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Research Article

Environmental Design and Sustainable Development of Ecological Environment by Big Data Analysis and Computing: A Case Study of Tianjin

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Sustainable development, as a new idea of development, has become a source of worldwide concern. Many elements, such as society, economics, resources, and the environment, have a role in the long-term evolution of the ecological environment. It is an intricate mechanism. Based on previous research, this study investigates the relationship between environmental design and the long-term evolution of the ecological environment in the new age. The following are the specifics. First, the conceptual model of ecological sustainable development is constructed, and the "low-carbon idea" environmental design approach is addressed. Then, using Tianjin as an example, an assessment method for environmental sustainable development in environmental design is constructed based on summarizing past studies. The ecological features are included in the DPSIR model, and the "low-carbon concept" environmental design method is used in Tianjin Binhai New Area. The findings show that, with the continued development of Binhai New Area, the adjustment of industrial structure, and the gradual improvement of people's awareness of urban sustainable development, the ecological environment's sustainability index will improve, with per capita ecological carrying capacity rising from 2019 and the per capita ecological carrying capacity of agricultural and livestock products, which are 0.09 hm^2 and 0.09 hm^2, respectively, rising significantly. Since 2019, the per capita ecological footprint has also declined.

1. Introduction

With the rapid development of modern economy and the acceleration of global economic integration, environmental problems have become increasingly prominent, such as acid rain, greenhouse effect, desertification, and sea-level rise, which have seriously threatened human survival and development [1]. Its essence is mainly the problems of resource crisis, environmental pollution and ecological degradation, destruction of ecological balance, and so on [2]. Nowadays, all countries in the world have focused on managing resources and environmental problems so as to closely connect the development of society, economy, and environment and realize sustainable development. Sustainability was first put forward by ecologists, that is, the so-called ecological sustainability, which represents the balance between natural resources and their development and utilization [3]. The symposium on sustainable development jointly held by the International Federation of Ecology and the International Federation of Biosciences deepens the natural attribute of the essentials of sustainable development and defines sustainable development as "protecting and strengthening the production and renewal capacity of the environmental system"; that is, sustainable development is a development that does not exceed the renewal capacity of the environmental system [4]. Starting from the biosphere essentials, defining sustainable development is another representation of sustainable development from the aspect of naturalness; that is, it is considered that sustainable development is to seek an optimal ecosystem to support the ecological integrity and the realization of human aspirations so as to make the human living environment sustainable. Ecological environment refers to the sum of the ecological conditions of the living space around biological organisms. The ecological environment is composed of many ecological factors, which play a comprehensive role in biological organisms [5]. Ecological factors include abiotic factors and biological factors. In nature, ecological factors do not act on organisms in isolation [6]. Each ecological factor is interrelated, affects each other, and shows its own role under comprehensive conditions [7].

Environmental design respects the integrity of the natural environment and cultural and historical landscape. It not only attaches importance to historical and cultural relations but also takes into account the needs of social development [8]. It is characterized by the combination of theoretical research and practical creation, environmental experience, and aesthetic guidance [9]. Environmental design takes the architecture in the environment as the main body, comprehensively uses artistic methods and engineering technology in its internal and external space, and implements the design of microenvironment, including urban and rural landscape, landscape architecture, and architectural interior [10]. Environmental design requires reasonably formulating design objectives and realizing value conception based on object environmental investigation and evaluation, comprehensive consideration of ecology and environment, function and cost, form and language, symbol and symbol, and material and structure [11]. The problem of environment and resources has aroused the thinking of "low-carbon," and it is no exception in the field of environmental design. In the past, the low-carbon concept expressed by the environment was often ignored in the process of environmental design, and the artificial means were excessively used to replace the natural regulation function, resulting in huge energy consumption and environmental deterioration [12]. As one of the high energy-consuming industries, environmental design and environmental construction urgently require a low-carbon concept to guide environmental design and build it into the sustainable development of the natural environment [13].

The design of New York Central Park by Olmsted and Fox made the urban park from a private manor to a part of the public shared urban environment, which opened the prelude to the western modern environmental design [14]. After the rapid development of western environmental design, different countries have formed different schools and styles, but generally speaking, they all emphasize the rational design of space and function, with the tendency of "modernism." The 14th World Conference of the International Association of architects set the theme as "architecture, people, and environment" and adopted the Warsaw Declaration, which marked that environmental design put forward a formal program and regarded environmental awareness as an important factor considering people and architecture [15]. Wu, R [16] published the book landscape ecology, which has a great impact on environmental design. After the 1990s, ecologism began to withdraw from the main position of environmental design, and environmental design showed diversified development [17]. Mondino, E., and Beery, T. believed that environmental design is a framework that plans, produces, and evaluates objects of all sizes, including products, buildings, parks, human settlements, and infrastructure, and places them in the relationship between the function and elasticity of natural systems [18]. Environmental design has significantly changed some design practices by explicitly considering the ethics and time of design across generations and beyond the simple human-centered concern [19]. It inspires landscape designers, urban designers, architects, interior designers, and industrial designers who have an instinctive response to the environment to take the environmental cost of their work as the core index for evaluating success [20]. Therefore, these practices introduce energy conservation, natural resources, and materials into the design process, production objects, space, and landscape and increase durability and long-term social flexibility. Su, Y. Y. [21] put forward "new environmental design": environmental design is committed to using an overall, people-oriented, and sustainable way to create and promote a sustainable "life, space, and ecosystem," including experience, communication, and place in the process of interaction between human and environment. It can be seen that the focus of environmental design has changed from the material environment to people's cognitive experience in the environment, sustainable living space, and other nonmaterial objects. This paper mainly explores the correlation analysis between environmental design and sustainable development of ecological environment in the new era from the perspective of environmental design [22]. The "low-carbon concept" is applied to environmental design, and the problems in the application of low-carbon concept in environmental design are analyzed combined with a questionnaire survey [23].

2. Relevant Theories

2.1. Construction of Conceptual Model of Ecological Sustainable Development. The sustainable development of a city is the pursuit and goal of the construction and development of a sustainable ecological city [24]. According to the theoretical research, the sustainable development of an urban system must be ensured on the premise of ensuring the sustainable development of the natural system. Considering the sustainable development, the system must optimize its structure, enhance its openness, dynamics, adjustability, and environmental adaptability, and improve the input-output conversion efficiency [25]. Through the description of the social and economic situation of the system, the mutual adaptation and adjustment mechanism with resources, population, and environment, and the changes of resource conversion efficiency, population suitability, and environmental adaptability, the development status of urban system can be evaluated. The joint action of external and internal forces of the city affects the development and change of the city, which is likely to be caused by the migration of population, the change of industrial structure, the change of cultural concept, the change of traffic form and route, the development of new technology, and even the needs of social life [26–28].

The sustainable development of ecocity means that the development of the previous generation cannot affect and damage the development of the next generation, and the development of one part of people cannot hurt the development of another part of people in the process of development. Urban development cannot be at the expense of wide area environmental development; that is, while promoting economic development, we must fully consider the externality of economic activities and ensure that contemporary and future generations can meet the requirements so as to achieve common and coordinated development between this region and other regions. Figure 1 shows the connotation of ecological sustainable development.

The sustainable development of ecocity spatial system is based on the understanding of the complexity of ecocity space. The most important factor affecting urban development and construction is the complex relationship between various elements [29, 30]. It regards respecting the internal law of ecocity spatial system as the basis for realizing sustainable development and provides "inclusiveness" and "adaptability" for realizing the construction of sustainable ecocity. Firstly, "inclusiveness" reflects the diversity of urban space and supports the existence of diversified spatial structure and form. Secondly, "adaptability" can be understood as enabling people to pay attention to the complexity of urban spatial system and the specificity of space so as to deal with the changes of the outside world. Therefore, the complexity of urban spatial system is necessary to study the sustainable development of ecological urban space.

2.2. "Low-Carbon Concept" and Environmental Design. Since the Copenhagen Climate Change Conference, "low-carbon" has become the hottest topic in the world. As climate change has become more and more recognized, the common will of the international community to deal with climate change is becoming stronger and stronger. The low-carbon future has become an important direction of social and economic development, and many people have begun to deeply reflect on the current human production and lifestyle. In the process of environmental design, the construction of indoor and outdoor environment is facing unprecedented pressure from energy conservation and emission reduction. Since 2004, energy shortages such as power shortage and coal shortage have erupted all over the country, and the national energy is extremely tight. As the largest construction market in the world, building energy conservation has become a necessary choice in the energy dilemma. According to the statistics of relevant parties, at present, steel, cement, brick and tile, wood, and other building materials consumed by construction in China account for 30% of the national energy production every year, and 60% of the carbon emissions in cities come from the building maintenance function itself. Although the development of low-carbon environmental design is imminent, there are still some puzzles in theory and practice. Some government officials and even designers still have two puzzles to solve: first, does the realization of low-carbon environmental design mean reducing the living standards of urban residents? Second, the living habits and consumption patterns formed by urban residents for a long time are difficult to change in a short period of time. Under this inertial life mode, is the implementation of low-carbon environmental design just a theoretical fantasy? What changes will take place in the future environmental design driven by the new lifestyle of low-carbon lifestyle? These problems deserve our attention.

3. Environmental Design Means of "Low-Carbon Concept"

This paper has collected and studied works and articles on low-carbon design and environmental design at home and abroad, browsed some special websites of environmental design at home and abroad, searched a large number of articles, reports, and cases on the low-carbon concept and environmental design through professional websites, enriched empirical data, sorted out the research results of low-carbon environmental design at home and abroad, analyzed and summarized them, and discussed the interaction and development trend between environmental design and sustainable development of ecological environment, as well as some assessment methods and standards of low-carbon assessment and environmental design. The specific route is shown in Figure 2.

3.1. Main Design Level. The low-carbon consideration of the design subject mainly refers to whether the work and design methods adopted by designers in designing buildings and environment meet the low-carbon standards, such as paperless design, low-carbon travel, and electronic office, so as to reduce carbon emissions through low-carbon working methods. In fact, the low-carbon consideration of the design subject is mainly to achieve low-carbon work. At this stage, we can implement the low-carbon work from the following aspects.

3.1.1. Reduce Inaction Consumption of Electricity. When the light is sufficient, try to turn off the indoor lighting. When the computer is not used for a short time, let the computer enter the "standby" mode, and the energy consumption can be reduced by about 50%. Turn off the speaker, printer, and other types of peripheral equipment when not in use. The unused programs should also exit in time: less hard disk, USB drive, and optical drive work at the same time. Reduce the brightness of the display properly, set the screen saver to "none," and then set the time to turn off the display in the power use scheme. Turning off the display directly saves power compared with any screen saver. Pay attention to the power plug of the printer. If it is not used for a long time, turn off the power of the printer and its server, and pull out the plug to reduce energy consumption.

3.1.2. Reduce Paper Consumption. Among the many wasted papers, office paper is absolutely "among the best," and the waste of paper used for printing and copying accounts for the majority. Therefore, it is suggested to strengthen the constraints in this regard and prevent individuals from using

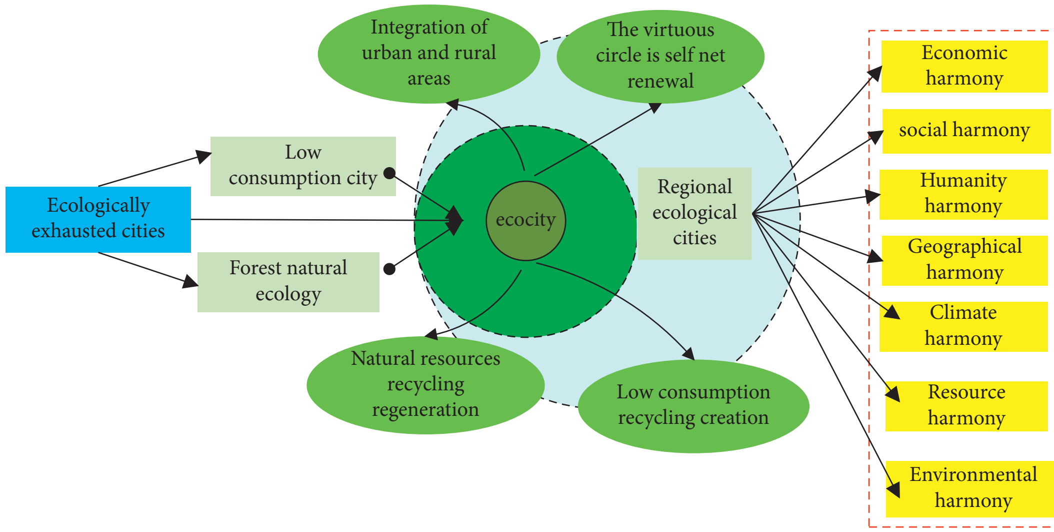

FIGURE 1: Connotation of ecological sustainable development.

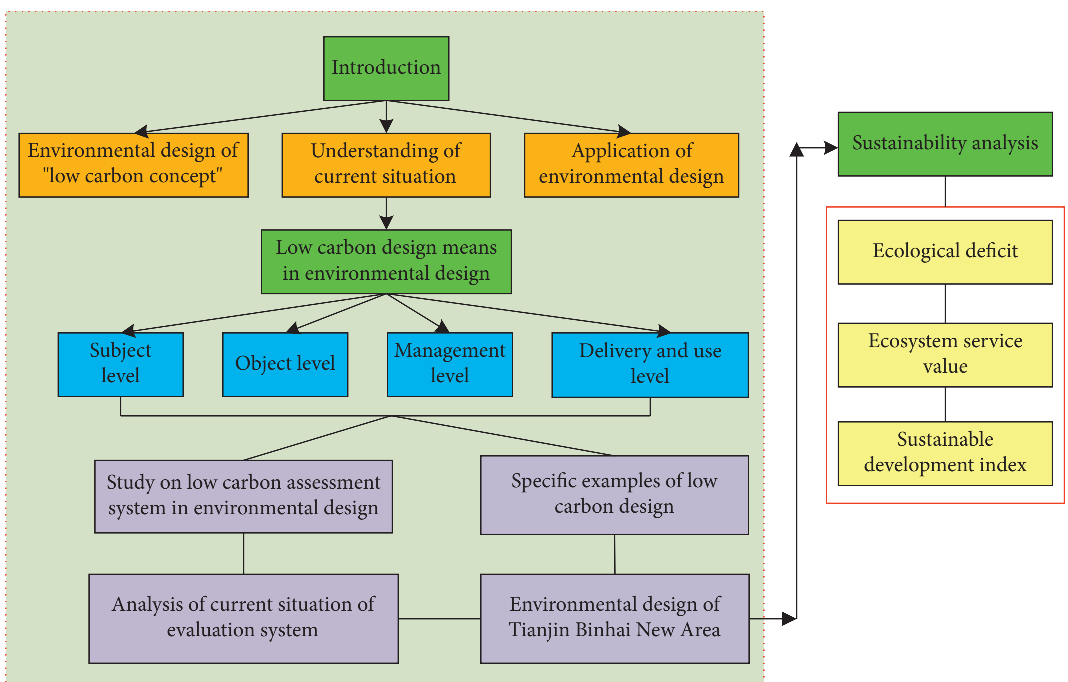

FIGURE 2: Environmental design roadmap of "low-carbon concept."

printers. It is best to reduce the page margin and line margin, reduce the font size, and use paper on the front and back as much as possible, which can save half of the paper. If the font cannot be bold or black, do not use it as much as possible, which can also save a lot of toner or lead powder. Proofread the text before printing, do not waste the whole paper because of a few wrong words, and make a waste paper recycling box. When making text, do not pursue the paper specification and thickness too much. The number of texts should be controlled.

3.2. Design Object Level. Architecture is the most important and the largest design element of the human living environment. Broadly speaking, it includes all the transformation activities of human beings to their own environment. Human low-carbon design of buildings and other environments needs to comprehensively consider various factors. From the perspective of the whole life cycle of the building, we should try to carry out the design and construction of low-carbon buildings according to scientific standards and clarify the control standards of each stage of the building in the design. See Table 1.

3.3. Operation and Maintenance Level. The energy consumption of various buildings in the use stage is analyzed (Table 2). It can be seen that there are many sources and types of energy consumption in the use stage of buildings, and the

Table 1: The control indicators of the building life cycle table.

Main project	Index	Planning stage	Construction stage	Acceptance phase	Operation phase
Environmental design	Low-carbon travel		✓	✓	
	Utility feasibility	✓	✓	✓	
	Greening vegetation	✓	✓	✓	
Environment layout	Shape coefficient			✓	
	Monomer orientation	✓	✓	✓	
Peripheral environment structure	Envelope performance	✓	✓	✓	
	Roof structure	✓			✓
	External sunshade status	✓			✓
Internal power supply system	High power energy heating				✓
	High-efficiency electric products		✓		
	Water supply system		✓		✓
Lighting system	Natural lighting of space		✓	✓	✓
	Energy-saving lamps		✓	✓	
	Lighting energy-saving control		✓	✓	✓

energy consumption is very large. Taking lighting power as an example, lighting energy consumption is an important part of building energy consumption. In 2020, China's total lighting power consumption will exceed 500 billion kWh, accounting for more than 15% of the country's total power consumption, with an annual growth rate of 13~14%. The lighting energy-saving design will reduce the building power consumption as much as possible and further give play to the value of low-carbon buildings. After the completion of the building, it will be gradually delivered for use. The use stage of the building mainly involves the mechanical and electrical equipment of the building, including building weak current system, air conditioning system, and communication system. In the process of operation and maintenance of existing buildings, on the premise of fully meeting and improving the functions of buildings, reduce energy consumption and improve energy utilization, rather than simplifying the functional requirements of buildings and reducing their functional standards. See Table 2.

Table 2: Energy consumption of various types of buildings.

Civil housing 56%	Commercial 17%	Industrial 27%
Electricity 28% fuel 72%	Electricity 25% fuel 75%	Electricity 27% fuel 73%
Indoor heating 52%	Indoor heating 42%	Manufacturing process 50%
Wall heating 11%	Wall heating 21%	Steam boiler 14%
Lamps 8%	Lamps 9%	Motor system 8%
Freezer 6%	Freezer 5%	Equipment heating 7%
Refrigerated 8%	Refrigerated 6%	Lighting and others 5%
Kitchen 2%	Kitchen 4%	CPU 3%
Computer 3%	Computer 5%	Refrigeration 3%
Home appliances 3%	Home appliances 5%	Kitchen 5%
Others 7%	Others 3%	Others 5%

4. Impact of Environmental Design on Ecological Environment

4.1. Evaluation System of Sustainable Development Based on DPSIR Model. DPSIR model is an effective tool to determine the causal relationship between environmental state and environmental problems. It analyzes the interaction between society and environmental system from the perspective of system analysis. Its index system is divided into driving force, pressure, state, impact, and response, which basically covers the four elements of economy, resources, environment, and society. Among them, "driving force" refers to the driving force to promote economic growth and social development, mainly referring to the internal potential and development trend of regional economic activities and industrial development. "Pressure" means the hindrance of human production activities to resources, environment, ecological construction, and other related systems. "State" mainly refers to the characteristics of society, resources, and environment under the current driving force and pressure. "Impact" refers to the ability of human production activities to change resources, environment, ecosystem, and the quality of social and economic development under the current system state. "Response" means that human beings adjust the current economic growth, social development, resource consumption, and environmental pollution so as to enhance the "driving force," reduce the "pressure," optimize the "state," and strengthen the "impact." The relationship between them is shown in Figure 3.

There are 31 basic indicators involved in the comprehensive evaluation index system of sustainable development based on the DPSIR model in this chapter. Because the uncertain factors in the index system are large and its weights are complex, the analytic hierarchy process, principal component analysis, and fuzzy comprehensive evaluation are generally used for evaluation. Therefore, on the basis of referring to relevant literature and consulting relevant experts, the weight influence of the system layer on the comprehensive index layer is calculated. Then, the principal component analysis method is used to calculate the sustainable development index of the five system layers, and finally, the comprehensive index value is obtained.

Principal component analysis is a multivariate statistical method that transforms multiple indicators into several

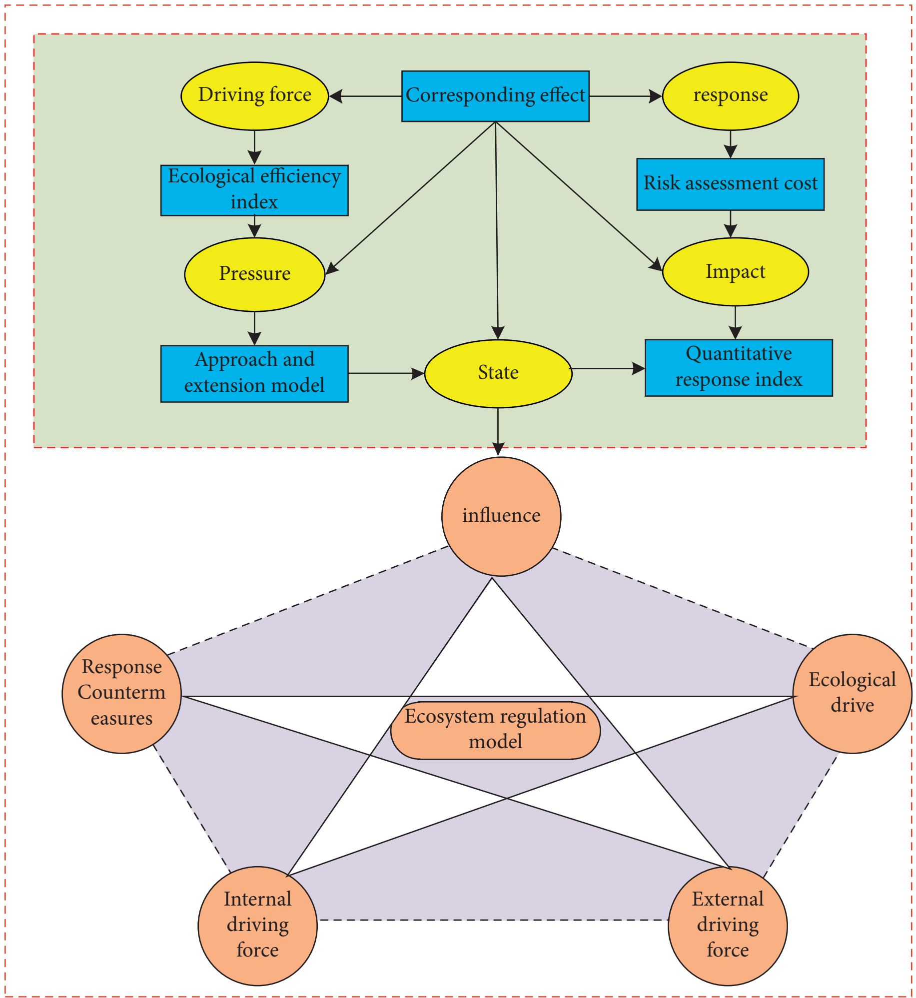

Figure 3: Schematic diagram of DPSIR model.

comprehensive indicators on the premise of little information loss. Generally, the comprehensive index of transformation is called a principal component, in which each principal component is a linear combination of original variables, and the principal components are not related to each other, which makes the principal component have some better performance than the original variables. In this paper, the principal component analysis method is used to conduct factor analysis on 6 variables of the driving force system, 10 variables of the pressure system, 5 variables of the state system, 5 variables affecting the system, and 5 variables of the response system, and the common factor with a cumulative contribution rate of more than 85% is taken.

Calculate system values as follows:

$$C_i = \sum_{i=1}^{n} S_{\mathrm{ij}} A_{\mathrm{ij}}, \quad i = 1, 2, \ldots n; \, j = 1, 2 \ldots n,$$
$$C_B = \sum_{i-1}^{n} C_i V_i, \quad i = 1, 2, \ldots n; \; A = D, P, S, I, R. \tag{1}$$

This paper involves 31 indicators, both quantitative and qualitative, and each indicator has different attributes and units, which cannot be measured by unified standards, so it is difficult to compare directly. Therefore, this paper uses the Z score method to convert all index data into dimensionless values with a mean value of 0 and a variance of 1.

$$Z_i = \frac{(v_i - \overline{v})}{S}, \quad i = 1, 2, \ldots, n,$$
$$\overline{v} = \frac{1}{m} \sum_{i=1}^{m} v_i, \quad i = 1, 2, \ldots, n, \tag{2}$$
$$F = \sqrt{\frac{\sum_{i=1}^{n} (v_i - \overline{v})^2}{n-1}}, \quad i = 1, 2, \ldots n,$$

where Z is the standardized data of the i-th index value, X is the original index value, and V is the standard deviation.

4.2. Value Evaluation of Ecosystem Sustainable Development Services. Ecosystem service value is the estimation of ecosystem services and natural capital by economic rules. According to the specific characteristics of social economy and natural ecology, the equivalent calculation method adopted by Xie Gaodi and others is widely used in relevant research. The equivalent factor of ecosystem service value represents the

Table 3: Equivalent value of ecosystem services per unit area.

Primary classification	Secondary classification	Agriculture	Ecology	Forestry	Rivers
Supply side	Original product	2	1.33	0.63	0.43
	Secondary processing	0.35	2.38	0.26	0.25
Regulatory aspects	Temperature regulation	0.32	2.32	1.9	0.58
	Weather regulation	0.91	3.07	1.32	2.14
	Flow regulation	0.74	4.01	1.19	18.23
	Pollution treatment	1.23	1.11	1.89	14.12
Support aspects	Field protection	1.28	3.02	2.89	0.89
	Ecoregulation	1.98	2.51	1.09	2.43
	Landscape protection	0.19	2.39	1.87	4.09

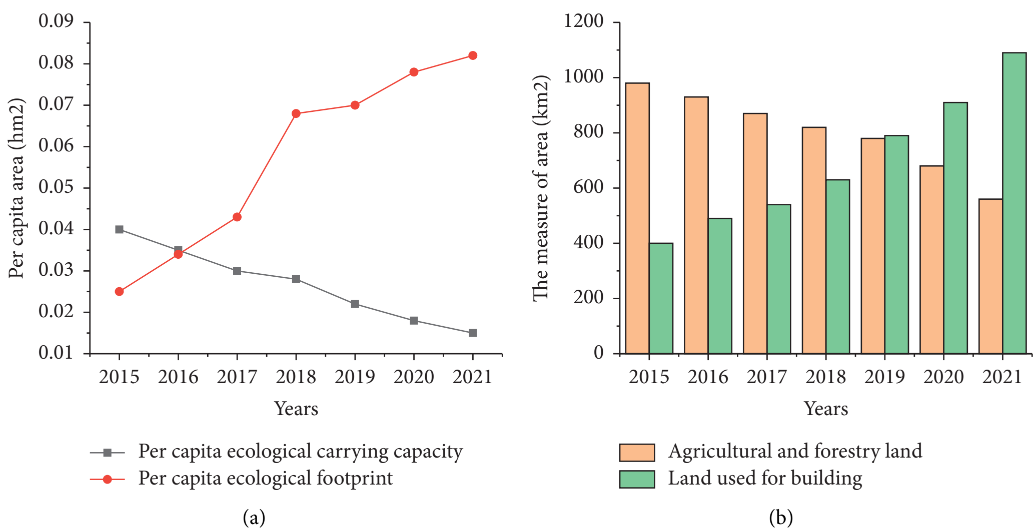

Figure 4: Per capita ecological carrying capacity, ecological footprint, and land use change in Tianjin Binhai New Area.

contribution potential of ecological services corresponding to various elements in the ecosystem, that is, the economic value of annual grain yield of 1 hectare of average yield cultivated land. On this basis, combined with the actual ecological situation of Tianjin Binhai New Area, the corresponding ecosystem service value can be calculated according to the equivalence factor. In this study, the regional ecosystem service function is divided into four first-class classifications and nine second-class classifications. See Table 3.

4.3. Analysis of Ecological Sustainability of Binhai New Area. According to the calculation results of per capita ecological carrying capacity and per capita ecological footprint of each category, the per capita ecological carrying capacity and per capita ecological footprint of Tianjin Binhai New Area can be obtained so as to calculate the response ecological profit and loss and sustainable development index. As shown in Figure 4, from 2015 to 2021, the per capita ecological carrying capacity of Tianjin Binhai New Area generally showed a downward trend, while the per capita ecological footprint generally showed an upward trend, the difference between the two increased year by year, and the ecological deficit gradually intensified. Based on the analysis of the population, economy, and land layout of Binhai New Area, the reasons can be drawn: with the social and economic development, the population is increasing, and the urban land layout is changing, resulting in the increase of urban resource and energy consumption and the gradual decline of ecological carrying capacity. The consumption of resources and energy required for population and economic growth increases year by year, the natural land decreases year by year, which increases the per capita ecological footprint year by year, the consumption of ecological resources and energy exceeds the ecological carrying capacity, and the ecological deficit is becoming more and more serious. See Figure 4.

According to the analysis of the composition of per capita ecological carrying capacity (as shown in Figure 5), the per capita ecological carrying capacity of Tianjin Binhai New Area generally shows a downward trend, but it has rebounded in recent five years. The per capita ecological carrying capacity of agricultural and livestock products accounts for a large proportion, and the per capita ecological carrying capacity of livestock products increased from 2015 to 2021, while the per capita ecological carrying capacity of aquatic products, labor services, and renewable energy changed gently. It can be seen that the change of per capita ecological carrying capacity in Binhai New Area mainly

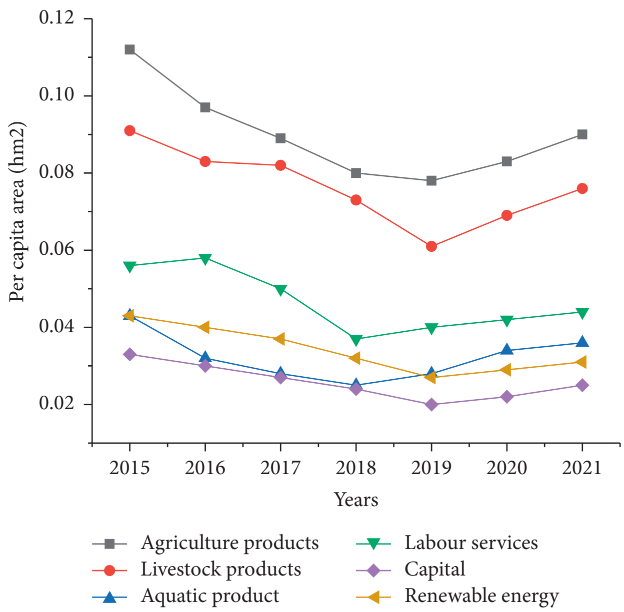

Figure 5: Per capita ecological carrying capacity of Tianjin Binhai New Area.

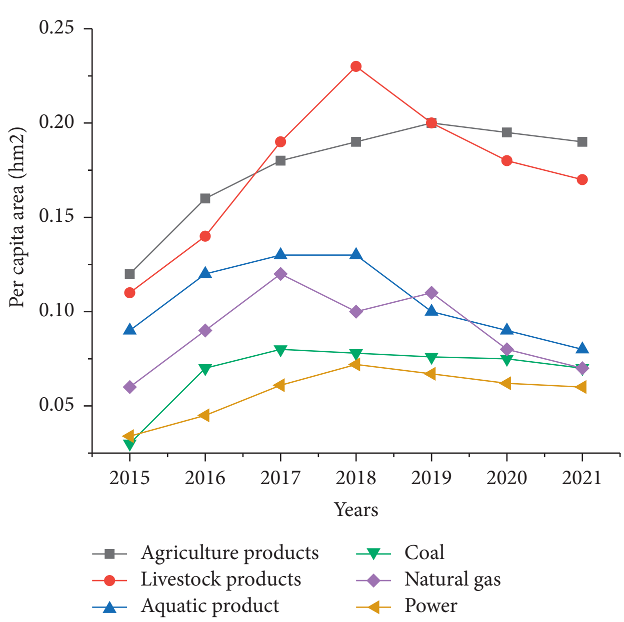

Figure 6: Change of per capita ecological footprint in Tianjin Binhai Area.

comes from the change of agricultural, livestock products, and funds. See Figures 5 and 6.

From the analysis of the composition of per capita ecological footprint (as shown in Figure 6), it can be seen that the overall per capita ecological footprint of Tianjin Binhai New Area shows an upward trend because the consumption of livestock products, oil, and electricity increases year by year, accounting for a large proportion, and the growth rate is fast in the early stage of urban development of Binhai New Area and gradually flat in the later stage. As the direct reason for the overall increase of per capita ecological footprint in Binhai New Area, energy consumption can be attributed to the industrial growth mode dominated by industrial development in the early stage of urban development in Binhai New Area. With the intervention of modern environmental design in the new era, the industrial structure is gradually adjusted, and high-tech industries are vigorously developed. Therefore, the increasing trend of per capita ecological footprint gradually slows down. The per capita ecological carrying capacity has rebounded since 2019, and the per capita ecological carrying capacity of agricultural and livestock products has rebounded significantly, which are 0.09 hm^2 and 0.076 hm^2, respectively. The per capita ecological footprint has also decreased since 2019. With the continuous development of Binhai New Area, the concept of low-carbon and green environmental design is gradually rooted in the hearts of the people, the industrial structure adjustment and people's awareness of urban sustainable development are gradually improved, its sustainability index will change, and the phenomenon of ecological deficit will ease.

5. Conclusion

First, this study organizes and analyzes low-carbon theory and technology in the field of environmental design. This study investigates the application state of low-carbon concept in environmental design and analyzes the issues of low-carbon concept in environmental design using a questionnaire survey, which is paired with numerous typical symbolic events of green construction. After that, this study focuses on low-carbon design methods of environmental design analysis, starting with the intricacies of the design and construction process. The DPSIR model is then used to assess Tianjin's ecological environment's long-term viability. The findings reveal that the eco-environmental sustainable development index of Binhai New Area has improved as a consequence of the intervention of "low-carbon concept" environmental design, and the growing trend of per capita ecological footprint has progressively decreased.

Binhai New Area's sustainable development system is a composite ecosystem made up of ecological environment, economics, and society, which is made up of single components and subsystem parts that are linked together. The purpose of an urban development sustainability analysis is to assess the level of development, long-term viability, and coordination of the environmental, economic, and social composite system in the study area in order to guide residents, including relevant government officials, urban planners, and ordinary residents, in coordinating their production, life, and ecological environment through efforts to change their production and lifestyle.

Data Availability

The data used to support the findings of this study are included within the paper.

Conflicts of Interest

No conflicts of interest exist concerning this study.

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