in the secondary and tertiary industries (C_9) showed that this single index changed relatively gently. With the increase in economic development, the structure of the secondary and tertiary industries in Tumushuke City is becoming more and more reasonable, but there is still much room for improvement. This requires the optimization and upgrading of the primary industry, the accelerated development of the secondary industry, the upgrading of the tertiary industry, and the integration and development of the primary, secondary, and tertiary industries.

Infrastructure: As can be seen from Figure 5, the evaluation value of C_{10} (road area per capita) showed a downward trend as a whole, with different degrees of decrease from 2016 to 2019, which is inseparable from the rapid growth of the population of Tumushuke City in recent years. The number of C_{11} (number of road lighting lamps) has not a significant change from 2017 to 2020. The evaluation value of C_{12} (natural gas consumption population) is generally rising, with the fastest increase in the value from 2019 to 2020. This is because Tumushuke City, the third division, started the natural gas household project in 2015, which enabled some residents in Tumushuke City to access natural gas within a few years. The evaluation value of C_{13} (gas penetration rate) showed an upward trend from 2015 to 2017, and gradually decreased from 2017 to 2019, and picked up from 2019 to 2020. The value of C_{14} (total water supply) showed an overall upward trend from 2015 to 2020. With the development of society, Tumushuke City paid more and more attention to the development, utilization, and protection of water resources, determining scientific and practical water resources protection planning, and strengthening the construction of pipeline facilities. The value of C_{15} (water supply penetration rate) increased slowly from 2015 to 2018, and decreased from 2018 to 2020. The value of C_{16} (construction land area) remained unchanged from 2015 to 2017, with an obvious upward trend from 2017 to 2018, and a decrease from 2019 to 2020.

Society: As can be seen from Figure 6, the urbanization rate (C_{17}) increased steadily in Tumushuke City from 2015 to 2018, decreased from 2018 to 2019, and stabilized from 2019 to 2020. The value of C_{18} (number of beds in medical and health institutions per 1000 people) increased slowly from 2015 to 2020. This is because since the counterpart aid to Xinjiang was launched, and Guangdong Province has trained a main force for the sustainable development of medical and health undertakings in Tumushuke City, the third division. In addition, the government has also gradually strengthened its economic investment in medical and health facilities. The value of C_{19} (educational input) showed a stable trend from 2015 to 2016, with a rapid upward trend from 2016 to 2018, a decline from 2018 to 2019, and a rise in 2020. The number of C_{20} (number of legal entities in health, social security and social welfare services) fluctuates greatly, and it remains unchanged from 2015 to 2016 and from 2017 to 2018. It increased greatly from 2016 to 2017, but decreased rapidly from 2018 to 2019 and raised back up in 2020; The value of C_{21} (number of libraries) increased between 2018 and 2019. The value of The number of C_{21} (number of students in ordinary middle schools) showed an overall upward trend from 2015 to 2020, especially from 2018 to 2019, with an obvious upward trend. This is because this city has strengthened the construction of scientific research, culture, education, sports

and other facilities, people are more and more aware of the importance of education, and residents' education level is gradually improved.

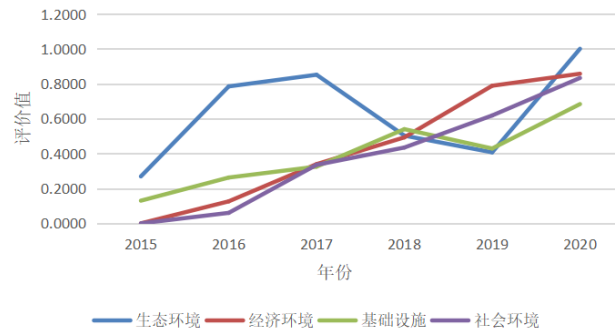


Figure 1 2015-2020 History map of evaluation value of human settlements subsystem in Tumushuke City

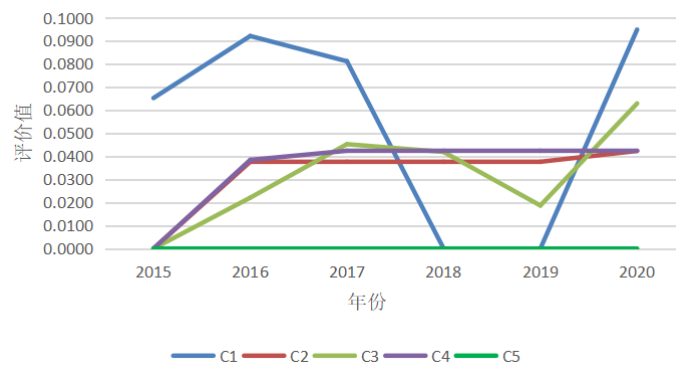


Figure 3 2015-2020 History chart of evaluation value of ecological environment single index in Tumushuke City

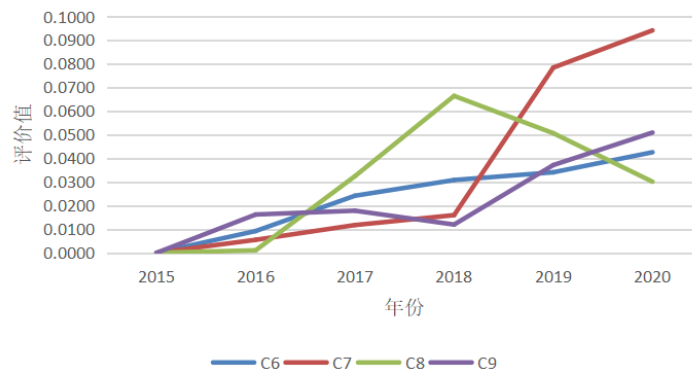


Figure 4 2015-2020 History chart of evaluation value of economic and environmental indices in Tumushuke City

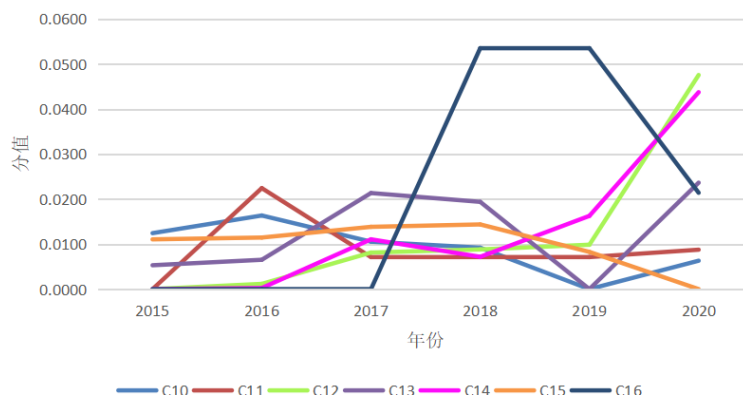


Figure 5 2015-2020 History chart of evaluation value of single index of infrastructure in Tumushuke City

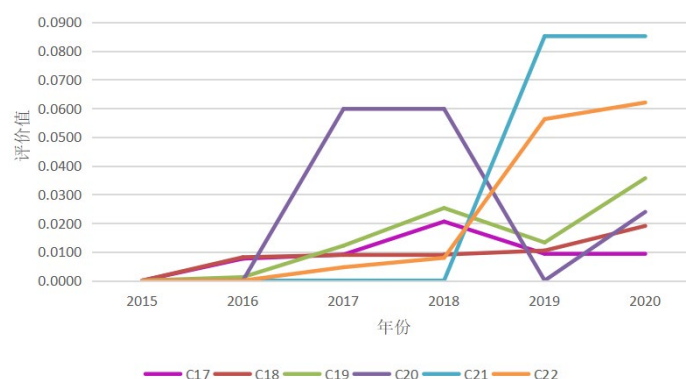


Figure 6 2015-2020 History chart of evaluation value of social environment single index in Tumushuke City

8.3 Suggestions on optimization of human settlement environment

8.3.1 Infrastructure optimization measures

(1) Broaden the road area and improve the pavement facilities.

Relevant departments should establish a complete and sound set of policies, regulations, and guarantee mechanisms for traffic infrastructure investment, ensure a good investment environment, and improve the efficiency of fund allocation in road construction. Besides, the departments should also conduct a comprehensive investigation of traffic facilities, summarize the investigation problems one by one, and optimize them in time. Finally, according to the urban and rural planning and the public's traffic demand, the departments should improve the layout of traffic lines, increase the number of public transport vehicles, especially in areas with large passenger flow, and expand the full coverage of traffic lines.

(2) Improve the regional energy supply network

According to the relevant planning of natural gas and the requirements for the construction of gas storage capacity of various main bodies in various links specified by the State Council, the departments may formulate and publish the list of major projects for the construction of annual gas storage facilities in the city, and clarify the key construction tasks. Besides, the government should actively plan the construction of solar power stations, push forward the construction of liquefied gas stations, lay natural gas pipelines, and improve the regional energy supply network.

8.3.2 Social environment optimization measures

(1) Enhancement of medical and health care

Use the methods of public management and economic instruments to realize the rational allocation of medical resources. Maximize the use of existing medical resources, and quickly adjust the current layout of large urban hospitals with excess medical resources, underutilized medical equipment, and crowded and wasteful professional and technical personnel, as a result of the widespread concentration of high, sharp, and sophisticated medical equipment and senior experts in large urban hospitals. Strengthen the construction of health personnel, the introduction of a number of high-level health professionals and technicians, strengthen the prevention and control measures for major contaminated diseases, and properly handle public health emergencies on time.

(2) Refinement of the social security system

The financial investment in social security is the foundation of social security, further expanding the coverage of various social insurances and gradually improving the treatment level of various social insurances. Expand the financing channels and realize the diversification of social security funds. Expand the coverage of social security and gradually establish a social security system covering all urban and rural workers.

8.3.3 Ecological environment optimization measures

(1) Improve garbage disposal efficiency

The government may strive to build a domestic waste treatment system with the aim of “overall planning of urban and rural areas, reasonable technology, sufficient capacity, and environmental protection standards”. Domestic waste treatment adheres to the principles of reduction, recycling and harmlessness, encourages and promotes classified collection and disposal of garbage, and encourages the reuse of garbage resources. The government should play the leading role in establishing and improving the public participation mechanism, encouraging and guiding the masses and social forces to participate in and support the work of domestic waste collection and disposal.

(2) Strengthen the management of sewage discharge

Strictly control the total amount of pollutant emissions, continue to cut industrial pollution, the polluting industries such as iron and steel, electric power, chemical industry, coal and other key polluting industries to promote the zero discharge system of wastewater recycling closed circuit, and effectively strengthen the audit and supervision of polluting emission units. Accelerate the construction of the water-saving industry and water-saving society. Further study industrial water conservation management methods, standardize the scope of water conservation in enterprises, and strictly implement water quotas and water conservation standards for key water pollution emission industries. Vigorously promote urban sewage treatment and resourcefulness. Fundamentally avoid the continued deterioration of the urban water environment, in addition to improving the urban drainage system and improving the technical level of urban sewage treatment.

8.3.4 Economic and environmental optimization measures

(1) Industrial structure adjustment

Because the foundation of the primary industry is weak, the quality of the secondary industry is not high, and the development of the tertiary industry lags, it is necessary to adjust the structure of the three major industries, vigorously strengthen the primary industry, adjust and improve the secondary industry, and actively develop the tertiary industry.

(2) Urban-rural linkage reform

Urban areas mainly focus on the development of the market economy, which not only strengthens the level of industrialization but also provides many employment opportunities for the local people. However, rural areas mainly focus on the development of the agricultural economy, which in turn realizes large-scale and mechanized production.

9. Conclusion

The human settlement environment is the material basis for human survival, and any human activity cannot be separated from it. The evaluation and analysis of human settlement environment quality are of great significance to the construction of the human settlement environment. Based on the current development conditions of Tumushuke City, the evaluation system of human settlements in Tumushuke City was constructed from four aspects: ecology, infrastructure, society, and economic environment. And the development and changes of human settlements in Tumushuke City from 2015 to 2020 were comprehensively evaluated. Based on these evaluation results, a series of suggestions on optimizing human settlements in Tumushuke City, a town of corps were put forward. Through the objective evaluation results, it can be seen that the quality of the human settlement environment in Tumushuke City keeps a stable development trend from 2015 to 2020, which also means that the quality of human settlements in Tumushuke City is getting better and better. Finally, this paper only selects 22 indicators from 2015 to 2020 as measurement data, which cannot fully reflect the quality of human settlements in Tumushuke City. Therefore, future studies can increase the number of indicators, establish a more complete and comprehensive evaluation system, extend the time node, and discuss the construction of human settlements from a more detailed scale.

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