A preliminary study on the evaluation index system of low carbon city development level

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Abstract: Based on the clarification of the DPSIR model and the development history and specific connotation of low carbon cities, this paper proposes the design basis, design principles and design steps of the low carbon city development level evaluation index system based on the DPSIR model by analysing the application of the DPSIR model in the evaluation of the development level of low carbon cities, and forms the low carbon city development level evaluation index system.

Keywords: DPSIR model, low carbon city, indicator system

1. Introduction

With the accelerated urbanisation process, China's resources and environmental problems are becoming increasingly prominent, such as deteriorating air quality, shortage of water resources, significant urban heat island effect, traffic congestion, backward environmental facilities, low energy efficiency and waste of resources^[1]. In recent years, China has attached great importance to environmental protection and sustainable development, and many regions have been piloting low-carbon cities, a new green development model based on low energy consumption, low pollution and high energy efficiency, which requires human society to follow an "environment-friendly" path. In recent years, more and more cities have begun to integrate the concept of low carbon development into their urban planning and development strategies, promoting the application of this concept in China through policy guidance and market mechanisms, and continuing to promote the process of building low carbon cities. Assessing the level of low carbon development in these cities will help the government and relevant departments to formulate better urban development strategies and policies, strengthen urban planning and construction, improve urban management and achieve sustainable economic development.

However, in the planning and construction of low carbon cities, an important reason affecting the planning and construction of low carbon cities is unreasonable land planning^[2]. Regarding the evaluation of the development level of low-carbon cities, there are problems such as the lack or imperfection of the index system, the uncertainty of statistical data, and the ambiguity in the formulation of targets. The introduction of the DPSIR model can provide a comprehensive evaluation of all aspects of the city, clarify the links between the elements, provide a scientific basis for the development of the city, provide support for decision-making and policy implementation, and contribute to the promotion of low-carbon urban development.

DPSIR is a systematic approach to research that uses human-ecological interactions as evaluation indicators ^[3]. This paper uses hierarchical analysis to divide the indicators of the five dimensions of Driving Force, Pressure, State, Impact and Response into three layers, namely category layer, primary indicator layer and secondary indicator layer, so as to construct the evaluation index system of low carbon city development level. Among these factors, dynamics are the potential factors that drive change in the environment; pressure is the pressure that the driving force exerts on the environment; state is the real situation that exists in the environment; impact is the effect of environmental change on human health and the impact on the economy and society; and response refers to the response made by people. The model can be used to evaluate the complexity of environmental problems, the sustainability of solutions, and to guide environmental policy and governance.

ISSN 2616-7433 Vol. 5, Issue 6: 60-64, DOI: 10.25236/FSST.2023.050609

2. Low carbon city development level evaluation index system based on DPSIR model

A low-carbon city development assessment index system based on the DPSIR model evaluates the development level of low-carbon cities from five aspects: driving factors, pressure factors, state factors, impact factors, and response factors.

2.1. Basis of design

2.1.1. The role of environmental Kuznets theory in guiding the evaluation of the level of development of low carbon cities

The essence of the environmental Kuznets theory is to develop the economy on the basis of sustainable ecological development, emphasising the correlation between the environment and the economy. The environmental Kuznets curve, derived from the evolution of per capita income and environmental pollution indicators, illustrates the role of economic development in the level of environmental pollution. The ultimate goal of a low carbon city is to reduce carbon emissions so that the rate of growth of carbon emissions is less than the rate of growth of the city's economic development, thereby reducing the negative impact of ecological damage on economic development. Therefore, by drawing on the ideas and methods of this theory, in evaluating the development level of low carbon cities, the introduction of indicators such as total energy consumption, energy consumption structure, energy intensity, urban GDP and water pollution index can be considered[4-6].

2.1.2. The role of systems theory in guiding the evaluation of the level of development of low carbon cities

Systems theory is the study of the essential characteristics, operation and frontiers of complex systems from a holistic and local perspective. The evaluation of the level of development of low carbon cities involves economic, environmental and social factors, which are not isolated from each other, but are interrelated, interconnected and interacting at multiple levels. These factors are themselves made up of smaller systems, but are also part of a larger system, namely the environmental, economic and social systems. In the comprehensive evaluation of low carbon cities, the uncertainty in the selection of indicators and the difficulty in obtaining the weight values of each indicator make it difficult to achieve the desired results by traditional methods. Therefore, with the system optimisation as the starting point, comprehensive analysis and measurement of the urban objectives that should be achieved, evaluation indicators such as the value of ecosystem services, health impacts, and urban planning and design can be introduced.

2.1.3. The role of low carbon economic theory in guiding the evaluation of the level of development of low carbon cities

The theory of low carbon economy means that through technological innovation, energy structure reform and industrial transformation, economic development can be ensured while reducing carbon emissions. A low carbon economy emphasises the reduction of waste and consumption of energy and resources, and promotes the efficient use of energy and the development and utilisation of renewable energy, with innovation in energy use technologies and energy management systems at its core. Therefore, to evaluate the development level of low-carbon cities based on the theory of low-carbon economy, it is necessary to consider the low-carbonisation of the energy utilisation process and the reduction of greenhouse gas emissions, etc. Evaluation indicators such as energy conversion efficiency, energy utilisation efficiency and greenhouse gas emissions can be introduced.

2.1.4. The role of sustainable development theory in guiding the evaluation of the level of development of low carbon cities

The theory of sustainable development is about ensuring that the needs of future generations are met through the harmonious development of the economy, society and the environment, while meeting the needs of the present. The concept of sustainable development not only emphasises the efficient use and protection of resources but also the balance of social interests, encouraging the participation of all sectors of society in urban development. This requires the evaluation of low carbon city development levels to take into account the improvement of economic efficiency, the change of consumption patterns and the protection of ecological and environmental quality, and can introduce evaluation indicators such as low carbon energy development, energy saving and emission reduction policies and ecological impact.

ISSN 2616-7433 Vol. 5, Issue 6: 60-64, DOI: 10.25236/FSST.2023.050609

2.2. Design Principles

The design of the low carbon city development level evaluation index system based on the DPSIR model should follow the following four principles. Firstly, to clarify the evaluation objectives and the hierarchical structure of the indicator system, and to determine the hierarchical structure and components of the evaluation indicators, so as to ensure the comprehensiveness and systematicity of the evaluation indicators. Secondly, clarify the coverage of indicators, determine the spatial and temporal scales of evaluation objects and indicators, as well as the degree of refinement and coverage of indicators, so as to ensure the comprehensiveness and system. Thirdly, consider the interrelationship between indicators, and give full consideration to the interaction and influence between indicators in order to ensure coordination and consistency between evaluation indicators. Finally, ensure the measurability of the indicators and the availability of data to ensure the interpretability and operability of the evaluation results, so as to provide a scientific evaluation basis and decision-making support for the development of low carbon cities. Following the above principles will help to establish a comprehensive, systematic and operational evaluation indicator system for the development level of low carbon cities.

2.3. Design Steps

The design steps for constructing a low-carbon city development level evaluation index system include the formulation of evaluation objectives, determining the hierarchical structure of the index system, clarifying the scope and boundaries of the evaluation objects and evaluation indicators, sorting out the internal links between the indicators, acquiring and processing data for the evaluation indicators, and explaining and applying the evaluation results. In the above process, we first analyse and study the factors affecting the construction of low-carbon cities, and then select the appropriate model to complete the corresponding work according to these factors. Both of these steps should be considered in relation to the actual situation of the city, policy orientation, scientific method and many other elements, so as to build a scientific and reasonable evaluation index system. On this basis, the evaluation indicator system is elaborated according to the specific requirements of the different levels. It also defines the scope of the evaluation indicators, clarifies the interlinkages between indicators, and improves the data acquisition and processing to ensure that the evaluation indicator system is scientific and operational, providing a scientific evaluation method and decision support for the sustainable development of low carbon cities[9-10].

2.4. Low carbon city development level evaluation index system

Category	Tier 1 indicators	Secondary indicators
Driving force	Energy consumption	Total energy consumption
		Energy consumption structure
		Energy intensity
	Population growth	Number of people in the city
		Population growth rate
		Population density in built-up areas
	Economic Development	City GDP
		Economic growth rate
		Urbanization rate
		Share of secondary sector
Pressure	Greenhouse gas emissions	CO ₂ Emissions
		CH ₄ Emissions
		Industrial fume emissions
	Energy consumption efficiency -	Energy use efficiency
		Energy conversion efficiency
	Waste disposal efficiency	Waste disposal capacity
		Waste separation rate
Status	Air Quality	PM2.5 concentration
		Ozone concentration
	Water quality conditions	Water quality
		Water Pollution Index
	Land use	Urban land area

Table 1: Low carbon city development level evaluation index system

The Frontiers of Society, Science and Technology
ISSN 2616-7433 Vol. 5, Issue 6: 60-64, DOI: 10.25236/FSST.2023.050609

		Green space coverage
Impact	Climate change impacts	Average temperature change
		Rainfall variation
	Health effects	Environmental pollution-related mortality
		Incidence of diseases related to environmental pollution
	Ecological impact	Ecosystem service values
		Biodiversity Index
Response	Low carbon energy development	Percentage of new energy
		Restructuring of energy consumption
	Energy saving and emission	Measure implementation rate
	reduction policy	Policy support rate
	Urban planning and design	Percentage of green buildings
		Level of public transport development

By combining the actual situation of the city and the mutual influence and synergy between different indicators, as well as the weight and evaluation criteria of each indicator, the DPSIR model is used as the basis for a profound analysis of the development level of low carbon cities, and the relevant environmental protection standards and requirements in China are combined to establish a low carbon city development level evaluation index system, as shown in Table 1.

3. Conclusions

The construction of low carbon cities is one of the most important ways to cope with environmental changes and meet the requirements of sustainable development, involving economic, environmental, technological, educational, management and policy aspects. In the process of building a low-carbon city, evaluating its level of construction is a key aspect. By introducing the DPSIR model, this paper focuses on the five major elements of society, economy, energy, technology and ecology, and selects reasonable evaluation indicators from the logical relationship of "what happens, why it happens and how to respond". The study explores how to construct a comprehensive, scientific and practical evaluation index system for the development level of low carbon cities. The study of low carbon city development level evaluation index system is a key part of promoting the improvement of low carbon city construction level, and is also an inevitable requirement to promote the sustainable development of low carbon cities.

Acknowledgements

Chongqing University of Science and Technology postgraduate innovation plan project (YKJCX2220615).

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