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Sustainable Development Path of Resource-Based Cities—Taking Datong as an Example

Risheng Qiao [1,*], Weike Chen [1] and Yongsheng Qiao [2]

[1] School of Management, Tianjin University of Technology, Tianjin 300384, China
[2] School of Business, Nankai University, Tianjin 300071, China
* Correspondence: tjutqiao@126.com; Tel.: +86-185-1971-6987

Abstract: Sustainable development has become a global consensus, and cities are important spatial carriers to achieve sustainable development. There are more than 200 resource-based cities in China. These cities have a single industrial and energy structure. With the gradual depletion of urban resources, they are generally facing problems such as difficult industrial transformation, lagging development of alternative industries, and serious damage to the ecological environment. They are facing multiple challenges to achieve sustainable development. Our paper creatively uses the multiple interactive feedback relationships among the systems of "driving force–pressure–state–influence–response" in resource-based cities to establish a comprehensive evaluation model for the sustainable development of resource-based cities through the comprehensive evaluation index system of sustainable development. It is concluded that the higher the coordination degree of each subsystem in the model is, the stronger the sustainable development ability of the city is, which provides new ideas and suggestions for the sustainable development of resource-based cities. The case study shows that the coordinated dispatching C value tends to 2.216, indicating that the sustainable development evaluation values of each subsystem in the model tend to be close, and the coordination between subsystems is high. This confirms the rationality of establishing a comprehensive evaluation model for the sustainable development of resource-based cities.

Keywords: resource-based city; sustainable development; transformation; a comprehensive evaluation model

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1. Introduction

Achieving sustainable development has become the consensus of human social development. In 1987, the World Commission on environment and development published "Our common future", which formally proposed the concept of "sustainable development", defined as "development that meets the needs of contemporary people without harming the ability of future generations to meet their needs" [1]. In September 2015, the United Nations Summit on Sustainable Development formally adopted "Transforming our world: 2030 agenda for sustainable development", which puts forward 17 Sustainable Development Goals (SDGs) and 169 specific goals, covering social, economic and environmental aspects; these have become important guidelines for global sustainable development after the Millennium Development Goals. The Chinese government attaches great importance to the implementation of the 2030 agenda for sustainable development. In September 2016, China issued China's national program for the implementation of the 2030 agenda for sustainable development, proposing to promote the establishment of innovative demonstration areas for the implementation of the national agenda for sustainable development, so as to accumulate experience for the implementation of the 2030 agenda. In December 2016, the State Council issued a detailed plan for innovation demonstration zones for China's implementation of the 2030 agenda for sustainable development, creating about 10 national innovation demonstration zones for the agenda for sustainable development, creating a number of replicable and replicable practical models of sustainable development, and providing the world with a Chinese plan for sustainable development by building an exchange and cooperation platform with the theme of scientific and technological innovation driving sustainable development.

By the end of 2019, China's urbanization rate had reached 60.6%, and it is expected to rise to 75% by 2030. Among more than 600 cities in China, 262 are defined as resource-based cities by the national sustainable development plan for resource-based cities (2013–2020) issued by the State Council, more than one third of the number of cities in China. These cities have made great historical contributions due to their abundant resources. However, as they have entered the mature and declining periods, the contradictions between economic and social development and ecological protection and environmental protection have become increasingly prominent. Some cities have even fallen into the predicament of economic recession, industrial contraction and weakening of factor aggregation capacity due to the exhaustion of resources. It is necessary to explore a sustainable development transformation and upgrading path suitable for resource-based cities.

The resource-based city is a city type that takes the exploitation and processing of natural resources in the region as the leading industry. They provide the country with a large volume of the means of production, huge profits and taxes [2]. The sustainable development of resource-based cities should not only meet the needs of contemporary people, but also take into account the needs of future generations [3]. Since the beginning of the 21st century, with the coordinated development of economy, society and environment, and the massive exploitation of resources in resource-based cities, the resource exhaustion of such cities has become a hot topic. Research on sustainable development of resource-based cities has become one of the key topics pursued by many scholars [4]. The goal of sustainable development is the common vision of mankind. As the node of a country and the engine of economic growth, how to improve a resource-based city's sustainable competitiveness has attracted much attention. Cities with good sustainable competitiveness can support the optimum development of economy, society and environment, and better and more continuously meet the needs of urban residents.

Scholars have also established an index system of sustainable development [5]. For example, some scholars believe that urban sustainable development should be the coordinated development of economy, environment and society, and can link the sustainable development status with ecological efficiency. In the process of specifically promoting the sustainable development of the country and the city, some scholars have quantified the sustainable development framework system and integrated the concept of sustainable development with competitiveness to reflect the long-term growth level and ability of the city. They believe that achieving long-term sustainable economic growth is the goal of improving competitiveness, and focusing only on short-term economic growth will lead to long-term welfare loss. Therefore, we need to combine sustainable development with enhancing competitiveness. Balkyt and Tvaronaviciene put forward the concept of sustainable competitiveness, and believed that globalization, economic growth, social welfare, sustainable development and competitiveness should be integrated [6]. Morgado and other scholars further introduced the idea of sustainable development into the urban competitiveness system, integrated the relevant indicators of the two, and constructed a sustainable competitiveness indicator, which is used to explain the sustainable competitiveness of cities.

The current research themes of sustainable development of resource-based cities in China are different. At the beginning of these studies, most of the countermeasures were discussed from a macro perspective. The research type was relatively uniform, and most of the conclusions were relatively general. Although some scholars established indicators and models, there was a lack of empirical research. At present, the research on the sustainable development of resource-based cities in China is relatively mature, but few studies study the sustainable development path of resource-based cities from the perspective of the difference and balance of various influencing factors. Our paper combs the problems and research status of sustainable development of resource-based cities, constructs an evaluation system for sustainable development of resource-based cities, and uses the comprehensive evaluation method based on "driving force–pressure–state–influence–response" to discriminate the multiple feedback relationships among economy, society and environment. Taking the sustainable development agenda of Datong City as a case, it studies the sustainable development path of resource-based cities. This study has strong theoretical and practical significance for developing sustainable development paths for resource-based cities.

2. Sustainable Development of Resource-Based Cities and Its Research Status

2.1. Problems in Sustainable Development of Resource-Based Cities

Urban areas use 60% of global resources and account for about 70% of carbon emissions, which aggravates environmental pollution and overburdens urban infrastructure and services [7]. Rapid urbanization has brought serious challenges to the sustainable development of China's economy, society and environment. In the context of the current transition from high economic growth to high-quality development, it is of great significance to promote the transformation, upgrading and sustainable development of resource-based urban areas. The leading industry of resource-based cities mainly relies on natural resources. With the country's rapid economic development and large-scale development of resources, the sustainable development of resource-based cities is facing more serious challenges.

Path dependence is the main problem faced by the transformation and development of most resource-based cities in China. Path dependence will have a double locking effect on technology and institutions, leading to a decline in the potential for industrial transformation and a dilemma of urban transformation in the period when resources are exhausted [8]. In addition, the existence of path dependence also makes for reliance on a single industrial sector, usually dominated by resource-based industries [9]. This rigid industrial structure is the main bottleneck of the transformation of resource-based cities. Qin et al. [10] believe that resource-based cities at the stage of relatively abundant resources can basically get rid of the path dependence problem of relying on resources for economic development by changing the mode of economic growth, but for resource-based cities at the stage of exhaustion, their capacity for sustainable development is relatively weak. This shows that the sustainable development of resource-based cities faces two difficulties. On the one hand, when resources are abundant, the power of the message of sustainable development transformation of resource-based cities is insufficient; on the other hand, when resources are scarce, the capacity for sustainable development transformation of resource-based cities is insufficient.

From the perspective of urbanization development, the relationship between resource-based cities and ecological environment is uncoordinated. Urbanization lag is one of the main reasons, mainly manifested in the unitary structure of urban economic development, backward basic service functions of cities and weak public infrastructure [11]. In terms of the urban development mechanism and system, an unreasonable development mechanism, imperfect system and excessive and inefficient development of natural resources in urban development aggravate the rate of resource exhaustion. In addition, in resource-based cities, the government's science and education support is relatively redundant and may fail to match the economic system invested in by the city [12]. With the gradual deepening of China's economic and social construction, the role of resource-based cities in supporting national development becomes more and more obvious. The contradiction between the continuing expansion of demand for national resources and energy and the diversified development of resource-based cities will also continue to intensify, and the development problems of resource-based cities will become more prominent [13].

2.2. Research Progress on Sustainable Development of Resource-Based Cities

The sustainable development of resource-based cities belongs to the category of urban sustainable development, so it is of great significance to clarify the connotation and research status of urban sustainable development for accurately grasping the challenges of sustainable development for resource-based cities. The sustainable development of a city refers to the realization of highly developed urbanization and modernization through long-term sustained urban growth and structural optimization on a certain time-space scale, so as to meet both the practical needs of contemporary urban development and the development needs of future cities [14].

From the perspective of research content, research related to urban sustainable development mainly focuses on three aspects: first, qualitative research examines strategies and ideas for achieving sustainable development at the urban level. The second approach is to evaluate the sustainable development level or capacity of the city as a whole or in a certain aspect by building an index system, such as innovation capacity, ecological construction, urban resilience and disaster management. The third research direction is to quantify the impact of a single factor or problem on urban sustainable development, including urban financial aggregation, inequality, accessibility, and public attitudes. However, the city is a complex ecological coupling body. In order to realize the sustainable development of the city, it is necessary to understand the ecological coupling relationship among its three subsystems of economy, society and environment, so as to achieve coordinated development, which requires the adoption of a comprehensive analytical framework based on the combination of multiple methods. Most of the existing studies focus on a certain aspect of society, economy or environment, and there is a lack of systematic thinking and quantitative research on the overall sustainable development of different types of cities.

From the perspective of the research methods on urban sustainable development, based on the expansion of the "pressure–state–response (PSR)" method, the European Environment Agency (EEA) proposed the "driver–pressure–state–impact–response (DPSIR) model [15], which is widely used in the fields of environmental management and protection, resource protection and sustainable development. Zhu [16] used the "pressure–state–response" method to systematically diagnose and analyze the problem of sustainable development. Lv [14] systematically discussed how to realize urban transformation based on DPSIR model theory.

A large number of documents have analyzed the development models, policies and paths of industrial transformation and economic transformation in the transformation and upgrading of resource-based cities. Through literature analysis, it can be found that innovation drive is an important factor to realize the transformation and upgrading of resource-based cities, but the efficiency of transformation and upgrading of resource-based cities not only depends on scientific and technological innovation, but also is affected by non-scientific and technological factors such as institutional, policy and management changes [17]. Therefore, it is necessary to consider all aspects of institutions, industries and elements in a comprehensive and multi-level manner to promote the transformation of resource-based cities through integration and interaction. The sustainable development of resource-based cities needs the promotion of policies. Ruan [18] evaluated the complexity of achieving sustainable development in resource-based cities, analyzed the formulation, implementation and response of relevant policies, and suggested that the government should establish a management system with absolute rights and responsibilities, and should formulate standardized and flexible implementable policies.

To sum up, most of the existing studies on the sustainable development of resource-based cities focus on single aspects such as economic transformation or ecological development. There is a lack of thinking about the complex relationship between different urban systems, and a lack of relevant research combined with the SDGs framework [19]. Based on this, our paper establishes an evaluation index system and model of comprehensive capacity for sustainable development, and studies the sustainable development path of resource-based cities with the Datong innovation demonstration area as a case study.

3. Evaluation Model Construction

As complex systems, resource-based cities need to be fully considered from the perspective of multi fields, multi dimensions and multi subjects in order to achieve their overall sustainable development. Therefore, based on the characteristics of resource-based cities and the Sustainable Development Goals of 2030, our paper constructs a sustainable development index system of resource-based cities, establishes a DPSIR model, and takes Datong City as an example to analyze the sustainable development capacity and path of resource-based cities.

3.1. Construction of Sustainable Development Indicator System of Resource-Based Cities

The evaluation index system is an important basis for evaluating the current situation of sustainable development of resource-based cities, and also the primary premise for designing the path framework of sustainable development of resource-based cities [20]. Therefore, our paper evaluates the sustainable development status of resource-based cities by constructing an evaluation index system. The DPSIR model can be used to analyze the problems in the sustainable development of resource-based cities, the multi-dimensional subjects and the multi-dimensional feedback relationship between different indicators. On the basis of the existing research, our paper constructs an index system including the target layer, the system layer and the index layer based on the DPSIR model and the sustainable development characteristics of resource-based cities. Among them, the target layer provides for comprehensive measures of the level of sustainable development of resource-based cities. The system layer is divided into five subsystems according to the DPSIR model. In the indicator layer, 30 measurement indicators are selected, and according to the national program for China's implementation of the 2030 agenda for sustainable development, these indicators corresponding to the Sustainable Development Goals in the same field, as shown in Table 1. The maximum and minimum values referred to in the standardization process are taken from the latest United Nations SDGs report, the SDSN indicator board and the 2015 China Environmental Status Bulletin.

Table 1. DPSIR evaluation index system for sustainable development of resource-based cities.

Target	System	Index	Number	Unit	Positive and Negative
Comprehensive capacity of sustainable development of resource-based cities (Q)	Driving force (D)	Per capita GDP	X_1	¥10,000	+
		R & D investment intensity of the whole society	X_2	%	+
		Turnover of technology contracts	X_3	100 million	+
		Per capita disposable income of urban residents	X_4	¥10,000	+
	Pressure (P)	Water consumption per ¥10,000 GDP	X_5	m^3	-
		Energy consumption per ¥10,000 GDP	X_6	tce/¥10,000	-
		Total combustion	X_7	10,000 t	-
		¥100 million GDP production safety accident mortality	X_8	person	-
		Registered urban unemployment rate	X_9	%	-
		Income ratio of urban and rural residents	X_{10}		-
	Status (S)	Proportion of high-tech industry added value in industrial added value above designated scale	X_{11}	%	+
		Proportion of added value of service industry in GDP	X_{12}	%	+
		Proportion of added value of cultural industry in GDP	X_{13}	%	+
		Number of professional doctors per thousand population	X_{14}	person	+
		Number of elderly care beds per 1000 elderly population	X_{15}	bed	+
		Share rate of public transport travel	X_{16}	%	+
		Forest coverage	X_{17}	%	
	Impact (I)	Average life expectancy	X_{18}	age	+
		$PM_{2.5}$	X_{19}	ug/m^3	-
		concentration	X_{20}	ug/m^3	-
		Proportion of days with excellent urban air quality	X_{21}	%	+
		The proportion of surface water reaching or better than class II water body ①	X_{22}	%	+

Table 1. *Cont.*

Target	System	Index	Number	Unit	Positive and Negative
	Response (R)	Number of invention patents owned by 10,000 people	X_{23}	piece	+
		National innovation platform base	X_{24}	Unit	+
		Safe utilization rate of polluted cultivated land	X_{25}	%	+
		Comprehensive utilization rate of bulk industrial solid waste	X_{26}	%	+
		Green coverage rate of built-up area	X_{27}	%	+
		Control rate of water and soil loss	X_{28}	%	+
		Harmless treatment rate of municipal solid waste	X_{29}	%	+
		Urban sewage treatment rate	X_{30}	%	+

Notes: R&D = research and development, GDP = Gross Domestic Product. $PM_{2.5}$ refers to particles with diameter less than or equal to 2.5 microns in the atmosphere. ①—Bricaud and Morel proposed a method to divide Class I water area and Class II water area. The basic principle of this method is that the change of sea surface remote sensing reflectance Rrs (560) at 560 nm mainly reflects the change of water particle scattering coefficient. Based on this principle, Bricaud and Morel established a criterion to distinguish the two types of water bodies, namely, the relationship between Rrslim (560) and pigment concentration. At a certain pigment concentration, if Rrs (560) < Rrslim (560), the water body is a class I water body; if Rrs (560) > Rrslim (560), the water body is a Class II water body.

3.2. Comprehensive Evaluation Model of Sustainable Development of Resource-Based Cities

Because there are great differences in units, dimensions, orders of magnitude and positivity and negativity between the selected 30 indicators, the range method is used to standardize the original data of the forward and reverse indicators before analysis [21–23]. The method is as follows.

After the index weight information is obtained, the level value of each subsystem is calculated by the weighted synthesis method:

$$X_i = \begin{cases} X_i^+ = \frac{X_i - X_{imin}}{X_{imax} - X_{imin}} \\ X_i^- = \frac{X_{imax} - X_i}{X_{imax} - X_{imin}} \end{cases}$$

where $X_i^+ \in [0,1]$ is the normalized value of the positive indicator, $X_i^- \in [0,1]$ is the normalized value of the reverse indicator, X_i is the original value of the indicator, X_{imax} is the maximum value of the indicator X_i, and X_{imin} is the minimum value of the indicator X_i.

Although the evaluation of SDGs is equally important for each Sustainable Development Goal at the goal level, the sustainable development of resource-based cities has different focus areas at different stages. Therefore, when further aggregating the standardized data to the subsystem level, it involves the setting of indicator weights. This development feature can be effectively identified by using the entropy weight method, thus providing a basis for identifying the path of sustainable development [24–26]. In our paper, the entropy weight method is used for objective weighting, and the specific calculation process is as follows.

For the evaluation objects of m-time series, the entropy value of the nth sustainable development evaluation index is defined as:

$$e_i = -\frac{\sum_{j=1}^{m} p_{ij} \ln p_{ij}}{\ln m},\ i = 1,2,\ldots,n; j = 1,2,\ldots,m$$

Among them, $p_{ij} = \frac{X_{ij}}{\sum_{j=1}^{m} X_{ij}}$, and assuming $\lim X_{ij} \to 0, p_{ij} \ln p_{ij} = 0$. Based on this, the weight of the indicator X_i can be expressed as:

$W_i = \frac{1-E_i}{\sum_{i=1}^{n}(1-E_i)}$, where $W_i \in [0,1]$ and $\sum_{i=1}^{n} W_i = 1$. After the index weight information is obtained, the level value of each subsystem is calculated by the weighted synthesis method:

$$Q_i = \begin{cases} Q_{Di} = \sum\limits_{i=1}^{D} X_{ij}W_i, i = 1, 2, \ldots, D \\ Q_{Pi} = \sum\limits_{i=1}^{P} X_{ij}W_i \;, i = 1, 2, \ldots, P \\ Q_{Si} = \sum\limits_{i=1}^{S} X_{ij}W_i, i = 1, 2, \ldots, S \\ Q_{Ii} = \sum\limits_{i=1}^{I} X_{ij}W_i, i = 1, 2, \ldots, I \\ Q_{Ri} = \sum\limits_{i=1}^{R} X_{ij}W_i, i = 1, 2, \ldots, R \end{cases}$$

where Q_{Di}, Q_{Pi}, Q_{Si}, Q_{Ii}, Q_{Ri} are the sustainable development evaluation values of the driving force, pressure, state, influence and response subsystems, respectively [27–30].

For the calculation of the comprehensive capacity (Q) of sustainable development of resource-based cities in the target layer, the calculation method of equal weight is adopted to calculate the arithmetic average of the scores of the five subsystems [31–33]. This is consistent with the annual report on the Sustainable Development Goals issued by the United Nations Sustainable Development Solutions Network and the calculation methods indicated for the SDGs. It reflects that urban sustainable development is a complete and indivisible whole, and there is a tight causal chain between various subsystem levels, which should be treated fairly. The 17 Sustainable Development Goals also need to be given equal attention.

Further, in order to measure the coordination degree between subsystems, the coordination degree function is introduced in our paper, and the calculation formula is:

$$C = \frac{Q_{Di} + Q_{Pi} + Q_{Si} + Q_{Ii} + Q_{Ri}}{\sqrt{Q_{Di}^2 + Q_{Pi}^2 + Q_{Si}^2 + Q_{Ii}^2 + Q_{Ri}^2}}$$

where C is the coordination degree. When the sustainable development evaluation values of the subsystems tend to be close, the values tend to 2.216, which indicates a high coordination degree of the subsystem. When the sustainable development evaluation values of subsystems differ greatly, it indicates that the coordination degree of subsystems is lower.

4. Case Analysis

In order to further verify the effectiveness of the comprehensive evaluation model of sustainable development of resource-based cities, Datong City was selected as a case study. Datong is a national energy and heavy chemical industry base, with rich energy "family background", coal, graphite, basalt, geothermal hot springs and other resources. Since the founding of China, Datong has contributed more than 3 billion tons of high-quality thermal coal to the country. Datong is also trapped in coal, and its excessive reliance on coal has resulted in a unitary and primary industrial structure. The extensive development relying on resources for a long time has led to the lack of economic growth momentum and the worsening ecological environment in Datong. According to the opinions of the State Council on supporting Shanxi Province to further deepen reform and promote the transformation and development of the resource-based economy, Datong's sustainable development still faces some bottleneck problems, including frequent mining disasters, ecological fragmentation, environmental pollution and resource waste. More importantly, when the situation of the coal market fluctuates, the economic structure of "one coal dominating the market" will always inflict heavy losses on the overall economy. In addition, the capacity for scientific and technological innovation is weak, the accumulation of talent capital is insufficient, and the mechanisms and system support for the transformation of resource-based economy are insufficient. These problems are restricting the comprehensive, coordinated and sustainable development of Datong's economy, society and environment.

4.1. Comprehensive Capacity Assessment of Sustainable Development in Datong

Based on the above-mentioned evaluation model of the comprehensive capacity of sustainable development of resource-based cities, the comprehensive capacity of sustainable development of Datong can be evaluated. By comparing the best/worst city data of the same index, the gap between Datong and other high-level cities can be better reflected. While evaluating the current situation of sustainable development in Datong, our paper also considers that the industrial structure of Datong, the coal capital, has changed from "coal power dominating" to "multi-industry support". Datong is currently focusing on strategic emerging industries and future industries to build a "hard support" for Datong to comprehensively promote high-quality development. Therefore, the rationality of the quantitative indicators of sustainable development formulated by Datong City to build an Economic and Technological Development and Innovation Zone and promote the 2030 sustainable development agenda is further evaluated. The original statistical values, standardized values, entropy values and weights of the sustainable development evaluation indicators of Datong City are shown in Table 2.

The indicators with the largest weight and more than 0.1 include SO_2, concentration (X_{20}), the proportion of added value of cultural industry in GDP (X_{13}) and per capita disposable income of urban residents (X_4), which are 0.18, 0.13 and 0.11, respectively. The indicators with the index weight value between 0.05 and 0.1 include the proportion of surface water reaching class II (X_{22}), per capita GDP (X_1), the turnover of technical contracts (X_3), and the number of elderly care beds per 1000 elderly people (X_{15}), which are 0.089, 0.088, 0.083, and 0.08, respectively. This shows that Datong attaches the most importance to air pollution and water pollution control, industrial transformation and diversification, people's livelihood welfare (especially resident income and elderly care) and innovation ability; this is also in line with Datong's plan for the transformation of a resource-based city. In this process, Datong is also exploring the linkage development of big data and new energy, shifting from coal transmission to data transmission and computing power, and accelerating the pace of transformation and development to take the lead in exploring a new path. At present, Datong has formed a certain industrial agglomeration effect, brand effect and regional driving effect. In 2022, the scale of Datong's data servers will increase from 200,000 to 800,000, and the whole big data industry chain that gathers "network, intelligence, digital, device and core" will be basically formed. Datong has built and put into operation the country's first photovoltaic "leader" demonstration base, becoming a demonstration city for the development of the general aviation industry in Shanxi Province. There are 74 provincial high-tech enterprises. In particular, in terms of environmental governance and ecological protection, Datong has become a national garden city. In 2020, for example, the number of good days above grade II[②] reached 315 days, and the average annual concentration of PM2.5 reached 31 micrograms/cubic meter. The two indicators ranked first in the province for many consecutive years. The market-oriented and diversified participation mode of "government led, market operated and industrial ecological park built" was adopted, and outstanding achievements in ecological construction were achieved. (②—The Technical Provisions on Ambient Air Quality Index (AQI) (for trial implementation) is formulated to implement the Environmental Protection Law of China, the Law of China on the Prevention and Control of Air Pollution and other laws, and regulate the daily and real-time reporting of ambient air quality index. Grading standard of air pollution index: Grade I, air pollution index $\leq$ 50, superior. Grade II, air pollution index $\leq$ 100, good. Grade III, air pollution index $\leq$ 150, light pollution. Grade IV, air pollution index $\leq$ 200, moderate pollution. Grade V, air pollution index $\leq$ 300, severe pollution. Grade VI, air pollution index > 300, severe pollution.)

Among the indicators, the registered unemployment rate of cities and towns (X_9), the death rate of production safety accidents per 100 million yuan (X_8) of GDP, the harmless treatment rate of urban domestic garbage (X_{29}) and the green coverage rate of built-up areas (X_{27}) have also been greatly improved. The city's annual new urban employment is more than 46,700, and the average annual rural labor transfer employment is more than 25,000. In 2020, the number of production safety accidents and deaths in Datong decreased by 30.4% and 34.6%, respectively, over the same period of the previous year. The harmless treatment of urban domestic garbage in Datong city adopts two treatment methods, namely, incineration power generation, which realizes the harmless reduction and resource-based treatment of domestic garbage, solves the problem of being surrounded by domestic garbage, and achieves the goal of controlling environmental pollution and improving the living environment of citizens. By the end of 2020, the newly increased green area of built-up areas in Datong was 1.377 million square meters, and the three indicators of green coverage, green space rate and per capita park green space in built-up areas of Datong reached 44.1%, 40.0% and 16.6 square meters per person, respectively, an increase of 10.29 percentage points, 10.81 percentage points and 10.16 square meters per person over the end of 2007. It can be seen that Datong has reached a high level in terms of indicators such as urban domestic waste treatment and green coverage of built-up areas.

Table 2. Evaluation of the comprehensive sustainable development capacity of Datong City.

System	Index No.	Original Value				Normalized Value				Entropy	Weight
		2015	2020	2025	2030	2015	2020	2025	2030		
Driving force (D)	X_1	6.1	8.0	11.2	15.3	0.11	0.17	0.21	0.32	0.94	0.09
	X_2	2.4	2.9	3.2	3.8	0.13	0.21	0.23	0.25	0.92	0.01
	X_3	50	90	113	146	0.25	0.43	0.50	0.65	0.95	0.08
	X_4	2.6	3.7	5.2	7.6	0.09	0.11	0.16	0.23	0.94	0.11
Pressure (P)	X_5	23.1	22.0	19.9	17.3	0.61	0.69	0.71	0.75	0.98	0.01
	X_6	0.89	0.81	0.70	0.62	0.51	0.60	0.65	0.70	0.95	0.41
	X_7	5693	4257	3981	3417	0.33	0.60	0.63	0.73	0.91	0.04
	X_8	0.04	0.037	0.034	0.029	0.95	0.95	0.95	0.96	1.00	0.01
	X_9	3.40	3.40	3.40	3.40	0.89	0.89	0.89	0.89	1.00	0.00
	X_{10}	1.90	1.90	1.80	1.60	0.40	0.40	0.50	0.61	0.96	0.00
Status (S)	X_{11}	38	42	48	52	0.63	0.72	0.81	0.89	0.96	0.01
	X_{12}	60.3	60.1	59	53	1.02	1.01	1.00	0.89	0.97	0.00
	X_{13}	3.5	7	9	10	0.20	0.45	0.63	0.76	0.91	0.12
	X_{14}	4.3	4.9	5.1	5	0.54	0.61	0.69	0.72	0.95	0.01
	X_{15}	15	32	39	43	0.14	0.32	0.37	0.40	0.91	0.07
	X_{16}	28	33	37	42	0.20	0.31	0.39	0.41	0.92	0.02
	X_{17}	18	26	29	32	0.20	0.27	0.29	0.31	0.93	0.01
Impact (I)	X_{18}	75.3	77	77.5	78	0.81	0.82	0.83	0.84	1.00	0.00
	X_{19}	57.1	50.2	45.6	30.1	0.52	0.59	0.61	0.76	0.94	0.00
	X_{20}	72	59	50	31	0.12	0.26	0.39	0.58	0.89	0.18
	X_{21}	60	77	82	86	0.59	0.75	0.80	0.83	0.94	0.01
	X_{22}	20.1	53.2	53.4	62.7	0.20	0.52	0.55	0.65	0.93	0.09
Response(R)	X_{23}	10	14	17	20	0.20	0.31	0.42	0.51	0.93	0.03
	X_{24}	16	19	24	28	0.32	0.39	0.49	0.58	0.96	0.03
	X_{25}	88	88	92	95	0.72	0.73	0.91	0.94	1.00	0.00
	X_{26}	66	71	74	78	0.65	0.70	0.67	0.60	0.96	0.00
	X_{27}	39	40	40	40	0.39	0.40	0.40	0.40	1.00	0.00
	X_{28}	56.8	71.2	80.6	88.1	0.55	0.71	0.80	0.87	0.97	0.02
	X_{29}	96.2	96.5	97	97.5	0.96	0.96	0.96	0.97	1.00	0.00
	X_{30}	88.2	98	98	98	0.88	1.00	1.00	1.00	0.97	0.00

This study has further calculated the evaluation values and degree of coordination of the DPSIR model, and the calculation results are shown in Table 3. From 2015 to 2030 (forecast), the comprehensive capacity of sustainable development in Datong increases steadily, and the evaluation values of all systems improve. The coordination degree is basically close, but gradually decreases with time, which indicates that Datong still needs to pay more attention to the overall coordination degree when formulating sustainable development goals. From the perspective of the driving force system, maintaining economic development, increasing innovation investment and increasing resident income can effectively improve the level of comprehensive sustainable development. Compared with the state system and the impact system, the driving force system also plays a greater role in promoting and driving. The impact (I) system and state (S) system that contribute the most to the comprehensive index of sustainable development mainly include specific indicators such as industrial transformation, air and water pollution, and medical health. Datong has set high goals in these aspects, which is consistent with the development concept of the sustainable development agenda. However, the overall goal setting still has shortcomings in the pressure (P) system and the response (R) system. It is necessary to further strengthen the attention to the response system and take more practical and effective actions to improve the innovation ability and improve the quality of the urban environment.

Table 3. Evaluation values and coordination degree of Datong DPSIR system for sustainable development.

System	2015	2020	2025	2030
Driving force (D)	0.046	0.075	0.098	0.110
Pressure (P)	0.026	0.037	0.039	0.045
Status (S)	0.060	0.106	0.138	0.162
Impact (I)	0.059	0.118	0.139	0.193
Response (R)	0.033	0.040	0.048	0.053
Comprehensive capacity for sustainable development (O)	0.045	0.075	0.092	0.116
Coordination	2.141	2.049	2.034	2.005

4.2. Analysis of Sustainable Development Path of Datong

The above research and analysis show that the comprehensive capacity of sustainable development in Datong is improving year by year. Datong City can solve the air pollution and water pollution problems caused by long-term coal overexploitation and extensive development of heavy industry from the two aspects of ecological protection and energy efficiency improvement. Specific measures include focusing on equipment manufacturing, modern medicine, cultural tourism and new energy, and creating new growth points around big data, new materials, electronic information, general aviation, modern textiles and intensive processing of agricultural products. In view of the problem of industrial transformation and in combination with the foundational and strategic needs of industrial development, Datong focuses on linkages with Beijing Tianjin Hebei, Yangtze River Delta, Pearl River Delta and other regions, and throws "olive branches" to central enterprises, state-owned enterprises and powerful private enterprises. In 2020, Datong signed a total of 318 investment promotion projects, with a total signed investment of 151.98 billion yuan. At the same time, we also enhance our independent innovation ability by strengthening key technology innovation, optimizing innovation service systems, and building innovation communication platforms. In view of the shortcomings of people's livelihood security, Datong City has made specific efforts to overcome poverty and make people rich. For example, from 2004 to 2020, the total economic output value of YangJiaYao increased from 1.22 million yuan to 1 billion yuan, the collective economic income of the village increased from less than 10,000 yuan to 100 million yuan, and the per capita net income of farmers increased from 811 yuan to 50,000 yuan. The butterfly change of YangJiaYao is a microcosm of Datong's efforts to fight poverty and revitalize rural areas in recent years. Datong has expanded employment channels through multiple channels in recent years. From January to July 2021, 30,760 new jobs were created in Datong cities and towns.

At the same time, as an old industrial base in China, Datong is unswervingly focusing on transformation and accelerating the growth of development momentum. We continued to set off a new upsurge in the construction of "six new" projects, and signed contracts for projects such as general aircraft R & D and manufacturing bases. The construction of a modern pharmaceutical industrial park, pumped storage power station, Datong base of Shanghai Reshape Energy Technology Co., Ltd. has started. LongJi green energy and newly developed hydrogen energy projects were completed and put into operation. Following the successful holding of the first provincial tourism conference, Datong's National Tourism reform and innovation pilot zone was successfully approved, and the strategy of strengthening the city through culture was initiated. In the process of optimizing the urban space and industrial pattern, not only the radiation and driving capacity of the central urban area has been comprehensively improved, but also the urban construction has taken on a new look. While pursuing sustainable economic and environmental development, we will focus on the people and continue to improve the livability of cities and people's happiness.

The development zone is the main battlefield to promote and support transformation and development, with the main engine driven by innovation, and the new driving force of economic growth. Datong is located at the junction of Shanxi, Hebei and Inner Mongolia. It has abundant energy, convenient transportation, good ecological environment, a solid industrial foundation and "congenial conditions" for the construction of the development zone. Datong gives full play to the location and resource advantages of one national level Economic and Technological Development Zone and seven provincial-level economic and technological development zones, closely focuses on the national industrial opportunities, constantly innovates development concepts and measures, focuses on improving infrastructure such as roads, water supply and drainage, power supply and communication, and strives to create a business environment of "no difference, no obstacle, no worries" and "predictable, reliable and developable", constantly improves the industrial innovation level and carrier function. Datong Economic and Technological Development Zone, based on the development of the economy, is mainly responsible for the main industrial sector, and adheres to creating a structural pattern of diversified industrial support. It has initially formed an industrial layout with the pharmaceutical and equipment manufacturing industries as the pillar, and new energy, new materials, electronic information, general aviation, trade logistics and food processing as the auxiliary. The output values of the pharmaceutical industry and equipment manufacturing industry have both exceeded the ten billion yuan mark. Industrial transformation and remodeling not only need to promote the high-end development of traditional industries, but also need to embrace new technologies, new industries, new forms of business and new models, and give birth to new economic growth points.

Based on the above analysis, the author designed the sustainable development path of Datong City, and proposed an innovation driven transformation and upgrading path based on enhancing key technology innovation, improving independent innovation ability, optimizing innovation service systems and building an innovation exchange platform. It proposes specific tasks and actions for industrial support, ecological protection, energy utilization, improvement of urban comprehensive functions and livelihood security. At the same time, we have built a support and guarantee system for the transformation and upgrading of resource-based cities, including scientific planning, institutional innovation, information sharing, coordinated development and multilateral cooperation.

The sustainable development of a city is a complex problem with multi-level, multi-dimensional and multi-agent aspects. In addition to the above development themes and action measures to stimulate the endogenous power of a city and improve its internal structure, it also needs the support and cooperation of external factors and seeks the driving force of sustainable development from the outside. Datong is located at the junction of the eastern, central and western economic plates. It is not only the ecological neighbor of the capital Beijing, but also a strategic base for undertaking the industrial transfer from Beijing, Tianjin, Hebei and the Bohai rim. It plays an important role in the overall layout of the country. Therefore, establishing a cross regional ecological environment information sharing platform, promoting joint prevention and control of the ecological environment in Beijing, Tianjin and Hebei, and seeking multilateral cooperation including countries and regions of the "the Belt and Road" are of great significance to externally promote Datong's economic transformation and ecological governance.

4.3. Formatting of Mathematical Components

Looking back at the thinking underpinning Datong's economic development, it can be said that it has been a process of gradually maturing the concept of transformation. In accordance with the requirements of the concept of sustainable development, Datong has established the development theme of "resource-based city transformation" and formed the development strategy of "transformation development and green rise". Transformation and development means that Datong will change from the traditional development track of a resource-based city to the track of sustainable development, and gradually realize the transformation from a traditional coal energy base to a new energy base, from a traditional cultural resources city to a first-class historical and cultural city, from a traditional old industrial city to an eco-industrial strong city, and from a traditional trade distribution center to a modern logistics center city [34]. Green rise is to change the backward mode of production and lifestyle in accordance with the fundamental requirements of the scientific concept of development, from an extensive development mode relying solely on resource consumption, capital investment, the increase in the number of production factors and even the sacrifice of the environment, to an intensive development mode relying mainly on scientific and technological progress, the improvement of the quality of workers and management innovation, so as to build Datong into a city with culture as the soul, ecology as the guarantee and emerging industries as the support—a resource-based city with sustainable development characterized by livability and leisure. From "black" to "green", its transformation path provides strong theoretical support for transformation and development (See Figure 1).

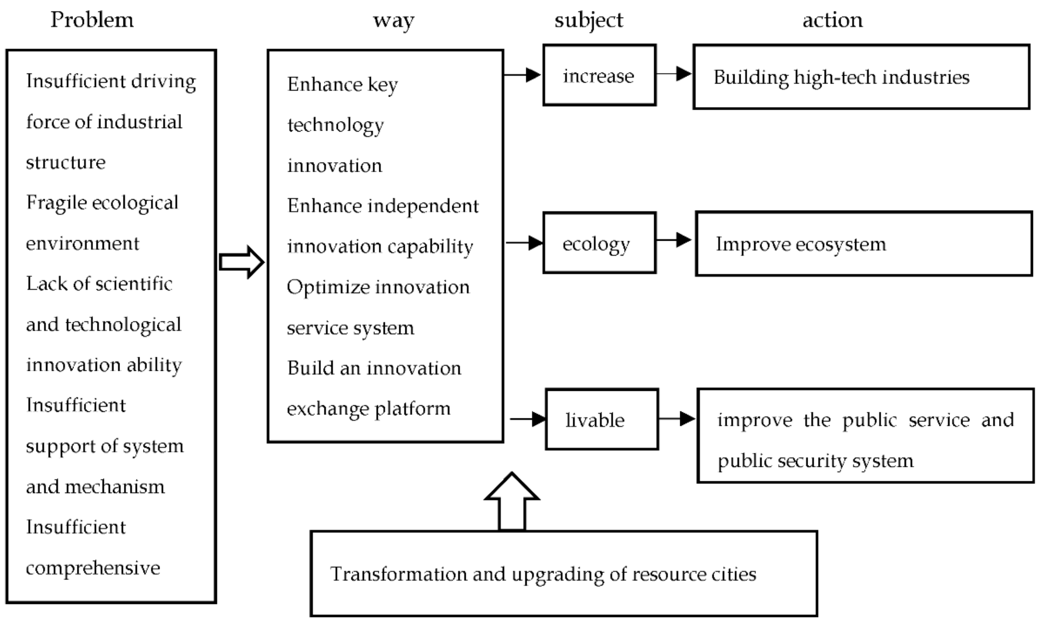

Figure 1. Sustainable development path of Datong.

5. Discussion

5.1. Leading Transformation with Scientific Development Concept

Transformation aims not to deny resource advantages, but to make efficient use of resources [35–41]. The transformation is to jump out of the strange circle of "mining exhausted city decline" of resource cities. This is not abandoning resources, but amplifying resource advantages. At present, Datong has basically broken the pattern of "one coal dominating the market", built a diversified development pattern of coal chemical industry, equipment manufacturing, medicine, metallurgy and chemical industry, building materials and characteristic agricultural products, and maintained a sustained growth trend in the economic aggregate.

Transformation is not abandoning traditional industries, but seeking new industries. Cultivating strategic emerging industries is the top priority of transformation, but the transformation and upgrading of traditional industries is still the "main content". Focusing on traditional industries, we implemented cluster planning and upgrading development of traditional competitive industries such as energy industry, coal chemical industry and equipment manufacturing, aimed at the high end of the industrial chain, focused on breakthrough core technologies, and cultivated a number of new and high-tech growth points [42–46].

Transformation is not a blind pursuit of the near, but a "long-term strategy and near implementation" of sustainable development. Transformation does not take a day, but we cannot deny the current growth. In response to the current complex international situation, we must unswervingly maintain growth, but we must not forget the transformation in "maintaining growth". We must always change the mode of economic development and coordinate it with economic growth, resist immediate temptation, resist temporary pain, and strive to achieve the unity of ensuring growth and sustainable development.

5.2. Strive to Walk Out of a New Path of Transformation and Leap

The transformation of resource-based cities focuses on the transformation from resource driven to innovation driven, from resource dependent to science and technology dependent, and from "environment for development" to "green for development". Key policy features include:

1. Leading the transformation with emerging industries. Strategic emerging industries are the engine of transformation and the forerunner of building a new industrial system. While promoting the adjustment and upgrading of traditional advantageous industries, we plan for development in 5 and 10 years, determine low-carbon economy and circular economy as the main direction, focus on the development of new energy, new materials and new pharmaceutical industries, and formulate relevant industrial plans and supporting policies. Focus on cultivating a complete vertical industrial chain and horizontal supporting industrial clusters from R & D to manufacturing.
2. Accelerating the transformation with service industry. We adhere to the cultivation of modern service industry as a pillar industry. Through the implementation of the revitalization plan for culture, tourism, business logistics, financial services and real estate, the growth rate of the service industry should be significantly higher than the GDP growth rate, the growth rate of the added value of the service industry should be significantly higher than the industrial growth rate, and the growth rate of investment in the service industry should be significantly higher than the growth rate of fixed assets investment in the whole society.
3. Promote transformation with urbanization. To meet the needs of economic transformation, we should grasp several key points in the process of promoting urbanization. First, we should pay equal attention to "spatial expansion" and "function improvement". According to the idea of "central breakthrough, cluster development, urban and rural integration and echelon promotion", we should open up the urban framework in a large span and focus on breaking through the problems of small-scale cities, low bearing functions and weak aggregation capacity. Second, the "industrial development form" and the "urban space form" are mutually integrated, focusing on the integrated development of industry and city, and optimizing the industrial spatial layout. Third, "infrastructure" and "service facilities" advance together, relying on airports, bus stations, railway stations and other nodes, aiming to optimize the integrated functions of transportation facilities, and based on expressways, to promote the construction of a large transportation system.

6. Conclusions

6.1. Research Significance

Our paper constructs a sustainable development indicator system based on DPSIR, which measures the comprehensive capacity of resource-based cities for sustainable development under the framework of the SDGs by using indicators that correspond with the SDGs and taking Datong City as a case study. We evaluate the sustainable development capacity of resource-based cities from five subsystems: driving force, pressure, status, impact and response. This model provides a significant reference for the transformation and development of resource-based cities. The research shows that:

(1) Innovation driven transformation and upgrading is an effective way for resource-based cities to take the path of sustainable development. Single and low-level industrial structure, imperfect systems and mechanisms, and insufficient innovation capacity are the main reasons why resource-based cities lack endogenous power for sustainable development [47–52]. The sustainable development of resource-based cities needs to be realized through the overall transformation and upgrading of system, economy, environment and society. Resource-based cities usually have a high proportion of heavy industry. Innovation drive is the core of relieving low-end production capacity, promoting the transformation and extension of the industrial chain to high technology and high added value, and developing new and diversified alternative industries.

(2) Ecological fragility and environmental pollution caused by extensive development are the main problems restricting the sustainable development of resource-based cities [53–55]. Water pollution and air pollution are the bottlenecks and shortcomings of the transformation and development of a large number of resource-based cities. Through system, management mode and technological innovation, we can give full play to the positive role of the government and the market, build a market-oriented and diversified participation mode of “government led, market operation and industrial ecological park building”, and achieve outstanding results in ecological construction.

(3) “Growth, ecology, low carbon, livability and happiness” is the theme and goal of sustainable development of resource-based cities. Urban sustainable development emphasizes the coordinated development of economy, society and environment [56–60]. In the past, it was difficult to completely solve the root problems restricting the sustainable development of resource-based cities by unilaterally emphasizing industrial upgrading and pollution control. The government, enterprises, scientific research institutions and other stakeholders need to deepen their understanding of the concept of sustainable development and strengthen systematic and holistic thinking.

(4) To achieve sustainable development, resource-based cities need to improve their internal functions and enhance their endogenous power [57–64]. At the same time, they also need to strengthen opening-up and multilateral cooperation, establish cooperation and linkage mechanisms, make full use of policy advantages, other cities, regions, countries and other external factors to promote local transformation and upgrading. This will support an internally and externally coupled development model, and jointly help cities achieve comprehensive transformation and upgrading.

6.2. Research Prospect

Finally, it should be noted that the analysis framework constructed by the author is open, and the specific indicators in the DPSIR sustainable development indicator system can be replaced according to the actual situation of the research area. The authors take note of the long-term development status of the Sustainable Development Goals. However, since the data in 2025 and the future are predicted values, they can be used as the basis for measuring whether the urban goal setting is reasonable. Their relationship to the real situation of the future sustainable development of the case study city will need to be verified later.

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