THE CHINESE ENVIRONMENTAL POLICY RESEARCH WORKING PAPER

Issue 22 Volume 5 No.7 August 2018

Chinese Academy of Environmental Planning
http://www.caep.org.cn

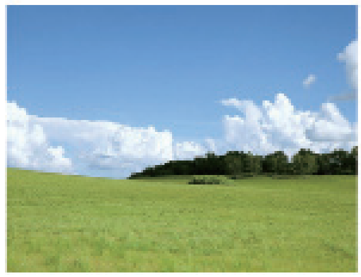
Analysis of Provincial Environmental Performance Trend in China

DONG Zhanfeng, HAO Chunxu, LI Hongxiang, GE Chazhong, YUAN Zengwei, SHENG Hu, XU He, WENG Junhao, XU Yuan, WANG Huijie

Foreword »

Editor in Chief: Prof. WANG Jinnan





Since its opening-up and reform, China has been in the process of rapid economic development with its people enjoying an increasingly improved standard of life. Meanwhile accompanying this dramatic economic growth is the degradation of environment which has, to some extent, damaged the gains of the opening-up and reform and prevented the economy from a healthy and sustainable development. The Chinese government is increasingly aware of that without addressing the environmental issues it is facing now, will jeopardize its long term goal of the great rejuvenation of the Chinese nation. Given the magnitude and complexity of the environmental issues in China, there is no easy way in addressing them and the solution to them entails an equal priority being given to environmental protection, ecological conservation and economic development or even higher than the latter by mainstreaming the former into the overall socio-economic decision-making process. As a matter of fact, China has been in the struggle against environmental pollution since the very beginning of its economic take-off and trying to explore a pathway that could help address China's environmental issues in the way most suitable to China's specific circumstances.

In recent years, especially since the 12th Five-Year Plan period, the enhanced measures including legislation, policy, regulatory and economic means have been taken by the Chinese government in dealing with environmental problems, of which environmental policies have played an important role in this regard. Corresponding to this situation and in meeting the demand of governments at different levels for environmental policy tools, the environmental policy research projects on topics of a wide range have been conducted by some Chinese environmental research institutions including the Chinese Academy of Environmental Planning (CAEP).

CAEP founded in 2001, is a research advisory body supporting governments in the development of key environmental planning, national environmental policies, and major environmental engineering projects. In the past more than 10 years, CAEP has accomplished the development of the overall planning of national environmental protection for the 10th, 11th and 12th Five-Year Plan periods; water pollution prevention and control planning for key river basins; air pollution prevention and control planning for key regions; soil pollution prevention and control planning; and some regional environmental protection plans. In the same period of time, CAEP also actively engaged in research on such topics as green GDP, environmental taxation, emission trading, ecological compensation, green financing, etc. By so doing, CAEP has become an indispensable advisory body in the environmental decision-making in mainland China. According to *2013 Global Go To Think Tanks Report and Policy Advice* published by University of Pennsylvania, CAEP was ranked 31 in the field of environment in the world. Many of CAEP's research results and project outcomes regarding environmental policies have drawn great attention of decision makers and international institutions, and have been utilized to contribute to the formulation of national environmental policies concerned.

The Chinese Environmental Policy Research Working Paper (CEPRWP) is a new internal publication produced by CAEP for the purpose of facilitating the academic exchange with foreign colleagues in this field, in which the selected research papers on environmental policies from CAEP are set out on the irregular basis. It is expected that this publication will not only make CAEP's research results on environmental policies be known by foreign colleagues but also serve as a catalyst for creating opportunity of international cooperation in the field of environmental policies, and environmental economics in particular, with a view of both the academic research and practical policy needs.

Environmental performance is a comprehensive reflection of the overall level of environmental protection in a country or a region. Establishing an environmental performance assessment index system reflecting China's development stage and national conditions is the core content of China's environmental management transformation and ecological civilization system construction, and is also an urgent and important task for China to actively implement the UN Sustainable Development Goals (SDGs). CAEP has been working on environmental performance evaluation since 2006 and successively participated in many projects. This study is one of these projects. Based on the official statistics released by China, this study systematically carries out dynamic assessment of environmental performance assessment changes in China during the past 10 years, demonstrating the efforts and achievements of China's environmental protection and ecological civilization construction, and the law of heterogeneous development in sub-national regions. This is an important way for the international community to deeply understand the complexity of China's environmental problems and the achievements of environmental protection efforts. It is also a good way for China's ecological civilization stories to spread to the world.

Contents

1. INTRODUCTION

1.1 Research Background

China is the most populous country and the largest developing country in the world. Over the past decade, it has experienced rapid economic development, with its economic aggregate leaping to the second place in the world. China has made extensive efforts to push forward with urbanization, poverty alleviation, ecological environment protection and other areas and also made outstanding contribution to world's sustainable development. By the end of 2014, China's energy consumption and carbon dioxide emissions per unit of GDP had decreased by 29.9% and 33.8% respectively over those of 2005, emissions of the four main pollutants (COD), ammonia nitrogen, sulfur dioxide and nitrogen oxide had continued to decrease substantially, the proportion of V cross sections of large rivers had greatly decreased, and acid rain had reverted to levels seen in the 1990s. It is particularly difficult for a large developing country undergoing industrialization to achieve all of these goals. However, given the specific developmental stage China is in, there are still great gaps between environmental problems and expectations in all sectors of society. During the 13th Five Year Plan, China has made it clear that green development will be its new theme. It will pursue green low-carbon development, dedicate itself to improving the quality of the ecological environment, build a beautiful China featuring blue skies, green grasslands, and clean rivers, and make consistent efforts to fully promote an ecological civilization. These will surely make new and ever-greater contributions to the world's sustainable development. Environmental performance is a comprehensive reflection of the level of the overall environmental protection of a country and region. A pressing and critical task for China in pursuing the sustainable development goals of the United Nations is to conduct environmental performance evaluations, explore the development laws in environmental protection and identify key factors affecting environmental protection. Carrying out environmental performance assessment helps to improve the level of environmental governance systems and modernize governance capabilities.

Chinese Academy for Environmental Planning (CAEP) has been working on environmental performance evaluation since 2006. We have successively participated in a great many of projects, such as OECD environmental performance evaluation, ADB's Mekong River Basin performance evaluation, the study about environmental performance index by Yale University and Columbia University, ADB's Livable City Index System, and environmental performance assessment of listed companies. We have accumulated some experience in the exploration of the theoretical methods of performance evaluation and pilot practices. We track the progress of national government environmental performance assessment and management practices, establish a performance evaluation method system, which is applied to performance evaluations at national, provincial and city levels, and develop a national environmental performance assessment information system.

1.2 Evaluation Objectives

Evaluation of China's sub-national and sub-regional environmental performances, analysis of their characteristics of variation and identification of the major factors affecting environmental performance will provide reference for making scientific decisions to better implement the requirements for sustainable development goals set by the United Nations.

1.3 Research Scope

This report focuses on the environmental performance evaluations of 30 province-level regions in China. The evaluation scope includes the past decade (from 2004 to 2013).

1.4 Main Contents

An operable province-level environmental performance evaluation index system for China should be universally applicable, suited to the country's actual conditions, and reflect its major areas of concern at a given developmental stage by:

(1) Quantitatively evaluating the environmental performance level of province-level regions in China and analyzing the variation in the laws relating to environmental performance of province-level regions in China, the relationship between environmental performance and economic development level, and variations in the laws of different provinces;

(2) Analyzing environmental performance index scores for China's eastern, central and western regions in spatial heterogeneity, and identifying China's characteristics of environmental performance in regional spatial patterns;

(3) Analyzing the distribution of environmental performance laws of sub-national administrative regions, analyzing the variation in environmental performance of all province-level regions and identifying key indexes affecting environmental performance of province-level regions.

2. METHODOLOGY

2.1 Main Framework Methods

This report attempts to establish an environmental performance evaluation index system that can reflect China's characteristics at different developmental stages by identifying the key environmental problems of China in the past decade.

2.2 Correlation Analysis

This report analyzes the relevance of environmental performance and economic development, and identifies the essential links between environmental performance and level of economic development for China's province-level regions using the correlation analysis method. The judgment criteria for the results are as follows:

The rvalue is the Pearson correlation coefficient. Its attributes are:

(1) When $r>0$, the two variables are positively correlated, and when $r<0$, the two variables are negatively correlated.

(2) When $|r| \geq 0.8$, the two variables can be considered highly correlated;

(3) When $0.5 \leq |r| \leq 0.8$, the two variables can be considered moderately correlated;

(4) When $0.3 \leq |r| \leq 0.5$, the two variables can be considered loosely correlated; and

(5) When $0 \leq |r| \leq 0.3$, the degree of relevancy is low, and the two variables are basically uncorrelated.

2.3 Linear Weighting Method

Represent the environmental management level that alleviates environmental deterioration and improves the environmental condition by using the environmental performance index (EPI), process the evaluation indexes to standardize them, and calculate an overall evaluation of EPI in accordance with weight allocations, i.e.:

$$EPI = \sum_{I=1}^{n} (w_i x_i)$$

where i is the ordinal number of an index; n is the total number of indexes; Wi is the ith index weight; and Xi is the standardized value of the i^{th} index.

2.4 GIS Spatial Analysis Method

This method involves representing the level of variation in the EPI growth rates of different provinces using GIS spatial analysis, rendered level by level on the basis of growth rates, and visually displaying the environmental performance improvements for different provinces.

2.5 Radar Chart Method

With this method, variations in the third-level environmental performance indexes over the past decade are represented using the radar chart method and the performance characteristics of these indexes are analyzed in different province-level regions.

2.6 Clustering Analysis

Using this method, the environmental performance scores of 30 provinces over the past decade are classified according to general trends using a clustering methodology, grouping the data of provinces with similar levels of development and analyzing the environmental performance laws of different province-level regions.

2.7 Contribution Sequencing Value Method

Measure the importance of each fourth-level index in environmental performance scores using the contribution sequencing value method and identify the indexes that affect EPI variation. This report proposes a method in which the sequencing of each index at a given period in a given area is used to measure its importance. Assuming that all index values at a given period in a given area are Xi (i=1, ..., n), where n is the number of indexes, and these n indexes will be sequenced in descending order as R(Xi), then the value range of R(Xi) will also be from 1 to n. If Xi is a random variable, then R(Xi) is also a random variable, so the probability that the sequencing of the ith index Xi is j will be

$$\rho_{ij} = P(R(X_i) = j), \quad (i, j=1, \cdots, n)$$

According to the computation result of P_{ij}, we can arrive at the probability that the sequencing of the ith index Xi is less than j

$$P_{ij} = P(R(X_i) \leq j) = \sum_{k=1}^{j} \rho_{ik}$$

We can also obtain the relevant statistics of R(Xi):

$$E(R(X_i)) = \sum_{j=1}^{n} R(X_i) \rho_{ij}$$

$$Var(R(X_i)) = E(R(X_i)^2) - E(R(X_i))^2$$

$$= \sum_{j=1}^{n} R(Xi)^2 \rho_{ij} - (\sum_{j=1}^{n} R(X_i) \rho_{ij})^2$$

3. ESTABLISHING A PROVINCE-LEVEL ENVIRONMENTAL PERFORMANCE EVALUATION INDEX SYSTEM

3.1 Framework Design for the Index System

The objective is to identify major problems related to China's province-level environmental performance and sub-theme problems under all themes using a theme framework model and establish a four-tier multidimensional evaluation index system, including 4 second-level indexes, 14 third-level indexes and 47 fourth-level indexes.

■ **Figure 3-1 Province-Level Environmental Performance Evaluation Index System**

3.2 Setting of Policy Target Values

Various methods have been used to determine target values for different indexes. In determining a specific target value, the order of priority should be as follows:

(1) International standard target value method;

(2) Planned target value method;

(3) Ideal-state target value method;

(4) China-optimized level target value method;

(5) Empirical target value method.

Specific target values for all indexes are shown in Attachment 1.

3.3 Standardization of Index Data

This report uses the target incremental method to process all indexes to obtain standardized data. The indexes can be classified into positive and negative classes. The higher a positive index value, the better it is; the case is the opposite for a negative index. A positive index for which it is more desirable to have a higher value is standardized according to formula 3-1, and a negative index for which it is more desirable to have a lower value is standardized according to formula 3-2.

$$X_S = \frac{X - V_{min}}{t - v_{min}} \quad (3\text{-}1)$$

$$X_S = \frac{X - V_{max}}{t - v_{max}} \quad (3\text{-}2)$$

where Xs is the standardized value, x is the index value, Vmin is the minimum value and Vmax is the maximum value.

After being processed as above, the original statistical values of the 47 indexes are converted into comparable index scores that fall between 0 and 100. The standardized score will be 100 if the result is over 100.

3.4 Determining Index Weight with the Averaging Weight Method

To avoid duplication of index information, a correlation analysis of the 47 fourth-level indexes is performed and indexes with small variation coefficients are eliminated using differentiation analysis methods. This report uses the averaging weighting method to allocate weighting coefficients to China's province-level environmental performance evaluation indexes.

3.5 Data Sources

All index data were obtained from authoritative, publicly available sources.

4. RESEARCH FINDINGS

4.1 Dynamic Evaluation of the Environmental Performance Comprehensive Index

There appears to be a certain degree of fluctuation in the environmental performance indexes across province-level regions in China. The average score of comprehensive environmental performance for China's 30 province-level regions is 63.08 points. Among them, the four regions of Beijing, Tianjin, Fujian and Shandong all scored more than 68 points for environmental performance over the 10-year period, thus indicating outstanding performance. The two regions of Guizhou and Xinjiang scored an average of less than 57 points as their environmental performance indexes, and with the exception of Qinghai, the 20 other province-level regions experienced varying degrees of improvements.

Table 4-1 EPI Score for Different Province-Level Regions Over the10-Year Period

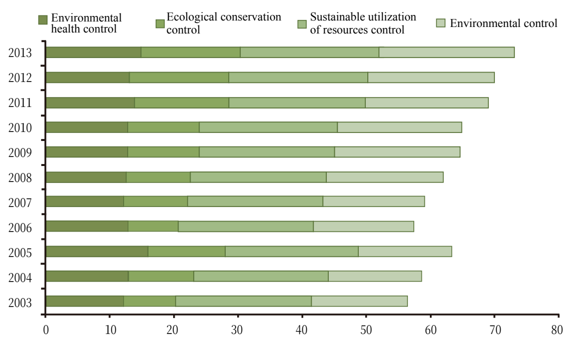
Region	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
National average	57.64	63.69	56.27	58.33	60.49	62.72	63.55	67.94	68.41	71.77
Beijing	74.13	81.75	72.76	70.40	71.68	76.66	74.34	79.46	79.74	83.97
Tianjin	64.79	70.44	65.34	68.42	69.97	72.76	70.40	74.73	74.60	78.42
Hebei	58.01	68.84	57.72	63.32	64.92	66.15	70.29	77.66	71.52	75.76
Shanxi	54.40	56.89	46.93	55.92	59.14	59.61	61.30	66.32	67.16	68.58
Neimenggu	57.04	59.00	54.96	52.95	59.07	60.60	61.58	66.58	69.96	76.62
Liaoning	59.50	66.16	57.71	58.42	61.44	63.63	62.70	68.10	70.04	71.68
Jilin	54.74	63.70	50.74	54.27	55.97	60.15	61.09	71.94	66.80	73.23
Heilongjiang	57.04	60.06	53.93	54.11	55.38	56.78	53.99	60.45	57.11	66.25
Shanghai	59.29	62.24	63.66	57.47	56.07	53.72	54.53	52.35	58.99	60.30
Jiangsu	62.77	70.95	63.61	65.09	67.39	67.05	68.00	71.06	71.96	75.11
Zhejiang	58.01	71.12	58.02	55.51	62.85	67.40	67.65	72.44	74.30	70.83
Anhui	60.08	68.82	61.12	62.01	63.30	63.44	64.26	70.55	73.37	77.70
Fujian	61.91	74.57	59.19	66.88	69.53	68.95	70.72	76.45	75.56	77.06
Jiangxi	59.02	65.96	60.39	62.05	64.05	68.10	70.26	79.60	77.18	78.29
Shandong	61.93	68.88	69.76	67.40	69.29	65.22	70.11	72.47	72.31	72.89
Henan	61.47	65.03	56.03	59.35	59.52	60.97	59.92	65.34	64.21	66.34
Hubei	57.20	62.19	54.31	57.48	60.07	64.71	63.33	69.09	70.21	74.51
Hunan	50.85	56.21	45.30	49.67	53.84	59.73	59.05	62.28	65.23	67.67
Guangdong	52.03	67.20	58.16	58.62	65.97	65.07	70.45	68.81	69.24	71.57
Guangxi	46.51	59.60	49.84	48.22	55.56	64.63	66.76	64.65	69.46	71.42

Region	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Hainan	61.19	69.96	58.48	60.58	59.57	61.19	58.06	60.97	68.27	68.64
Chongqing	48.87	57.26	56.73	62.88	60.74	59.71	66.34	74.71	73.72	78.46
Sichuan	56.88	61.61	58.20	60.87	62.00	63.00	67.84	73.67	71.10	72.44
Guizhou	43.42	46.69	40.90	38.38	42.51	45.59	46.62	52.16	57.81	64.43
Yunnan	62.54	60.25	50.76	59.34	60.02	67.48	69.43	72.85	68.59	75.45
Shanxi	56.09	60.94	52.51	54.61	62.95	66.26	67.96	70.11	72.81	70.04
Gansu	54.95	59.16	53.34	55.28	53.46	56.13	54.60	57.53	59.93	70.50
Qinghai	67.91	64.76	59.05	61.74	62.69	64.23	59.10	62.98	58.91	61.26
Ningxia	50.56	58.11	54.01	59.60	57.03	61.46	65.03	64.05	64.23	66.91
Xinjiang	55.21	52.40	45.65	49.12	48.72	51.18	50.65	55.88	57.87	66.66

Overall, China's environmental performance progressively improved over the 10 years. The average score maintained a rising tendency, achieving the highest score of 71.77 for average environmental performance in 2013. In particular, environmental performance scores continued to rise during 2004-2005. However, in 2006, environmental performance dropped significantly as compared with 2005 because scores for the two indexes of environmental health and ecological protection both declined by 3-4 points. In addition, seen from the average scores of second-level indexes, the average scores of environmental performance continued to rise during 2006-2013, and all four second-level indexes increased by varying degrees during these years. This shows that China's overall environmental performance level is improved. From 2006 to 2013, the index of sustainable utilization of resources occupied a large proportion of the four second-level indexes, indicating that China had a relatively high level of performance in that area. As can be seen from the rising trend in the scores, the indexes of ecological conservation and environmental control rose at a faster pace.

From 2004 to 2013, the average scores for China's regional comprehensive environmental performance indexes rose despite fluctuations but did not show a tendency to increase continuously year by year (Figure 4-1). Over the 10-year period, among all province-level regions in China, 29 showed positive growth in terms of the growth rate of comprehensive environmental performance index scores, and only Qinghai showed negative growth. The overall performance was thus good.

Figure 4-1 Variation of the Comprehensive Environmental Performance Index Over the10-Year Period



In 2013, 29 provincial regions in China had an EPI higher than that in 2004. Chongqing, Guangxi and Guizhou had a faster EPI growth rate, which increased by over 48%, and Henan and Shanghai had a slower growth rate, with both lower than 10%. Only Qinghai had a negative EPI growth rate, the main reason being that in the 2013 indexes including rural water transformation yield, regional ambient noise and rural sanitary toilet penetration, the aggregates per unit of GDP energy consumption were lower than those in 2004.

Environmental performance is continually improved. The scatter diagram of EPI scores vs. per capita GDP for each province-level region shows that the growth rate slowed down when the per capita GDP was between RMB30,000-60,000, whereas the performance scores increase more quickly when the value exceeded RMB60,000. With China's current average GDP (the per capita constant-price GDP was RMB26,431 in 2013), environmental performance scores will rise at a speed lower than that of economic growth if the historical scenario is maintained.

Figure 4-2 Grade Distribution for China's Regional Comprehensive Environmental Performance Index Growth Rate Over the10-Year Period

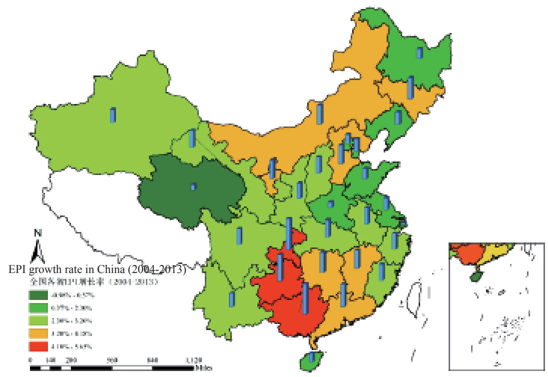


Table 4-2 EPI Growth Rate from 2004 to 2013

Region	Growth rate(Unit: %)	Region	Growth rate(Unit: %)	Region	Growth rate (Unit: %)
Beijing	13.27	Zhejiang	22.09	Hainan	12.17
Tianjin	21.04	Anhui	29.31	Chongqing	60.56
Hebei	30.59	Fujian	24.47	Sichuan	27.36
Shanxi	26.05	Jiangxi	32.65	Guizhou	48.40
Neimenggu	34.33	Shandong	17.70	Yunnan	20.65
Liaoning	20.47	Henan	7.92	Shanxi	24.88
Jilin	33.78	Hubei	30.26	Gansu	28.29
Heilongjiang	14.55	Hunan	33.07	Qinghai	-9.80
Shanghai	1.70	Guangdong	37.55	Ningxia	32.33
Jiangsu	19.65	Guangxi	53.55	Xianjiang	20.73

The variation in the performance index ranking of China's provinces, municipalities and regions from 2004 to 2013 is represented with the diagonal method in the graph below. The points above the diagonal show that the performance index ranking for 2013 is lower than that for 2004, thus indicating a downward trend in the performance ranking. The points below the diagonal show that the performance index ranking for 2013 is higher than that for 2004, thus indicating an upward trend in the performance ranking. It can be seen that the provinces and municipalities near the diagonal such as Beijing, Yunnan, Jiangxi and Hubei show no significant variation in performance ranking from 2004 to 2013.

Regions with developed economies had good overall environmental performance. The environmental performance of different province-level regions in China is significantly positive correlated with GDP and per capita GDP, thus indicating considerable consistency between regional socioeconomic development levels and environmental performance. To some extent, regions with good levels of socioeconomic development tended to have a higher level of environmental performance.

Figure 4-3 Variation in Environmental Performance Ranking for Different Province-Level Regions in China

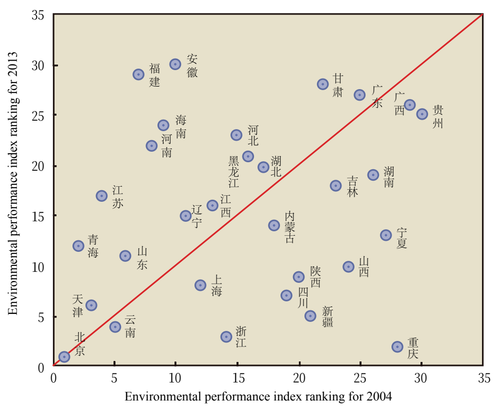


Figure 4-4 Relationship between Environmental Performance and Per Capita GDP (Cubic Curve Simulation)

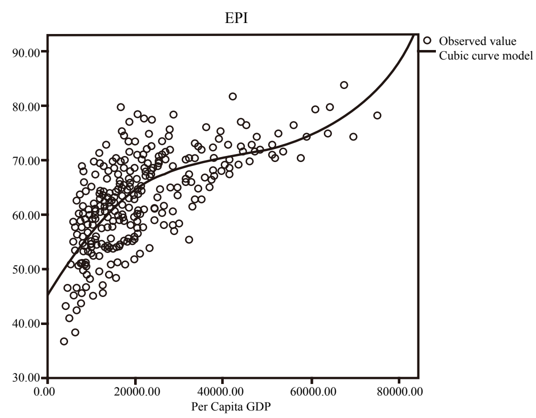


Table 4-3 Correlation Analysis

Pearson correlation	Environmental health	Ecological conservation	Sustainable utilization of resources	Environmental control	EPI	GDP	Per capita GDP
Environmental health	1	.209**	.211**	.281**	.598**	.274**	.365**
Ecological conservation	.209**	1	0.055	.291**	.651**	.233**	.323**
Sustainable utilization of resources	.211**	0.055	1	.391**	.592**	.337**	-0.03
Environmental control	.281**	.291**	.391**	1	.769**	.459**	.573**
EPI	.598**	.651**	.592**	.769**	1	.496**	.489**
GDP	.274**	.233**	.337**	459**	.496**	1	.541**
Per capita GDP	.365**	.323**	-0.03	.573**	.489**	.541**	1

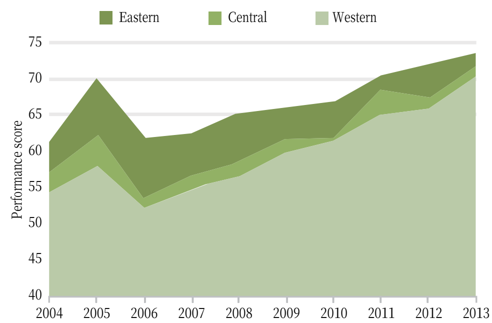
**Correlation is obvious at the 0.01 level (two tailed).

In particular, GDP has a significant positive correlation with environmental health, ecological conservation, sustainable utilization of resources, environmental control and environmental performance. That is, with a higher socioeconomic level, the higher such indexes as environmental health, ecological conservation, sustainable utilization of resources, environmental control and environmental performance, the better is the performance level. Per capita GDP has a significant positive correlation with environmental health, ecological conservation, environmental control and environmental performance. That is, with a higher per capita GDP level, the higher such indexes as environmental health, ecological conservation and environmental control, the better is the performance level accordingly. However, per capita GDP is not correlated with the index of sustainable utilization of resources; in other words, per capita GDP has no effect on the sustainable utilization of resources.

China's environmental performance was characterized by a gradient spatial pattern: the eastern region was better than the central region, and the central region was better than the western region. Seen from the overall environmental performance of China's eastern, central and western regions[1] , from 2004 to 2013 the eastern region performed better than the central region, and the central region performed better than the western region. Moreover, there was similar trend in the variation in environmental performance:

the gap between the central and western regions and the eastern region in EPI became smaller and smaller. The main reason for the regional differences is that the eastern region took the lead in China to open up and adopt policies of reform, and thus its level of economic development far outpaced that of the central and western regions. In addition, it invested more in environmental control. In 2004, the environmental performance score for the eastern region was 4.3 points higher than that for the central region and 6.7 points higher than that for the western region, whereas in 2013 the score for the eastern region was 1.7 points higher than that for the central region and 2.9 points higher than that for the western region. Thus, it is evident that the regional gap was narrowed.

Figure 4-5 Scoring Trend of the Environmental Performance Index for Eastern, Central and Western Regions of China



4.2 Dynamic Evaluation of the Secondary Indexes of Environmental Performance

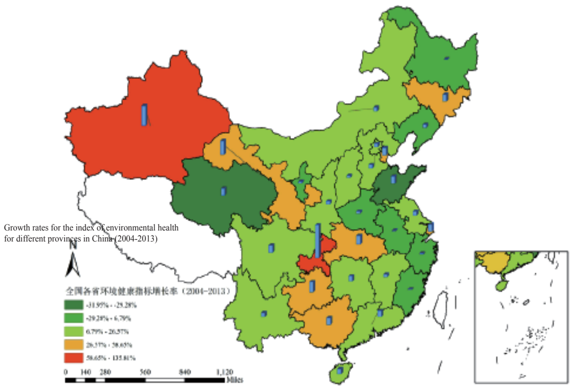
(1) Performance Index of Environmental Health

China had experienced great fluctuation in the growth rates of environmental health performance over the 10 years, but overall, environmental health performance was improved and the majority of province-level regions experienced positive growth. Among them, Chongqing performed remarkably, ranking the first with an increase of 135.81%, and Xinjiang and Gansu also performed well, with both registering growth rates of over 50%. Six

[1] The eastern region includes Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan; the central region includes Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunan; and the western region includes Inner Mongolia, Guangxi, Sichuan, Yunnan, Shaanxi, Gansu, Qinghai, Chongqing, Guizhou, Ningxia and Xinjiang.

province-level regions registered negative growth, including Liaoning, Heilongjiang, Fujian, Shandong, Henan and Qinghai. Environmental health remains a weakness of these provinces, and environmental protection needs to be further intensified.

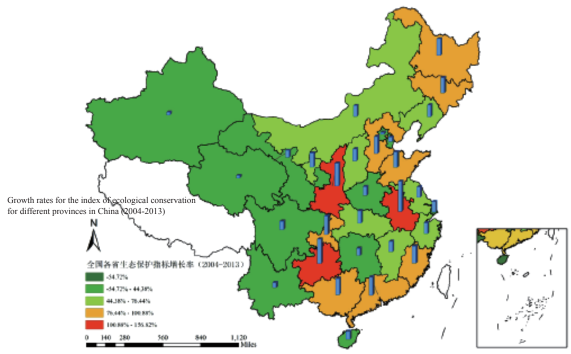
Figure 4-6 Distribution of Scores for Growth Rates of Environmental Health Performance for China's Different Regions Over the 10-Year Period



(2) Performance Index of Ecological Conservation

Gradually, ecological conservation performance was rated as good or excellent in more provinces (Figures 4-7). In 2004, no provinces were rated as good or excellent for ecological conservation performance, whereas in 2013, 9 provinces achieved the good or excellent ratings . Among all province-level regions, there were slightly fewer cases in which the ecological conservation performance was rated as ordinary or poor. Besides, Beijing and Xinjiang had no obvious variation in ecological conservation performance, increasing by less than 20%. Anhui, Guizhou, Shaanxi and Chongqing achieved marked progress in ecological conservation over the past 10 years, with all increasing by over 100%. Furthermore, Shanghai registered negative growth in ecological protection performance.

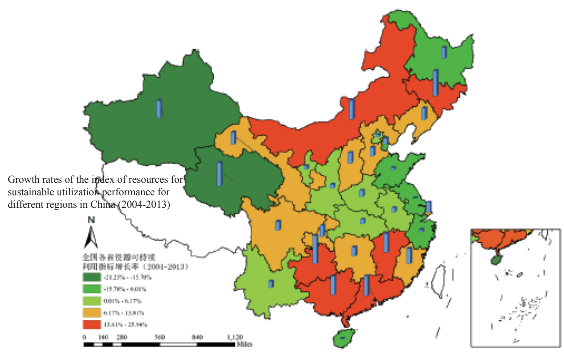
Figure 4-7 Distribution of Scores for Growth Rates of Ecological Conservation Performance for China's Different Regions Over the 10-Year Period



(3) Performance Index of Sustainable Utilization of Resources

The majority of provinces in China were rated as excellent or good for the performance index of the sustainable utilization of resources. The scores for all provinces for sustainable utilization of resources were higher than those for the other three secondary indexes. These growth rates showed that only a few regions were below the average level, and the distribution of growth rates for the sustainable utilization of resources index scores varied to some extent between the different regions. Seven provinces and municipalities, including Tianjin, Heilongjiang, Jiangsu, Zhejiang, Shandong, Qinghai and Xinjiang, registered negative growth. Of them, Qinghai registered the most negative growth, indicating that it urgently needs to enhance its efficiency in the sustainable utilization of resources. All provinces and municipalities that had positive growth registered a growth rate of less than 30%, and Guizhou performed best by only increasing 25.94%.

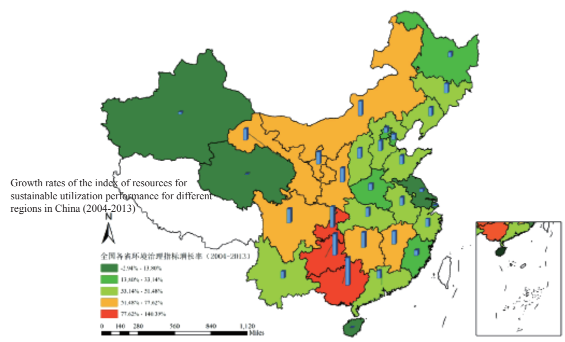
Figure 4-8 Distribution of Scores for Growth Rates of Sustainable Utilization of Resources Performance for China's Different Regions Over the 10-Year Period



(4) Performance Index of Environmental Control

Over the 10 years, there were great differences between provinces and municipalities in the growth rate of environmental control performance. Beijing, Tianjin and Jiangsu always had excellent performance, whereas with the exception of only one year in Shanghai (2009) and Hainan (2010), in which they showed good performance, both recorded excellent performance. China's regional environmental control performance was the best in 2013, with 20 regions displaying at least excellent or good performance. There were relatively larger differences between China's provinces and municipalities in scores for environmental control performance. Among them, the top three were Guangxi, Guizhou and Chongqing, with growth rates of over 100%. Shanghai registered negative growth, but other regions all registered positive growth of varying degrees.

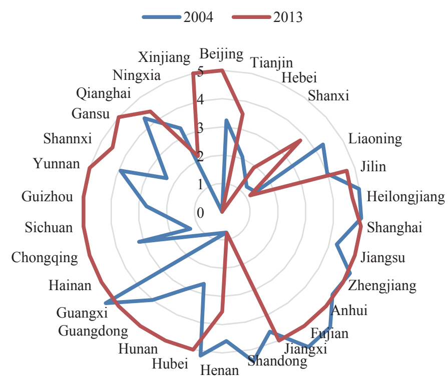
Figure 4-9 Distribution of Scores for Growth Rates of Environmental Control Performance for China's Different Regions Over the 10-Year Period



4.3 Dynamic Evaluation of the Tertiary Indexes of Environmental Performance

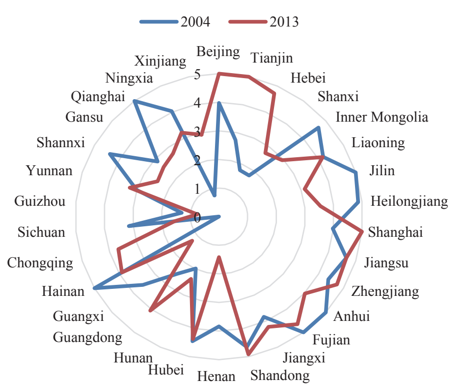
Air Quality: Scores for this index increased for most province-level regions. The regions that experienced marked improvements in air quality performance were Beijing, Xinjiang, Guizhou, Sichuan, Chongqing, Guangdong and Hunan. However, several province-level regions also experienced obvious deteriorations in air quality, including Shandong, Inner Mongolia, Hebei, Ningxia, Qinghai and Jilin.

Figure 4-10 Air Quality Score Comparison



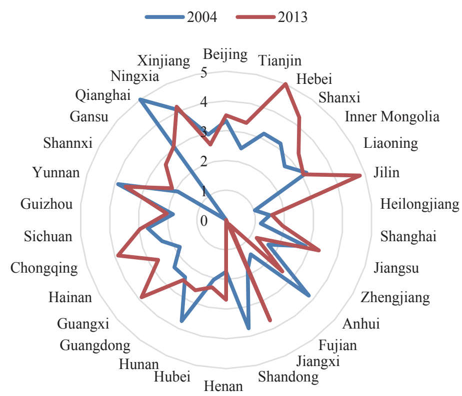
Water Environmental Quality: Overall, China's 30 province-level regions changed for the better over the 10 years. A majority of regions experienced varying degrees of improvement in water quality; however, in some regions, water quality performance declined. The provinces that experienced marked increases in performance scores included Hebei, Tianjin, Beijing, Xinjiang, Chongqing, Guangdong and Shanghai. Provinces that performed poorly included Qinghai, Ningxia, Shaanxi, Sichuan, Hainan, Anhui, Heilongjiang, Jilin and Inner Mongolia. Water environment quality in these regions needs to be further improved.

Figure 4-11 Water Environmental Quality Score Comparison



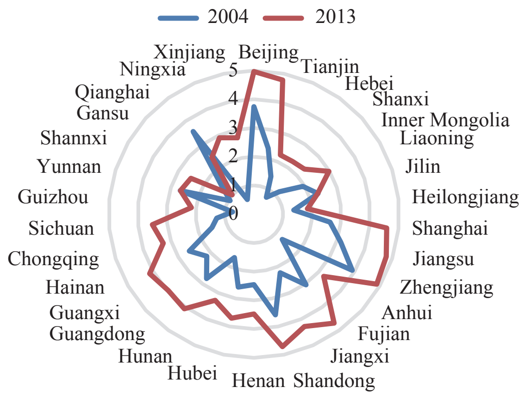
Noise Environmental Quality: There were great differences between China's 30 province-level regions, but overall performance greatly improved. The regions with the largest improvements included Hebei, Tianjin, Shaanxi, Chongqing, Guangxi and Heilongjiang. However, noise environmental quality in some regions, including Qinghai, Hunan, Shandong and Anhui, decreased.

Figure 4-12 Noise Environmental Quality Score Comparison



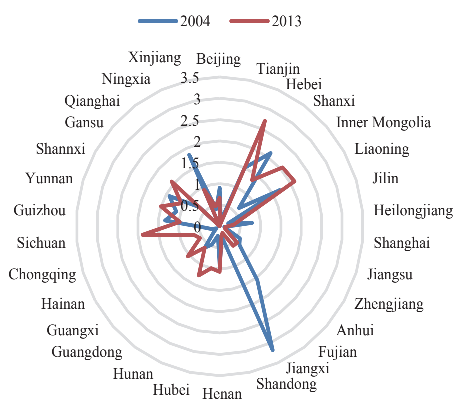
Environmental Sanitation: Most of China's province-level regions experienced varying degrees of improvement in environmental sanitation and overall changed for the better. Except for Qinghai and Gansu, all other provinces experienced increases in performance scores for environmental sanitation. The regions with better performance included Beijing, Tianjin, Shanghai, Jiangsu and Zhejiang. The region with the worst performance was Qinghai, for which the performance score for environmental sanitation was on the decline.

Figure 4-13 Environmental Sanitation Score Comparison



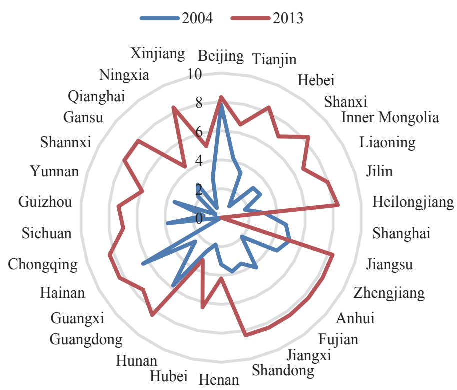
Waste Management: China's 30 province-level regions generally performed poorly in waste management. From 2004 to 2013, most regions improved their waste management to only a limited degree, with performance scores increasing by only slight margins. Meanwhile, performance scores for 2013 in quite a few regions were lower than those for 2004. Such regions include Ningxia, Inner Mongolia, Fujian and Jiangxi, in which more improvement is needed.

Figure 4-14 Waste Management Score Comparison



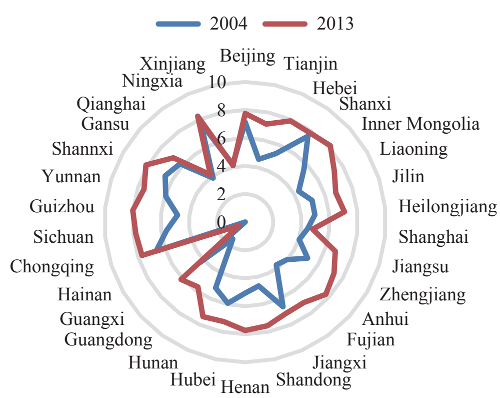
Urban Forestation: A great majority of China's 30 province-level regions have experienced substantial increases in the index of urban forestation, indicating that China has greatly improved in this area. Only Shanghai and Jiangsu have experienced a declining trend in performance scores. These two regions need to make greater efforts in urban forestation.

Figure 4-15 Urban Forestation Score Comparison



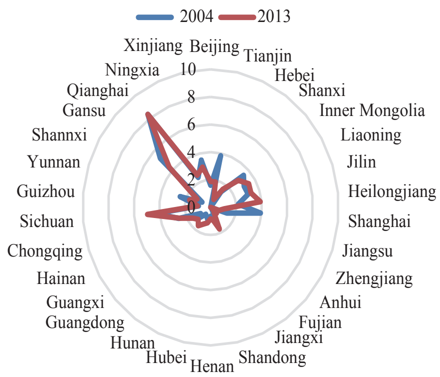
Agriculture and Land Management: Most of China's province-level regions had low performance scores for biodiversity, indicating below-average performance. Qinghai and Sichuan scored the highest for biodiversity and showed a tendency for the better. As seen from the variation trend, Liaoning, Heilongjiang, Jilin and Shandong all tended toward improvement, whereas Beijing, Tianjin, Yunnan and Shanghai all tended toward worse performance.

Figure 4-16 Agriculture and Land Management Score Comparison



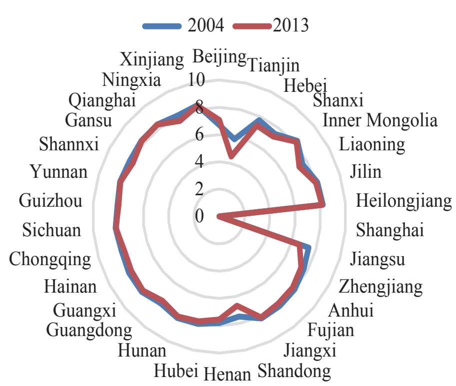
Biodiversity: Most parts of China performed poorly in terms of biodiversity, with much room remaining for improvement. Most regions changed for the better, but the variation is not obvious. Of note, Qinghai and Sichuan achieved high scores for both 2004 and 2013, and there was some tendency for variation.

■ **Figure 4-17 Biodiversity Score Comparison**



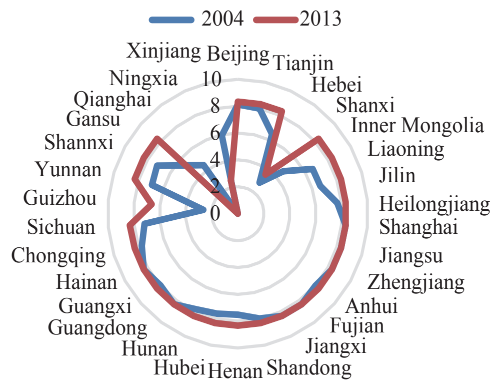
Climate Change: China's 30 province-level regions showed only slight variation for this index over the ten years. Yunnan, Guizhou and Sichuan basically remained unchanged, and Tianjin, Hebei, Jiangsu, Shandong and Ningxia experienced slight deterioration. Shanghai continued to perform poorly in this area, which will require more attention in the future.

■ **Figure 4-18 Climate Change Score Comparison**



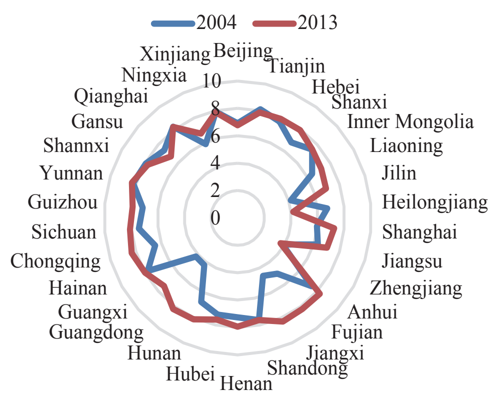
Energy Utilization: China's 30 province-level regions varied significantly in energy utilization, with most regions experiencing only slight but limited improvement. The regions with more substantial improvements included Hebei, Inner Mongolia, Jilin, Heinan, Guizhou and Gansu. However, Xinjiang and Ningxia experienced declines in energy utilization performance.

■ **Figure 4-19 Energy Utilization Score Comparison**



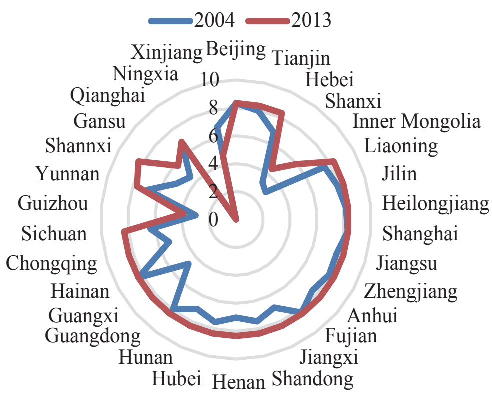
Resource Utilization: Most regions experienced varying degrees of improvement in performance levels of resource utilization. The regions with better performance included Jilin, Fujian, Jiangxi, Guangdong and Guangxi. Heilongjiang performed poorly in resource utilization and lagged behind to a great extent.

■ **Figure 4-20 Resource Utilization Score Comparison**



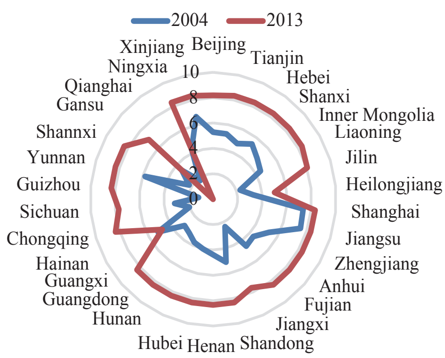
Pollution Control: All 30 province-level regions recorded lower performance scores for pollution control. Although the overall trend improved, the change was not very obvious. More efforts are needed in this area. Particular attention needs to be paid in Xinjiang, which experienced the most significant decrease in the performance score for this index.

■ **Figure 4-21 Pollution Control Score Comparison**



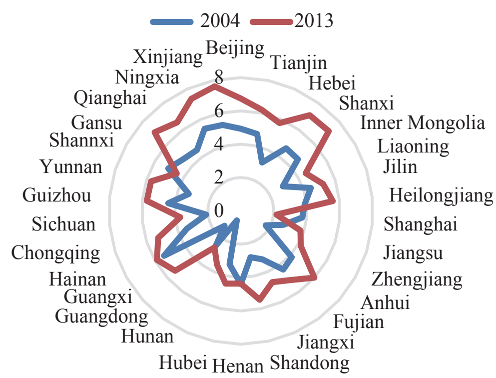
Pollution Governance: The majority of the regions improved their performance scores for pollution governance. This indicates that most of the regions realized effective payoffs from their investments and efforts in pollution governance. However, regions such as Qinghai and Hainan performed poorly, with their performance scores decreasing to some extent.

■ **Figure 4-22 Pollution Governance Score Comparison**



Environmental Management: Most of the regions improved their performance scores, and environmental management continued to improve, but the extent of improvement varied. The regions with the most improvement included Inner Mongolia, Shanxi, Hebei, Tianjin, Beijing and Gansu. However, some regions made unremarkable improvements in environmental management, such as Yunnan and Shanghai.

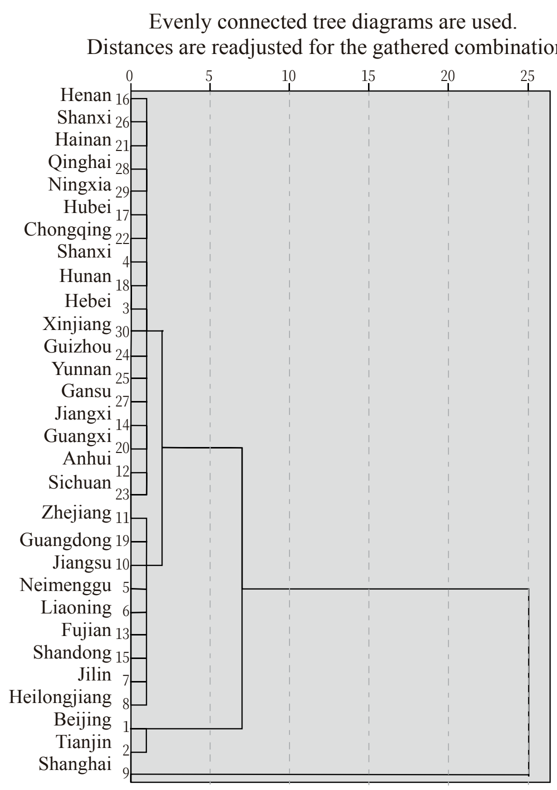
■ **Figure 4-23 Environmental Management Score Comparison**



4.4 Cluster Analysis Results

The levels of environmental performance of the 30 provinces and municipalities were not consistent with their levels of economic development. Based on different variation trends they can be classified into three categories by cluster analysis. The first category includes areas with higher performance scores and economic development levels, such as Beijing and Tianjin. The second category includes areas with lower environmental performance scores or economic development levels, such as Hebei, Shanxi, Anhui, Jiangxi, Henan, Hubei, Hunan, Guangxi, Hainan, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang. The third category includes areas with intermediate scores on environmental performance and economic development levels, such as Inner Mongolia, Liaoning, Jilin, Heilongjiang, Jiangsu, Zhejiang, Fujian, Shandong and Guangdong.

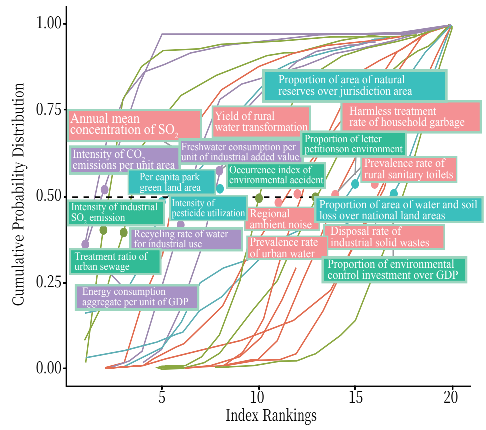
Figure 4-24 Cluster Analysis of Environmental Performance Indexes



4.5 Key Indexes Affecting EPI

Indexes with higher growth rates contribute more to scores of EPI than those with lower growth rates. The top 10 variables are CO_2 emission intensity per unit area, energy consumption aggregate per unit of GDP, industrial SO_2 emission intensity, treatment ratio of urban sewage, per capita park and green land area, annual mean SO_2 concentration, recycling rate of water for industrial use, pesticide utilization intensity, freshwater consumption per unit of industrial added value and incidence index of environmental accidents.

Figure 4-25 Distribution of the Cumulative Probability of Index Rankings



5. POLICY IMPLICATIONS AND SUGGESTIONS

China's overall pattern of variation of environmental performance during the 10 years under study indicates that the country had attached great importance to environmental protection, made hard-won achievements in the rapid process of advancing industrialization and urbanization, and also exerted much effort in environmental protection. However, major problems remain in air quality, water environmental quality and environmental hygiene, and more efforts are needed to improve these areas.

Over the 10 years, the comprehensive environmental performance and economic development of the province-level regions were well correlated. China should further increase its investment in environmental controls, intensify ecological conservation, better maintain environmental health and sustainable utilization of resources and promote a green economy to improve regional environmental performances.

The eastern region recorded weak performance scores for ecological conservation indexes. The central and western regions should strengthen their management of rivers as water sources, planning of urban construction and efficient utilization of resources. At the same time, they need to direct more manpower, materials and funds toward environmental control and management for better control of the environment.

Shanxi, Guizhou, Shaanxi and Gansu all have environmental health performance scores lower than the national average and should more closely follow air quality, water quality, noise and other indexes related to environmental health. Six regions, including Shanghai, Henan, Hubei, Hunan, Hainan and Guizhou, performed poorly in ecological conservation and should strengthen their performance in relation to indexes such as urban forestation and biodiversity conservation. Shanxi, Shanghai, Qinghai and Ningxia all performed far lower than the national average in their performance scores for the sustainable utilization of resources and should thus strengthen their efforts in areas related to indexes such as the efficiency of energy utilization.

China's provinces differ greatly in their endowments of local resources, so evaluations of environmental performance should consider such differences and combine provinces and municipalities with main functional areas to make evaluation more reasonable.

International communication and cooperation should also be strengthened. This should be done for key issues such as the theories, methodologies, evaluation framework and index system for environmental performance evaluation. A diversified assessment body should be used, and efforts should be made to speed up the collection of relevant data, strictly control data quality, and strengthen the utilization of information technology to provide support for environmental management.

REFERENCE:

1 Yale Center for Environmental Law and Policy. 2014Environmental Performance Index and Pilot Trend Environmental Performance Index. Yale University, 2014.http://epi.yale.edu

2 Yale Center for Environmental Law and Policy. 2012 Environmental Performance Index and Pilot Trend Environmental Performance Index. Yale University, 2012.http://epi.yale.edu

3 Yale Center for Environmental Law & Policy,International Earth Science Information Network (CIESIN),2010 Environmental Performance Index,http://epi.yale.edu

4 Yale Center for Environmental Law & Policy,International Earth Science Information Network (CIESIN),2008 Environmental Performance Index,http://epi.yale.edu

5 Yale Center for Environmental Law & Policy,International Earth Science Information Network (CIESIN),2006Environmental Performance Index,http://epi.yale.edu

6 Organization for Economic Co-operation and Development(OECD). OECD core set of indicators for environmental performance[R]. OECD/GD (93)179.Paris:OECD, 1993.

7 European Environmental Agency(EEA). EEA core set of indicators- guide[R]. European Environmental Agency, Report No. 1, Copenhagen: EEA, 2005.

8 Tung H. L., Tsai H., Lee C.M. A study of DSR indicator framework for sustainable development in Taiwan[J]. Journal of Humanities and Social Science, 2005(1), 1: 29-39.

9 Zhanfeng Dong, Qiong Wu, Jinnan Wang, Chazhong Ge,Dong Cao. Environmental indicator development in China: Debates and challenges ahead[J].Environmental development,2013(7):125-127.

10 Xuan Zuo, Hui Hua , Zhanfeng Dong. Environmental Performance Index at the Provincial Level for China2006–2011[J].Ecological Indicators, 2017,75:48–56

11 Shaofeng Chen. Research on China's Resource and Environment Comprehensive Performance Evaluation from 2000 to 2005[J]. Scientific Management Research, 2007, 25(6):51-53. (in Chinese)

12 Xiaocui Che, Pingyu Zhang. Resource-based City Economic Transformation Performance and Its Evaluation Index System[J]. Academic exchanges, 2011(1):94-96. (in Chinese)

13 Quying Hu. Review on the research dynamics of environmental performance evaluation at home and abroad[J]. Science & Technology Progress and Policy, 2011, 28(10):156-160. (in Chinese)

14 Zhanfeng Dong, Chunxu Hao, Ting Wang, et al. Research on Provincial Environmental Performance Evaluation Methods in China[J]. Environmental Pollution & Control, 2016, 38(2):86-90. (in Chinese)

15 Chunxu Hao, Junhao Wen, Zhanfeng Dong, et al. China’s provincial environmental performance assessment based on principal component analysis[J]. Resource Development & Market, 2016, 32(1):26-30. (in Chinese)

16 Zhanfeng Dong, Qiong Wu, Hongxiang Li, et al. Six key issues in the construction of China’s environmental performance assessment system[J]. Liaoning Urban and Rural Environmental Science & Technology, 2013, 33(9):4-11. (in Chinese)

17 Zhanfeng Dong, Chunxu Hao. Actively build an environmental performance assessment and management system[J]. Social observation, 2015(10):34-37. (in Chinese)

18 Zhanfeng Dong. China Provincial Environmental Performance Assessment. 2006-2010[M]. China Environmental Press, 2016. (in Chinese)

19 Zhanfeng Dong, Chunxu Hao, Zengwei Yuan, et al. Dynamic Research on Provincial Environmental Performance Assessment in China[J]. Science & Technology Review, 2018, 36(2):67-80. (in Chinese)

ATTACHMENT 1:

Table 1 Index System for the Evaluation of Province-Level Environmental Performance in China 2004-2013

Second level	Third level	Fourth level	Target Value	Unit	Source of Data
Environmental Health	Air quality	Annual average concentration of PM_{10}	20	mg/m^3	China Statistical Yearbook
		Annual average density of SO_2	40	mg/m^3	China Statistical Yearbook
		Annual average density of NO_2	40	mg/m^3	China Statistical Yearbook
		Proportion of days with air quality above level II over the whole year	80	%	China Statistical Yearbook
	Water quality	Urban water coverage	100	%	China Statistical Yearbook
		Yield of rural water transformation	100	%	China Environmental Statistical Yearbook
	Noise	Road traffic noise	Optimal	dB	China Statistical Yearbook
		Regional ambient noise	Optimal	dB	China Statistical Yearbook
	Environmental sanitation	Treatment rate of domestic garbage	100	%	China Statistical Yearbook
		Disposal rate of urban residents' feces	Optimal	%	China Environmental Statistical Yearbook
		Prevalence rate of rural sanitary toilets	95	%	China Environmental Statistical Yearbook
	Waste management	Equivalent amount of discharge of hazardous substances in industrial waste water (mercury, cadmium, six-valence chromium, lead, arsenic, volatile phenol and cyanide)	0	Ton	China Environmental Statistical Yearbook
		Safe disposal rate of industrial solid waste	100	%	China Statistical Yearbook
		Disposal rate of industrial solid wastes	100	%	China Statistical Yearbook

Second level	Third level	Fourth level	Target Value	Unit	Source of Data
Ecological conservation	Urban forestation	Per capita area of parks and green land	12	m^2	China Statistical Yearbook
		Green coverage ratio inbuilt-up areas	45	%	China Statistical Yearbook
	Agriculture and land management	Intensity of pesticide utilization	3	kg/hectare	China Statistical Yearbook
		Intensity of fertilizer application	250	kg/hectare	China Statistical Yearbook
		Proportion of areas with water and soil loss in national land areas	10	%	Bulletin for Water and Soil Loss
	Biodiversity	Proportion of natural reserve areas in jurisdictional areas	With reference to national standards for construction of ecological cities and counties, plains 15% and mountainous areas and hilly land 20%	%	China Statistical Yearbook
		Percentage of forest cover	20.4	%	China Statistical Yearbook
		Index of vegetation coverage	100.0	Dimension-less	China Environmental Statistical Yearbook
		Index of biological abundance	100.0	Dimension-less	China Environmental Statistical Yearbook

Second level	Third level	Fourth level	Target Value	Unit	Source of Data
Sustainable utilization of resources	Climate change	Intensity of CO_2 emission per unit of GDP	1.8	Tons/RMB 10,000 GDP	China Energy Statistical Yearbook
		Per capita CO_2 emission	4.4	Tons/person	China Energy Statistical Yearbook
	Energy utilization	Proportion of non-fossil energy consumption to total energy consumption	10.0	%	China Energy Statistical Yearbook
		Energy consumption aggregate per unit of GDP	1.1	Tons standard coal/ RMB 10,000 GDP	China Statistical Yearbook
	Resource utilization	Freshwater consumption per unit of GDP	27.0	m^3/RMB 10,000 GDP	China Statistical Yearbook
		Index of water resource scarcity	Optimal	Dimension-less	China Statistical Yearbook
		Freshwater consumption per unit of industrial added value	20.0	m^3/RMB 10,000 industrial added value	China Statistical Yearbook
		Recycling rate of water for industrial use	70.0	%	China Statistical Yearbook
		Utilization rate of urban reclaimed water	20.0	%	China Statistical Yearbook
		Rate of multipurpose utilization of industrial solid wastes	60.0	%	China Statistical Yearbook

Second level	Third level	Fourth level	Target Value	Unit	Source of Data
Environmental control	Pollution control	Intensity of industrial SO_2 emission	4.5	kg/RMB 10,000 GDP	China Statistical Yearbook
		Intensity of industrial nitrogen oxide (NO_x) emission	2.448	kg/RMB 10,000 GDP	China Statistical Yearbook
		Intensity of industrial soot emission	Optimal	kg/RMB industrial added value	China Statistical Yearbook
		Intensity of waste water COD discharge	3.5	kg/RMB 10,000 GDP	China Statistical Yearbook
		Intensity of waste water ammonia nitrogen discharge	Optimal	kg/RMB 10,000 GDP	China Statistical Yearbook
		Intensity of industrial solid waste discharge	Optimal	kg/RMB industrial added value	China Statistical Yearbook
	Pollution control	Industrial SO_2 emission compliance	100	%	China Statistical Yearbook
		Industrial soot emission compliance	100	%	China Statistical Yearbook
		Industrial waste discharge compliance	100	%	China Statistical Yearbook
		Disposal rate of urban sewage	85	%	China Environmental Statistical Yearbook
	Environmental management	Proportion of GDP allocated to environmental control investments	Optimal	%	China Environmental Yearbook
		Incidence of environmental accidents	Optimal	-	China Environmental Statistical Yearbook
		Proportion of personnel in environmental protection agency to total population of the region	0.0	-	China Environmental Statistical Yearbook
		Proportion of environmental petitions	3.5	-	China Environmental Statistical Yearbook

Prof. Wang Jinnan

Prof. Wang Jinnan, is the president of Chinese Academy for Environmental Planning (CAEP), the academician of Chinese Academy of Engineering (CAE). He is also the director of the State Key Laboratory of Environmental Planning and Policy Simulation, the core expert of three National Key Science and Technology Programs, the member of the National Science and Technology Commission of Environmental Protection, and the vice president of Chinese Society for Environmental Science. He works as chief editor and serves on the editorial board of eight core journals in the field of environmental science. Prof. Wang Jinnan is mainly engaged in environmental planning and policy research over last three decades. Since 1988 he has published 13 monographs, such as *Environmental Planning* and *Environmental Economics*, and over 300 academic papers. He has been awarded as the first national hundreds of talents, the national professional leader in environmental science and technology, the leading Chinese youth of science and technology, the green China special figure, and the State Council leading expert. He has also received more than 20 scientific and technological research awards at national and ministerial level.

Chinese Academy of Environmental Planning

8 Dayangfang, BeiYuan Road, Chaoyang District, Beijing 100012, China

Editor in chief: Prof. WANG Jinnan

President, Chinese Academy of Environmental Planning

Contact person: Mr. ZHANG Hongyu

Tel: 86-10-84917585

Fax: 86-10-84918581

E-mail: zhanghongyu@caep.org.cn

Web: www.caep.org.cn