Systematic Evaluation of Regional Human Sustainable Development Based on Euclidean Distance: A Case Study of Shandong Province, China

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Abstract. The evaluation theory system of human sustainable development is constructed based on Euclidean distance. The data of Shandong Province from 2012 to 2021 are selected for example verification. The range of sustainable development index (H) is [0.60,0.71], showing a gentle upward trend and a state of moderate and sustainable development. The evaluation results basically reflect the situation of human sustainable development in Shandong province, indicating that it is feasible to construct an evaluation method of human sustainable development based on Euclidean distance. The innovation and advantages of this method are as follows: first, it has a reliable methodology; Second, it avoids the influence of human factors; Third, the results are easy to understand and compare. The main reasons for the low level of sustainable human development in Shandong Province are Engel coefficient, labor force population ratio, unemployment rate and so on.

Keywords: Human sustainable development · Shandong · Zero system · Goal system

1 Introduction

The theoretical system of sustainable development is formed and perfected gradually with the change of times and the improvement of human ideology under the specific social background. In the 1950s and 1960s, under multiple environmental pressures, people began to question and reflect on the traditional model of blindly pursuing development [1]. It was not until 1987 that the concept of sustainable development was formally put forward by the United Nations Commission on World and Environment Development and received great attention from governments and media around the world. In 1992, at the United Nations Conference on Environment and Development, leaders of many countries and regions adopted a series of documents, including the Agenda Century, which made clear the inherent link between "development" and "human society" and put the theory of sustainable development into practice. Shortly after that, China adopted the Agenda 21 after deliberation and approval by The State Council. It establishes the important position of human sustainable development in China's economic development.

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Transforming our World - the 2030 Agenda for Sustainable Development (2030 Agenda for Sustainable Development) was unanimously adopted by the 193 Member States of the United Nations at the United Nations Summit on Sustainable Development in September 2015. The Sustainable Development Goals (SDGs), consisting of 17 targets and 169 sub-targets, have been established, making them the second in line with the Millennium Development Goals (MDGS). After MDGs, another binding target system was set by the United Nations to fully solve the three dimensions of development, namely social, economic and environmental issues, so as to promote mankind to the path of sustainable development [2]. Subsequently, the global indicator framework formulated by the United Nations Inter-agency Expert Group on SDG Indicators (IAEG-SDGs) provides tools for the world to monitor and evaluate the progress of SDGs [3]. Although the framework is designed for the global country level, international organizations, research institutions, and governments have been actively working to localize the global Indicator Framework so that it can be applied to evaluation at the subnational level. In this paper, the United Nations SDGs is introduced to point out the direction of human sustainable development. The idea of index system construction also provides a path reference for other types of cities to construct SDGS-oriented sustainable development evaluation system. Taking Shandong Province as the empirical object, this paper evaluates the sustainable development level of Shandong Province from 2012 to 2021, identifies the existing problems in its sustainable development, puts forward countermeasures and suggestions, verifies the feasibility of the evaluation technology, and provides references for other regions.

2 Evaluation Method

People's evaluation of the pros and cons of the human sustainable development system is generally compared with the established target reference values, which are scientifically represented by a large number of indicators in the research system, such as GDP per capita, urban green area, Engel coefficient, the number of medical practitioners per million people, etc. With the improvement of human statistical level, the recognized values of these indicators can be basically obtained. These indicators can be used as indicators of sustainable development to judge whether the sustainable development system of human is healthy. Therefore, the index system composed of these accepted values can be regarded as the target system (G). In order to better describe and explain how close the result value is to the target system, the zero system (Z) is introduced, which is equivalent to the zero scale on the scale, and all the index values are the worst values. The normal index of Z system is 0. Therefore, the distance difference between the zero system and the target system constitutes a scale for evaluating the sustainable development of human beings. The state value of the system to be measured can be measured by this scale, and its specific position can be transformed by Euclidean distance mathematical model to give dimension to the result value. The specific calculation method is as follows:

$$d_{IG} = \sqrt{\sum_{i,k=1}^{m,n} \left(\frac{X_{ik} - X_{Gk}}{S_k} \right)^2}$$

d_{IG} is the weighted Euclidean distance between the system under test and the target system, X_{ik} is the k evaluation index value of the system under test, and X_{Gk} is the k evaluation index value of the target system. S_k is the standard deviation of the K index.

All data should first be standardized and calculated as follows:

$$X_{ik} = \frac{x - m}{s}$$

x is the original value, m is the mean, and s is the standard deviation.

According to the Euclidean distance model of human sustainable development, the distance between the system to be tested and the target system is the numerator, and the distance between the target system and the zero system is the denominator, and its ratio is the sustainable development index. The formula is:

$$\mathrm{H} = 1 - \frac{d_{IG}}{d_{ZG}}$$

H represents the human sustainable development index, d_{IG} represents the distance between system I under test and target system G, and d_{ZG} represents the distance between zero system Z and target system G. The evaluation value of human sustainable development is divided into three sections: $0 < H < 0.60$ means low sustainability, $0.60 < H < 0.80$ means medium sustainability, and $0.80 < H < 1$ means high sustainability.

3 Construction of Index System

Based on the essence of human sustainable development [4], in accordance with the principles and methods established by the evaluation index system of human sustainable development, with comprehensive consideration of the actual situation in Shandong, China, 15 main indicators are selected from the social, economic, population, environment and other major aspects, and the status of human sustainable development is evaluated on them (Table 1).

4 Case Study and Discussion

Shandong is a coastal province in East China with a land area of 155,800 square kilometers. Shandong Province has jurisdiction over 16 prefecture-level cities, with a total of 58 municipal districts, 26 county-level cities and 52 counties, totaling 136 county-level administrative regions. Shandong Province is dominated by mountains and hills. The central and southern mountains protrude, the southwest and northwest are low-lying and flat, the east is the Shandong Peninsula with gently rolling hills, and the west and north belong to the North China Plain [5, 6]. It spans the Huaihe River, Yellow River, Haihe River, Xiaoqing River and Jiaodong River system. It is a warm temperate monsoon climate. Shandong Province is a large industrial province with a strong industrial foundation and 41 industrial categories. It is an important industrial base in China and a strategic fulcrum of economic development in northern China. The Shandong Peninsula city cluster is adjacent to Japan and South Korea, facing Northeast Asia and connecting the Belt and Road Initiative. Shandong is one of the most economically developed

Table 1. The index and the reference values of the goal system

No.	Index	Unit	Indicator reference value of the target system
1	Gross GDP	Trillion yuan	100000
2	GDP	Hundred million yuan	100000
3	Fiscal revenue	Trillion yuan	10000
4	The proportion of tertiary industry	%	60
5	Natural population growth rate	%	5
6	Length of schooling	Year	12
7	The proportion of the population in the labor force	%	75
8	Per capita disposable income	Yuan	60000
9	Unemployment rate	%	5
10	Engel coefficient	%	30
11	Average number of people working in high-tech industries	Ten thousand people	100
12	Proportion of investment in science and technology	%	5
13	Number of medical practitioners per million population	/	50
14	Highway mileage accounts for the proportion of the province's area	%	2
15	Urban greening ratio	%	50

provinces in China, one of the most economically powerful provinces in China, and also one of the provinces with rapid development. Since 2007, its economic aggregate has ranked the third place. In 2022, Shandong's GDP reached 8,743.51 billion yuan, an increase of 3.9% over the previous year at constant prices. The value added of the primary industry was 629.86 billion yuan, up by 4.3%; The added value of the secondary industry was 3,501.42 billion yuan, up by 4.2%; The added value of the tertiary industry was 4,612.23 billion yuan, up by 3.6%. The tertiary industrial structure is 7.2:40.0:52.8. In 2022, 1.202 million new urban jobs were created, 109.3% of the annual target. Some 539,000 unemployed people found jobs again, and 103,000 people had difficulty finding jobs, 161.0% and 158.7% of the annual target, respectively.

As can be seen from Fig. 1, the overall human sustainable development index of Shandong Province from 2012 to 2021 shows an upward trend, but it does not reach a high level, and is always at a medium level, with a large room for future increase. As can be seen from Fig. 2, the reasons for the low level of sustainable human development

in Shandong Province in 2021 include: Engel coefficient, labor force population ratio, unemployment rate, etc. Affected by the global COVID-19 epidemic, food prices in Shandong Province will rise higher in 2021, and local people pay more attention to diet, so they spend more money on food and other aspects [7, 8]. Also affected by the novel coronavirus pneumonia, the unemployment rate was at a high level in that year, but with the adjustment of China's policies, this phenomenon eased significantly [9]. Shandong Province is also a populous province in China, with a population of more than 100 million, a serious aging population and a low proportion of labor force are also the reasons why its human sustainable development index has not reached a high level.

Our results are basically consistent with those of the predecessors [10–12], which shows that our method has certain feasibility and accuracy. In addition, the evaluation method of human sustainable development based on Euclidean distance avoids human subjective error, and the evaluation results can reflect the actual situation of the surveyed area more accurately, thus providing accurate reference for the development of the surveyed area. And the results are simple and clear, the operation process is convenient, and it is more acceptable to the public.

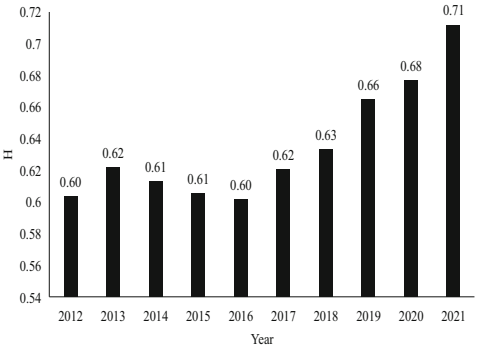

Fig. 1. H changes in Shandong Province

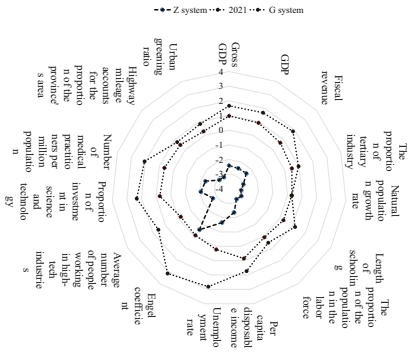

Fig. 2. Radar map of sustainable human development in Shandong Province in 2021

5 Conclusion

Euclidean distance methodology is very mature, and its evaluation results are more intuitive and easy to understand. This method avoids the influence of human factors and reduces the human error caused by the expert's personal educational background. According to the evaluation results of human sustainable development in Shandong Province obtained by Euclidean distance method, the trend of human sustainable development in this region is good, and is in the trend of sustained and stable growth, but there are some shortcomings, such as; Of course, it can be seen from the analysis of indicator data that the target reference value has been basically reached in terms of per capita disposable income, per capita grain and per capita housing area. To sum up, the sustainable development of people in Shandong Province has reached the state of medium sustainable development, and there is still a large room for improvement.

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