OPEN ACCESS Freely available online

IJESP International Journal of Environmental Sustainability and Protection

ISSN 2737-5447
Volume 1, Issue 1
https://www.iikii.com.sg/journal/IJESP
International Journal of Environmental Sustainability and Protection

Article

Evaluation of Sustainable Development Ability of China's Yangtze River Economic Belt

Yue Ding [1], Chengxiang Wang [2] and Pinrong He [2,*]

[1] School of Geographical Sciences, Fujian Normal University, China; 2246748741@qq.com
[2] Institute of Land and Urban-Rural Planning, Huaiyin Normal University, China; liutanghe@outlook.com
* Correspondence: hemojie@outlook.com; Tel.: +86-17351909506

Received: Oct 10, 2021; **Accepted:** Nov 10, 2021; **Published:** Dec 30, 2021

Abstract: Sustainable development is a critical theory and strategy to promote the development of the regional economy. The sustainable development of the Yangtze River Economic Belt (YEB) has essential significance for the development of China. In this paper, 11 provinces and cities in the YEB are taken as the research object, and the analytic hierarchy process is used to construct an evaluation index system for the sustainable development capacity of the YEB from the three aspects of the economy, society, and ecology, and quantifies the sustainable development capacity of the 11 provinces and cities. The results show that the overall level of sustainable development capacity of the YEB in China is low, the gap between provinces and cities is large, and the differences between provinces and cities with high levels of sustainable development are more pronounced. The economic, social, and ecological subsystems imply that scientific research and technological progress are essential components of the sustainable development index of the YEB and one of the essential means to promote the sustainable development of the YEB in the future. The economic development level, urbanization rate, and greening rate of provinces and cities also play an essential role.

Keywords: the Yangtze River Economic Belt, analytic hierarchy process, sustainable development

1. Introduction

The YEB is the region with the strongest comprehensive strength in China, accounting for nearly half of China's population [1,2]. However, rapid industrialization and urbanization have led to the deterioration of the resources and environment in the YEB [3], which has attracted the attention of all sectors of society. The collaborative relationship between economic growth and the environment is the key to a region or country [4]. How to coordinate the relationship between the economy and the environment has become a vital issue of concern from all walks of life. Sustainable development is one of the answers to the question. In this context, we evaluate the sustainable development capacity of 11 provinces and cities in the YEB. The results provide a scientific understanding of the sustainable development level of the YEB.

Achieving sustainable development is one of the main goals for any government [5]. From the end of the 20th century to the present, the resource-environment-oriented relationship between man and land has attracted the attention of scholars in various fields [6]. In 1987, the World Commission on Environment and Development formally proposed the concept of sustainable development [7]. The concept of sustainable development is applied in many fields, such as agriculture [8], energy [9], and urban development [10]. In assessing regional sustainable development capabilities, the Sustainable Development Index (SDI) is one of the essential tools to grasp the sustainable development level of the target object and solve the problem of the target object's sustainable development [11,12]. It is widely used to evaluate the sustainable development level of a region or country. Due to the different research objects, the application range of the sustainable development index is as extensive as the national scale. For example, Bolcárová and Kološta measure the sustainable development capacity of 27 EU countries [13]. It also goes to a local regional scale, such as the sustainability study of the Umbria region in central Italy [14], the province of Antioquia in Colombia [15], and the study of the sustainability of 51 cities in the province of Catania, Italy [16]. Due to different research areas and focuses, scholars have various selections of specific indicators. However, based on the common understanding that sustainable development capabilities are the multidimensional capabilities of successful operation in the three fields of society, economy, and environment [17], most scholars comprehensively consider the three aspects of economic, social, and ecological to construct an evaluation index system [18].

In China, the sustainable development index has also been widely used, both on the national scale such as the study of the changes in the sustainable development level of China in different time series [19] and on the provincial scale such as the study on the sustainable development level of Liaoning Province [20]. There are county-level scales, such as the sustainability study of 66

counties in the Yangtze River Delta [21]. Most of its research framework also follows three-dimensional considerations economically, socially, and ecologically. Although the sustainable development index is widely used to measure the sustainable development ability of administrative units, there is not much research on the sustainable development level of the YEB.

Chinese scholars mainly focus on environmental governance, industrial research, and regional heterogeneity, and regional spatial structure, while scholars from other countries mainly focus on the social-ecological system, water environment, water and soil conservation, urban system, and land use [22]. Most of the ideas and concerns about the sustainable development of the YEB have been incorporated into the above research hotspots. Several scholars use the city-state carrying capacity index to evaluate the sustainable development of the YEB [23]. However, there is still a lot of research space for the research on using the index to evaluate the sustainable development ability of the YEB.

In summary, as taking 11 provinces and cities in China's YEB as the research object, the economic, social, and ecological aspects, constructs a regional sustainable development index system are comprehensively considered to quantify the sustainable development of 11 provinces and cities in the YEB and to grasp the status quo of the sustainable development capabilities of the YEB and provide a data basis for future adjustment policies.

2. Methods

Analytic Hierarchy Process, or AHP for short, is a hierarchical weighted decision analysis method proposed by Saaty in the early 1970s. [24,25]. The comparative study of sustainability measurement methods by Dong et al. found that AHP has advantages in analyzing regional sustainable development capabilities [26]. Thus, we choose the AHP process to evaluate the city's sustainable development capabilities of 11 provinces in China's YEB. The socio-economic indicator data of the city comes from the 2017 provincial statistical yearbooks and related statistical reports.

2.1. Index selection

According to AHP, the indicator system is divided into a general goal, three sub-systems of economy, society and ecology, and related indicators are selected, as shown in Table 1.

Table 1. Regional Sustainable Development Capability Index System

Target system	Subsystem	Index layer	Index Weight
Regional sustainable development capability A	Economic Subsystem B1	GDP per capita (yuan)	0.1463
		The proportion of tertiary industry in GDP (%)	0.0379
		Contribution rate of consumption economy (%)	0.0294
		R&D expenditure input intensity (%)	0.1576
		Degree of opening to the outside world (%)	0.0722
	Social Subsystem B2	Inverse dependency ratio (%)	0.0051
		Income ratio of rural and urban residents (%)	0.0206
		Urbanization rate (%)	0.0430
		Density of road network in built-up area (km/km2)	0.0145
		Gas penetration rate (%)	0.0040
		Number of doctors per 10,000 people (persons)	0.0187
		Number of college students per 10,000 people (person)	0.0393
		Ratio of urban employees to unemployed (%)	0.0147
		The proportion of social security and employment expenditure (%)	0.0093
	Ecological Subsystem B3	Compliance rate of air quality above good (%)	0.0640
		Sewage treatment rate (%)	0.0246
		Harmless treatment rate of domestic garbage (%)	0.0151
		GDP per unit of energy consumption (ton of standard coal/yuan)	0.1422
		Land area per capita (m2/person)	0.0398
		Forest cover rate(%)	0.1017

2.2. Judgment matrix

With the 1–9 scale method, the expert evaluation and the judgment matrix are constructed. The square root method is used to calculate the eigenvector $W=(w_1,w_2,...,w_n)$ of the judgment matrix. The eigenvector $W=(w_1,w_2,...,w_n)$ is the corresponding weight vector of the judgment matrix.

2.3. Judgment Matrix Consistency Test

To ensure the consistency of the index judgment matrix, the judgment matrix must be tested. For the test, the eigenvector is used corresponding to the largest eigenroot as the weight vector of the degree of influence of the compared factor on the upper system, and the consistency index *C.I.*, the average random consistency index *R.I.* and the ratio of the two-random consistency ratio *C.R.* are introduced to judge the consistency of the matrix. The test result shows that the random consistency ratio of the judgment matrix is less than 0.10, which passes the consistency test. After normalizing the relative weight of the judgment matrix, the relative weight of the indicator to the regional sustainable development capacity is obtained, as shown in Table 1.

3. Results

The actual data of each indicator and the dimensionless processing of data are obtained from the statistical yearbooks of all provinces in China in 2017. Standardized data is multiplied by the weight vector in the regional sustainable development evaluation index system to obtain the sustainability index of 11 provinces and cities as shown in Fig. 1.

3.1. Overall level of sustainable development in the YEB is low, with large differences between provinces and cities

As shown in Fig. 1, the sustainable development level of the 11 provinces and cities in the YEB is relatively low, and the sustainable development capabilities between the provinces and cities show the characteristics of differentiation. The average SDI of the 11 provinces and cities in the YEB is 0.44, and the median SDI is 0.41. These two values indicate that the overall level of sustainable development is low, and there is more room for improvement. From a spatial point of view, the area with an SDI peak is the three provinces of Jiangsu, Zhejiang, and Shanghai in the eastern part of mainland China. The middle SDI area is mainly the provinces in the central part of the mainland and the two provinces and cities of Chongqing and Hunan. The low SDI area is the three provinces of Sichuan, Yunnan, and Guizhou. The sustainable development level of the YEB spatially shows a downward trend from east to west. It is worth noting that the central region has large internal differences in the middle section of SDI. For example, the level of Anhui Province has become a depression in the middle section, and that of Chongqing has become the peak of the middle section. This reduces the level of sustainable development of the YEB from west to east in an inverted "N" shape.

There is a big difference in the level of sustainable development between the provinces and cities in the YEB. Shanghai has the highest SDI index (0.49), while Guizhou has the lowest SDI index. This shows that the level of sustainable development is more severely imbalanced. According to the SDI index, 11 provinces and cities are grouped into three: Shanghai, Zhejiang, and Jiangsu with high value, Chongqing, Hunan, Jiangxi, and Hubei with middle value, and Anhui, Sichuan, Yunnan, and Guizhou with low value. There is a big difference in the level of sustainable development between high-valued provinces and cities. The difference in the level of sustainable development between the middle and low-value provinces and cities is relatively small, except that the SDI index of Guizhou and Sichuan has a large difference from that of other provinces and cities.

To a certain extent, the three provinces and cities of Jiangsu, Zhejiang, and Shanghai with the high-value have obvious polarizing effects which are beyond other provinces and cities. The three provinces and cities of Jiangsu, Zhejiang, and Shanghai play a trickle-down role to make the sustainable development of other provinces and cities, especially Guizhou, the province have the lowest SDI, should focus on breakthroughs.

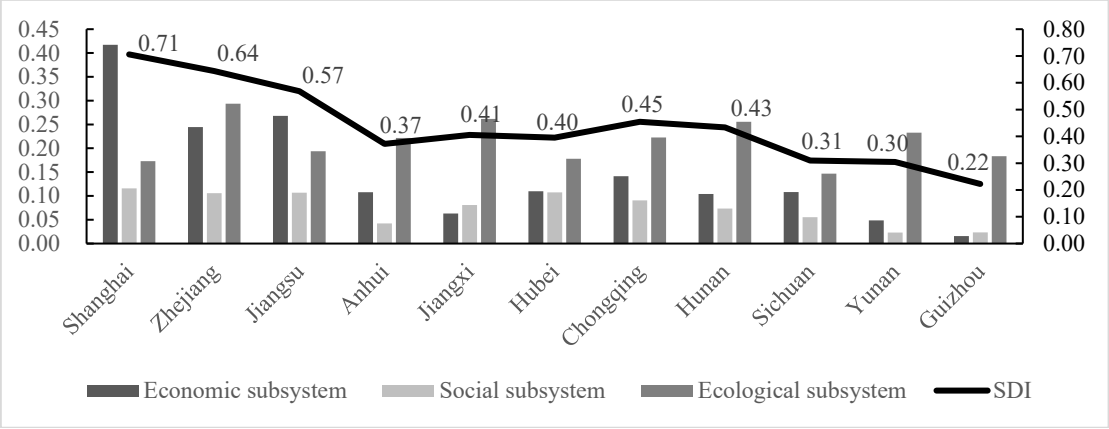

Fig. 1. Sustainable development index of 11 provinces and cities in the YEB.

3.2. Economy, scientific research, and economic level as an important influence on ability of sustainable development

When R&D investment intensity and per capita GDP account for relatively high and similar proportions, they are conducive to promoting the sustainable development of provinces and cities. Figure 2(a) shows that R&D investment intensity and per capita GDP are the two main aspects for the top four SDI-ranked Shanghai, Zhejiang, Jiangsu, and Chongqing, and these two indicators show similar proportions. Hunan, Jiangxi, Hubei, Anhui, Sichuan, Yunnan, Guizhou, and other provinces and cities ranked as 5–11 have large differences in the proportion of R&D investment intensity and the proportion of per capita GDP, and the larger the gap, the smaller the SDI. This shows that in the sustainable development capacity of the region, the investment in scientific research and technology (R&D expenditure input intensity) has an important position, followed by the level of regional economic development (per capita GDP). The vitality of scientific research is stronger, and technological innovation helps reduce resource consumption, promote green development, and improve the level of sustainable development in the region. Therefore, the low-ranking provinces and cities of SDI need to actively develop the economy, increase the per capita income level, and at the same time increase the intensity of technological research and development and scientific research investment for active development of green technology and building a coordinated and balanced relationship between economic development and the ecological environment.

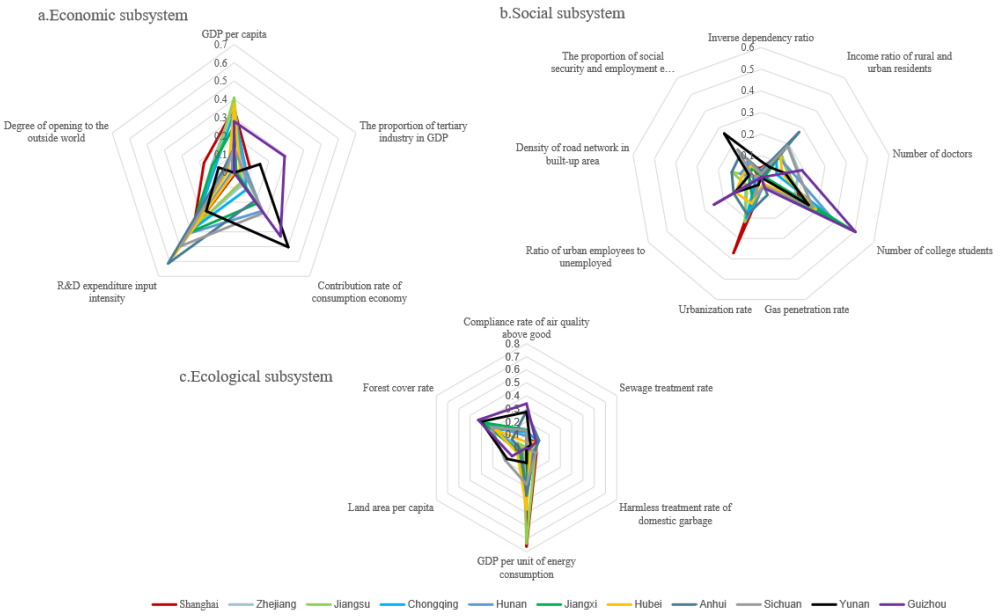

Fig. 2. Sustainable development of sub-systems in 11 provinces and cities of the YEB

3.3. Urbanization rate and education level in sustainable development capacity of the region

Figure 2(b) shows that at the social level, regional urbanization rate and education level (the number of college students per 10,000 people) is one of the important components of sustainable development capabilities, while indicators such as the gas penetration rate, the density of the road network in the built-up area, and the inverse ratio of support and other indicators are not prominent. In terms of regional education level, provinces and cities with high SDI have a considerable proportion of education level, while provinces and cities with low SDI have a high proportion of education level. However, there is a serious imbalance of the proportions of indicators related to sustainable development. This result is also consistent with the above conclusion. The regional education level is high, the local people's behavioral quality is relatively high, and the popularization of the concept of sustainable development is widespread. At the same time, a high level of education promotes regional scientific research, and technological innovation enhances the sustainable development capacity of the region. In the top-ranked provinces and cities, the urbanization rate accounts for a relatively large proportion of the sustainable development index, while in the lower-ranked provinces and cities, the urbanization rate significantly decreases. This shows the importance of sustainable development and urbanization in the region. There are certain links between the processes, so we need to actively promote the process of urbanization and sustainable development, especially in Yunnan, Guizhou, and other provinces and cities for further process of urbanization. At the same time, we need to coordinate various indicators to achieve balanced development.

3.4. GDP per unit of energy consumption and forest coverage as main components of sustainable development capacity of region

The provinces and cities with the top SDI rankings have a greater proportion of GDP per unit energy consumption in their sustainable development capabilities (Fig. 2(c)). For example, Shanghai, Jiangsu, and Zhejiang with the top three SDI indexes have high percentages of GDP per unit energy consumption, which shows a large difference from the cities with the second-highest index. Sichuan, Guizhou, and Yunnan have no outstanding performance in the proportion of GDP per unit of energy consumption. In the lower-ranked provinces and cities, the forest coverage rate as an existing protected resource is also an important component of SDI. This enlightens that the 11 provinces and cities in the YEB need to establish ecological compensation mechanisms for coordinated development. At the same time, they need to increase the protection of existing ecological resources, improve resource utilization efficiency, reduce resource consumption, and promote regional sustainable development.

4. Conclusion

The sustainable development capabilities of 11 provinces and cities in China's Yangtze River Economic Belt are assessed by using the analytic hierarchy process and constructing a regional sustainable development index evaluation system. The main conclusions are as follows.

1) The overall level of sustainable development in the YEB is not high. There are few provinces and cities with high sustainable development capabilities. The three provinces and cities of Jiangsu, Zhejiang, and Shanghai are the main ones, but there are many provinces and cities with low sustainable development capabilities. At the same time, there is a large difference in sustainable development capacity between provinces and cities, and the difference shows a trend of increasing according to the ranking. The provinces and cities with sustainable development capabilities are even worse. To promote the improvement of the sustainable development capacity of the YEB, the focus should be on reducing regional differences for coordinating regional development and giving full play to Shanghai's trickling role in the YEB.
2) Different sub-systems have different indicators that have a major impact on the sustainable development of provinces and cities. However, the same results are achieved by different methods, which are the intensity of R&D funding in the economic sub-system or the number of college students per 10,000 in the social sub-system and the GDP per unit energy consumption of China's ecological subsystem. Both present the positive impact of the level of economic development and scientific research technology on the sustainable development of the region. It is important to promote the sustainable development of the YEB and focus on scientific research and technological innovation. In addition, the per capita GDP in the economic subsystem, the urbanization rate in the social subsystem, and the forest coverage rate in the ecological subsystem all play an important role in the subsystem index.

As a preliminary study on the evaluation of the sustainable development capacity of the YEB in China, this study still has shortcomings. The proposed evaluation index system of regional sustainable development has yet to be improved. In addition, the result of the research on the sustainable development capacity of China's YEB takes provinces and cities provides general features. To obtain more accurate data and analysis results, in-depth exploration is needed. Therfore, it is necessary to further measure and analyze the city scale of typical regions of the YEB.

Author Contributions: Conceptualization, Y.D.; Formal analysis, Y.D.; Investigation, Y.D. and C.W..; Methodology, Y.D., C.W. and P.H.; Project administration, P.H.; Resources, Y.D. and C.W.; Software, Y.D., C. W. and P.H.; Supervision, Y.D.; Writing—original draft,Y.D.; Writing—review & editing, P.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research did not receive external funding..

Acknowledgments: We would like to thank anonymous reviewers for their valuable comments and suggestions for improving this paper

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Sun, Y.;Yang, Z.;Yu, X., et al. Evaluating Sustainable Development of Land Resources in the Yangtze River Economic Belt of China. *Journal of Global Information Management*, **2021**, *30*, 1–23.
2. Shi, F.;Xu, H.;Hsu, W.-L., et al. Spatial Pattern and Influencing Factors of Outward Foreign Direct Investment Enterprises in the Yangtze River Economic Belt of China. *Information*, **2021**, *12*, 381.
3. Chen, Y.;Zhang, S.;Huang, D., et al. The development of China's Yangtze River Economic Belt: How to make it in a green way. *Science Bulletin*, **2017**, *62*, 648–651.

4. Brock, W.A.;Taylor, M.S. Economic growth and the environment: a review of theory and empirics. *Handbook of economic growth*, **2005**, *1*, 1749–1821.
5. Mao, G.;Jin, W.;Zhu, Y., et al. Environmental Pollution Effects of Regional Industrial Transfer Illustrated with Jiangsu, China. *Sustainability*, **2021**, *13*, 12128.
6. Hsu, W.-L.;Shen, X.;Xu, H., et al. Integrated Evaluations of Resource and Environment Carrying Capacity of the Huaihe River Ecological and Economic Belt in China. *Land*, **2021**, 10.
7. WCED. Our Common Future, Brundtland Report. *Brundtland*, **1987**.
8. Pang, J.;Liu, X.;Huang, Q. A new quality evaluation system of soil and water conservation for sustainable agricultural development. *Agricultural Water Management*, **2020**, *240*, 106235.
9. Ahmad, M.;Jan, I.;Jabeen, G., et al. Does energy-industry investment drive economic performance in regional China: implications for sustainable development. *Sustainable Production and Consumption*, **2021**, *27*, 176–192.
10. Bian, H.;Gao, J.;Wu, J., et al. Hierarchical analysis of landscape urbanization and its impacts on regional sustainability: A case study of the Yangtze River Economic Belt of China. *Journal of Cleaner Production*, **2020**, 279.
11. Kwatra, S.;Kuma, A.;Sharma, P. A critical review of studies related to construction and computation of Sustainable Development Indices. *Ecological Indicators*, **2020**, 112.
12. Sun, L.;Ni, J.;Borthwick, A.G. Rapid assessment of sustainability in Mainland China. *Journal of environmental management*, **2010**, *91*, 1021–1031.
13. Bolcárová, P.;Kološta, S. Assessment of sustainable development in the EU 27 using aggregated SD index. *Ecological Indicators*, **2015**, *48*, 699–705.
14. Boggia, A.;Cortina, C. Measuring sustainable development using a multi-criteria model: A case study. *Journal of environmental management*, **2010**, *91*, 2301–2306.
15. Pineda, A.L.;Cerón, J.G.C. Evaluation of sustainable development in the sub-regions of Antioquia (Colombia) using multi-criteria composite indices: A tool for prioritizing public investment at the subnational level. *Environmental Development*, **2019**, *32*, 100442.
16. Angilella, S.;Catalfo, P.;Corrente, S., et al. Robust sustainable development assessment with composite indices aggregating interacting dimensions: The hierarchical-SMAA-Choquet integral approach. *Knowledge-Based Systems*, **2018**, *158*, 136–153.
17. Shmelev, S.E.;Shmeleva, I.A. Global urban sustainability assessment: A multidimensional approach. *Sustainable Development*, **2018**, *26*, 904–920.
18. Munda, G.;Saisana, M. Methodological considerations on regional sustainability assessment based on multicriteria and sensitivity analysis. *Regional Studies*, **2011**, *45*, 261–276.
19. Chen, C.-j.;Fu, X.-f.;Ma, X.-w., et al. Study on compositive evaluation of sustainable development in china. *China Population, Resources and Environment*, **2004**, 1.
20. Lu, C.-y.;zhang, L.;xue, B., et al. Space-Time Synthetic Measurement of Regional Sustainable Development in Liaoning Province. *Economic Geography*, **2015**.
21. Zhong, R.;Pei, F.;Yang, K., et al. Coordinating socio-economic and environmental dimensions to evaluate regional sustainability —towards an integrative framework. *Ecological Indicators*, **2021**, *130*, 108085.
22. Peng, M.;Xu, H.;Qu, C., et al. Understanding China's largest sustainability experiment: Atmospheric and climate governance in the Yangtze river economic belt as a lens. *Journal of Cleaner Production*, **2021**, *290*, 125760.
23. Sun, C.;Chen, L.;Tian, Y. Study on the urban state carrying capacity for unbalanced sustainable development regions: Evidence from the Yangtze River Economic Belt. *Ecological Indicators*, **2018**, *89*, 150–158.
24. Saaty, T.L. How to make a decision: The analytic hierarchy process. *European Journal of Operational Research*, **1990**, *48*, 9–26.
25. Hsu, W.-L.;Qiao, M.;Xu, H., et al. Smart City Governance Evaluation in the Era of Internet of Things: An Empirical Analysis of Jiangsu, China. *Sustainability*, **2021**, *13*, 13606.
26. Dong, Y.H.;Zhong, D.S.;Xiao-Li, L.U. Comparative study of the application of PCA and AHP to the analysis and evaluation of the regional sustainable development. *Journal of Safety and Environment*, **2016**.