Research on Comprehensive Evaluation of Green Development Level in Hunan Province

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Abstract: In response to the national policy of promoting ecological civilization, the Hunan Provincial Committee and Government have put forward the important strategic policy of building a "Green Hunan", demonstrating their determination to vigorously promote green development. As an important province in the central region for promoting development, Hunan Province must lead by example, ensuring both economic development and environmental protection. The level of green development is an important indicator for measuring the quality of regional economic development in the period of transformation. Therefore, measuring the level of green development in Hunan Province is of great significance to the construction of a green Hunan. This paper analyzes the current situation of green development in Hunan Province from three aspects: economy, resource environment, and government support, elucidating the achievements already made in green development in Hunan Province, as well as the current challenges. Based on previous research, a comprehensive evaluation indicator system for the level of green development in Hunan Province is established, and the comprehensive index of green development level in Hunan Province is calculated and analyzed using the entropy method evaluation model.

Keywords: Hunan Province; level of green development; comprehensive evaluation; entropy method

1. Introduction

The concept of green development has gained global consensus, as people realize that the "development-first, governance-later" model cannot fundamentally resolve the contradiction between economic development and the ecological environment. The 19th National Congress Report comprehensively expounded on China's concept of green development, as well as the current status and development goals of green development in our country. Currently, green development has become the mainstream theme of social development in the new era in China. After the 19th National Congress, Hunan Province took the lead in implementing comprehensive supporting reform experiments for building an innovative and environmentally friendly society, forming the Hunan Model for such construction. The concept of an innovative and environmentally friendly society specifically refers to an environmentally friendly and resource-efficient society, with its core being the sustainable development and harmonious coexistence of human production activities and natural ecological systems based on the premise of resource conservation. During the process of building an innovative and environmentally friendly society, Hunan Province has emphasized the need to increase efforts in energy conservation and emissions reduction, accelerate industrial restructuring, and achieve comprehensive green development. In 2015, the State Council approved the *Development Plan for the Central Region Urban Agglomerations in the Yangtze River Economic Belt*, highlighting the centrality of Changsha and establishing the Wuhan City Ring, the Changsha- Zhuzhou- Xiangtan City Cluster, and the Pan Yang Lake Urban Agglomeration as the main supercity clusters. Hunan Province has become a leading region in the construction of an innovative and environmentally friendly society. In December 2016, Hunan Province once again put forward the slogan of "Promoting Ecological Civilization and Building Beautiful Hunan", incorporating "becoming an ecologically strong province" into the development strategy of the province's "Five Strong Provinces". In 2017, the Communist Party Committee and the government of Hunan Province published an article titled *Enabling the People of Hunan to Share Green Benefits*, expressing the vision of constructing a rich, beautiful, and happy new Hunan. Therefore, during the present and foreseeable future, the level of green development will emerge as a crucial theme and significant issue in the economic and social development of Hunan Province.

The study on the level of green development has gradually become a hot topic in domestic research in recent years, with the assessment indicators and research methods showing a diverse trend. Ling Juan (2023) constructed an evaluation indicator system for the level of green development in Hunan Province based on relevant statistical data from 2012 to 2020, selecting 17 specific indicators from three aspects: green production, green society, and green environment [1]. Meanwhile, using the entropy method, the green development levels of different years in Hunan Province were calculated, and the existing problems and their causes were analyzed and summarized, along with corresponding countermeasures and suggestions for reference. Ma Hui et al. (2023) constructed an evaluation indicator system for green development in the Yangtze River Economic Belt from three dimensions: the degree of greenification

in economic growth, the carrying capacity of resources and environment, and the level of government support for green development. They used a "longitudinal and horizontal" approach to dynamically evaluate the green development level in the Yangtze River Economic Belt from 2011 to 2020[2]. Wei Lin et al. (2023) analyzed the level of agricultural green development in Gansu Province from 2011 to 2019 and identified the constraining factors using the entropy method, comprehensive index method, and obstacle factor diagnostic model [3]. Dong Tingxi (2022) constructed an evaluation indicator system for the level of green development based on the China Green Development Index Annual Report, selecting 9 secondary indicators from three dimensions, and used the entropy method to evaluate the green development level in 11 provinces and cities in the Yangtze River Basin in China [4]. Ji Ru (2022) established an indicator system for green development from three aspects: green increase length, green carrying capacity, and green security capability. They comprehensively evaluated the green development level in Inner Mongolia using the TOPSIS entropy weight method and obstacle degree model [5]. Zhang Wanjun (2022) constructed an evaluation indicator system for the level of green development in Qinghai Province from three dimensions: the degree of greenification in economic growth, the carrying capacity of resources and environment, and the level of government policy support. They comprehensively evaluated the green development level in Qinghai Province and its various cities and states from 2010 to 2019 using quantitative analysis methods such as the entropy method, grey prediction model, and obstacle degree model. They analyzed the regional differences in the green development level of Qinghai Province from both a temporal and spatial perspective, predicted the evolution trend of green development in Qinghai Province, and discussed the obstacles influencing the green development level of Qinghai Province and its various cities and states [6]. Xia Guochuan (2022) conducted a comprehensive evaluation study on the green development in Hunan Province by obtaining data from the statistical yearbooks of Hunan Province from 2010 to 2019 and questionnaire data on residents' satisfaction with green development in Hunan Province. They summarized and analyzed the objective situation of the green development stage and residents' subjective perception of green development, providing a comprehensive evaluation of green development in Hunan Province [7].

Despite the achievements made by scholars in the academic research on green development, there are still shortcomings. Specifically, firstly, as a new development paradigm, there is still some controversy among scholars regarding the concept of green development, and there is no unified definition formed yet. Secondly, the evaluation of regional green development levels remains insufficient. Each province and city has its unique characteristics, and there is a significant lack of literature directly evaluating the level of green development in Hunan Province. In other words, research on this aspect in Hunan is far from sufficient. The level of green development serves as an important indicator for measuring the quality of regional economic development during the transitional period. Therefore, measuring the level of green development in Hunan Province holds significant importance for the construction of a green Hunan [8]. This study analyzes the current status of green development in Hunan Province from three aspects: economy, resources and environment, and government support. It elucidates the achievements that Hunan Province has made in green development and also identifies the challenges it currently faces. Building upon previous research, a comprehensive evaluation indicator system for the level of green development in Hunan Province is established. Utilizing an evaluation model based on the entropy method, the study calculates the composite index for the level of green development in Hunan Province and provides a detailed analysis of the results obtained.

2. Constructing the Evaluation System for Green Development in Hunan Province

2.1. Construction of Indicator System

Regarding the construction of the indicator system for green development, this study refers to existing research achievements, combines the demands of comprehensive development in Hunan Province, and considers the availability of statistical data. As a result, a comprehensive evaluation system for green development is established based on three dimensions: the degree of greenification in economic growth, the carrying capacity of resources and the environment, and the level of government support (as shown in Table 1). In order to assess the degree of greenification in economic growth, indicators such as the rate of economic green growth and industrial green growth are employed. To evaluate the carrying capacity of the ecological environment, indicators such as resource abundance and environmental pressure are utilized. Additionally, the level of government support is assessed through indicators such as green investment and green infrastructure construction. The evaluation system consists of 47 specific indicators, including 29 positive indicators and 18 negative indicators.

Table 1. Evaluation indicator system for green development

First-level indicators	Second-level indicators	Third-level indicators	Attribute	Unit
		Per capita GDP growth rate	+	%
		Per capita disposable income of residents	+	yuan
		Energy consumption per 10,000 yuan of GDP	-	t/10,000 yuan
	Green growth efficiency	Water consumption per 10,000 yuan of GDP	-	t
		Ammonia nitrogen emissions per unit of GDP	-	t
		Nitrogen oxide emissions per unit of GDP	-	t
The greenification of economic growth		Total sulfur dioxide emissions per unit of GDP	-	t
		Chemical oxygen demand emissions per unit of GDP	-	t
		Labor productivity in the primary industry	+	%
	Primary industry	Land output rate	+	%
		Proportion of effective irrigation area	+	%
		Energy consumption of industrial value-added above a certain scale per 10,000 yuan	-	t/10,000 yuan
	Secondary industry	Comprehensive utilization efficiency of general industrial solid waste	+	%
		Labor productivity in the secondary industry	+	%
		Industrial water reuse rate	+	%
		Water consumption per unit of industrial value-added	-	t/10,000 yuan
		Proportion of value-added in the tertiary industry	+	%
	Tertiary industry	Proportion of employees in the tertiary industry	+	%
		Labor productivity in the tertiary industry	+	%
		Per capita water resources	+	t/people
		Afforestation area in the current year	+	Hectare
	Abound resources	Green coverage rate	+	%
		Forest coverage rate	+	%
		Fertilizer use per unit of arable land area	-	Kilogram/hectare
		Pesticide use per unit of arable land area	-	Kilogram/hectare
The carrying capacity of resources and environment		Ammonia nitrogen emissions per unit of land area	-	t/km^2
		Nitrogen oxide emissions per unit of land area	-	t/km^2
	Environmental pressure	Total sulfur dioxide emissions per unit of land area	-	t/km^2
		Chemical oxygen demand emissions per unit of land area	-	t/km^2
		Per capita ammonia nitrogen emissions	-	t/10,000 people
		Per capita nitrogen oxide emissions	-	t/10,000 people
		Per capita total sulfur dioxide emissions	-	t/10,000 people
		Per capita chemical oxygen demand emissions	-	t/10,000 people
		Proportion of scientific and technological financial expenditure to total fiscal expenditure	+	%
		Proportion of environmental protection expenditure to total fiscal expenditure	+	%
	Green investment	Proportion of urban maintenance and construction funds to GDP	+	%
		Proportion of industrial pollution control investment to GDP	+	%
		Sewage treatment rate	+	%
		Number of public transport vehicles per 10,000 people	+	Vehicle
		Number of health technicians per 10,000 people	+	People
The level of government support		Number of hospital beds per 10,000 people	+	Bed
		Public transport passenger volume	+	Ten thousand person-times
	Infrastructure	Per capita park green space area	+	Square meter
		Green coverage rate in built-up areas	+	%
		Water supply coverage rate	+	%
		Gas supply coverage rate	+	%
		Harmless treatment rate of household waste	+	%

2.2. Research Methodology

2.2.1. Entropy method

Currently, there are various research methods used in the academic field for studying green development. These include the entropy-weighted TOPSIS model, projection pursuit model, PSR and geographic detector model, and spatial autocorrelation analysis. Among these methods, the entropy method is widely used for measuring the level of green development. The entropy method is an objective weighting method, where the weights are determined based on the actual data of each indicator. This evaluation process is less influenced by subjective factors and can objectively and reasonably reflect the evaluation results. Taking advantage of the entropy method, this study applies it as a measurement method for the green development level in Hunan Province.

2.2.2. Calculation process

Step 1: As different indicators have varying dimensions and units, making direct comparison and calculation impossible. In order to address this, a standardization process is conducted before calculating the weights of each indicator

For positive indicators, the standardization formula is as follows:

$$x_{ij}^{'} = \frac{x_{ij} - x_j^{\min}}{x_j^{\max} - x_j^{\min}} \tag{1}$$

For negative indicators, the standardization formula is as follows:

$$x_{ij}^{'} = \frac{x_j^{\max} - x_{ij}}{x_j^{\max} - x_j^{\min}} \tag{2}$$

In these formulas, $x_j^{\max}$ represents the maximum value of the j-th indicator, while x_{ij} represents the data of the i-th sample for the j-th indicator in the original dataset. $x_{ij}^{'}$ represents the standardized data for the i-th sample and j-th indicator.

Step 2: After standardizing the values of some indicators, it is possible to encounter values of zero or negative. For the sake of uniformity and convenience in calculations, a shift process is applied to the standardized values to eliminate such cases.

$$x_{ij}^{''} = H + x_{ij}^{'} \tag{3}$$

Where, H represents the magnitude of the shift for the indicators, typically taking a value of 0.01. $x_{ij}^{''}$ represents the data of the i-th sample for the j-th indicator after the shift.

Step 3: Standardize the data using the weighting method

$$y_{ij} = \frac{x_{ij}^{''}}{\sum_{i=1}^{n} x_{ij}^{''}} \tag{4}$$

Where, y_{ij} represents the data of the *i*-th sample for the *j*-th indicator in the standardized data.

Step 4: Calculate the entropy value for the *j*-th indicator:

$$e_j = -\frac{1}{\ln n} \sum_{i=1}^{n} y_{ij} \ln y_{ij} \tag{5}$$

Step 5: The coefficient of variation for the *j*-th indicator is:

$$g_j = 1 - e_j \tag{6}$$

Where, $j = 1, 2, \cdots\cdots p$

Step 6: The weight for the *j*-th indicator is:

$$\omega_j = \frac{g_j}{\sum_{j=1}^{p} g_j} \tag{7}$$

Where, $j = 1, 2, \cdots\cdots p$

Step 7: Calculate the comprehensive score:

$$Z_i = \sum_{j=1}^{p} \omega_j x_{ij}^{'} \tag{8}$$

2.3. Data Sources

The original data for the analysis of the temporal evolution of green development level in Hunan Province is sourced from *China Statistical Yearbook* (2002-2022), *Statistical Bulletin of National Economy and Social Development in Hunan Province* (2002-2022), *Hunan Province Water Resources Bulletin* (2002-2022), *China Environmental Statistical Yearbook* (2002-2022), and *Hunan Statistical Yearbook* (2002-2022). Some of the calculated data are also compiled and calculated based on the original data from the aforementioned sources.

3. Evaluation and Analysis of Green Development Level in Hunan Province

3.1. Weighting of Indicators

Based on the calculation process described above, the weights of various elements of green development in Hunan Province are obtained (as shown in Table 2). By sorting the weights of each indicator, it can be observed that the top three indicators with the highest weights are the number of public transportation vehicles per ten thousand people, the proportion of environmental protection expenditure to fiscal expenditure, and the fertilizer utilization per unit of arable land area. Conversely, the three indicators with the lowest weights are the harmless treatment rate of household garbage, per capita water resources, and the proportion of industrial value-added of ten thousand yuan and above.

Table 2. Weighting of indicators for green development in Hunan Province

Indicators	Weight	Indicators	Weight
Per capita GDP growth rate	0.008955	Pesticide usage per unit of cultivated land area	0.007932
Per capita disposable income of residents	0.020877	Ammonia nitrogen emissions per unit of land area	0.010134
Energy consumption per 10,000 yuan of GDP	0.015578	Nitrogen oxide emissions per unit of land area	0.020774
Water consumption per 10,000 yuan of GDP	0.014951	Total sulfur dioxide emissions per unit of land area	0.030686
Ammonia nitrogen emissions per unit of GDP	0.016191	Chemical oxygen demand emissions per unit of land area	0.019667
Nitrogen oxide emissions per unit of GDP	0.014292	Per capita ammonia nitrogen emissions	0.026801
Total sulfur dioxide emissions per unit of GDP	0.01716	Per capita nitrogen oxide emissions	0.02018
Chemical oxygen demand emissions per unit of GDP	0.017111	Per capita total sulfur dioxide emissions	0.028321
Labor productivity in the primary industry	0.025158	Per capita chemical oxygen demand emissions	0.033422
Land output rate	0.025158	Proportion of scientific and technological fiscal expenditure to total fiscal expenditure	0.050991
Proportion of effective irrigation area	0.007512	Proportion of environmental protection expenditure to total fiscal expenditure	0.01705
Energy consumption of industrial value-added above a certain scale per 10,000 yuan	0.023396	Proportion of urban maintenance and construction fund expenditure to GDP	0.026735
Comprehensive utilization efficiency of general industrial solid waste	0.025492	Proportion of industrial pollution control investment to GDP	0.021864
Labor productivity in the secondary industry	0.025158	Sewage treatment rate	0.013964
Industrial water reuse rate	0.025158	Number of public transportation vehicles per ten thousand people	0.020181
Water consumption per unit of industrial value-added	0.007234	Number of healthcare technicians per ten thousand people	0.023594
Proportion of value-added in the tertiary industry	0.0163	Number of beds in healthcare clinics per ten thousand people	0.017167
Proportion of employees in the tertiary industry	0.044376	Public transportation passenger volume	0.015085
Labor productivity in the tertiary industry	0.032868	Per capita park green space area	0.022757
Per capita water resources	0.010227	Urban green space coverage rate	0.019189
Afforestation area in the current year	0.017532	Water utilization rate	0.036264
Green coverage rate	0.015502	Gas utilization rate	0.030321
Forest coverage rate	0.022303	Harmless treatment rate of domestic waste	0.010956
Fertilizer use per unit of arable land area	0.007232	indicaators	

3.2. Evaluation Results

3.2.1. Analysis of greenification level in economic growth

The greenification index of economic growth in Hunan Province shows an upward trend over the years (as shown in Figure 1). It gradually increased from 0.060942 in 2012 to 0.301332 in 2021, and slightly decreased to 0.299663 in 2022 (as shown in Table 3). The rising trend of the greenification index of economic growth signifies a favorable green development trend in Hunan Province during this period. It indicates that Hunan Province has placed emphasis on environmental protection and sustainable development throughout its economic development. By increasing the proportion of green economic industries and promoting environmentally friendly technologies, Hunan Province has actively propelled green development.

The growth rate of annual index data indicates an accelerated increase in greenification level in Hunan Province over the past decade. From 2012 to 2017, the greenification index of economic growth showed a relatively steady growth. However, between 2017 and 2020, the growth rate gradually intensified, rising from 0.195042 to 0.278087. This may reflect a heightened emphasis on green economic development in recent years in Hunan Province, accompanied by increased efforts in promoting relevant policies and measures. Although there was a slight decrease in the greenification index of economic growth in 2022, it does not necessarily imply a weakening momentum in green development. It is important to note that a single year's decline does not fully reflect the overall trend, as it could be influenced by specific economic conditions or policy adjustments. Therefore, it is necessary to consider multiple factors comprehensively and continue to monitor and evaluate the green development situation in Hunan Province.

3.2.2. Analysis on the level of resources and environmental carrying capacity

The environmental carrying capacity in Hunan Province reveals a fluctuating downward trend. Starting from 2012 with an index value of 0.04472, there was a slight increase in 2013 and 2014 to 0.045309 and 0.058475, respectively. However, from 2015 onwards, the index value rapidly rose to 0.101087, indicating an improvement in the capacity to bear resources and protect the environment. Subsequently, in 2016 and 2017, the index value further increased to its peak at 0.20745, demonstrating a significant enhancement in Hunan Province's resource and environmental carrying capacity. However, in the following years, the index values began to decline, notably in 2020 and 2021, reaching 0.205157 and 0.169895 respectively. Ultimately, by 2022, the index value hit its lowest point at 0.130874.

The fluctuating downward trend in the resource and environmental carrying capacity index in Hunan Province may be attributed to multiple factors. The slight increase

in the index value in the earlier years might reflect efforts in resource management and environmental protection in the region. However, with the passage of time, the economic growth and population increase in Hunan Province may have exerted greater pressure on the environmental resources, leading to an increase in the index value. Simultaneously, the rapid development of industries and urbanization processes may have also had a negative impact on the carrying capacity of resources and the environment, resulting in a decline in the index value.

3.2.3. Analysis on the level of government support

The level of government support in Hunan Province reveals a fluctuating upward trend in the government support index. Starting from 2012 with an index value of 0.036842, there was a slight increase in 2013 and 2014. However, from 2015 onwards, the index value rapidly rose from 0.108524 to its peak at 0.219382 in 2019. Subsequently, there was a minor decrease in 2020 and 2021, followed by a rapid increase to 0.28351 by 2022.

The fluctuating upward trend in the government support index in Hunan Province reflects the government's efforts in promoting economic growth and development. The increase in policy support in areas such as reforms, industrial upgrading, and investments may have contributed to the rapid increase in the index value. These policies may include tax incentives, streamlining administrative approvals, and measures to stimulate business investments and innovation. Additionally, the government's investment and support in infrastructure development, industrial growth, and economic park construction may have also played a positive role in the upward trend of the index value.

3.2.4. Analysis on the comprehensive green development level

The comprehensive analysis of the green development level in Hunan Province reveals a consistent progress and improvement, as reflected by the increase in the green development composite index from 0.142504 in 2012 to 0.725002 in 2022. The data demonstrates a year-on-year growth trend in the green development composite index in Hunan Province. The most significant growth occurred between 2015 and 2016, with an increase of 0.103891, resulting in a relative growth rate of 29.58%. Subsequently, the green development composite index in Hunan Province continued to increase, albeit at a slower pace. Apart from the significant growth observed between 2015 and 2016, there was a steady upward trend in the green development composite index in other years as well. This indicates the proactive achievements made by Hunan Province over the past decade in promoting environmental protection, resource utilization, and sustainable development.

The green development composite index in Hunan Province has gradually increased from a relatively low level in 2012 to a higher level in 2022. This reflects the efforts and achievements of Hunan Province in green development. However, green development remains an ongoing process, and Hunan Province can continue to strengthen relevant policies and measures in the future to further promote green development and achieve higher levels of sustainable development goals.

Table 3. Composite green development index in Hunan Province from 2012 to2022

	The greenification index of economic growth	Carrying capacity of environment and resources	Level of government support	Composite score
2012	0.060942	0.04472	0.036842	0.142504
2013	0.088	0.045309	0.068079	0.203579
2014	0.111831	0.058475	0.070401	0.251005
2015	0.13096	0.101087	0.108524	0.351088
2016	0.148821	0.169212	0.126209	0.454979
2017	0.195042	0.20745	0.131858	0.544868
2018	0.228201	0.21499	0.146109	0.600255
2019	0.24169	0.207674	0.219382	0.679701
2020	0.278087	0.205157	0.198434	0.692633
2021	0.301332	0.169895	0.194622	0.676805
2022	0.299663	0.130874	0.28351	0.725002

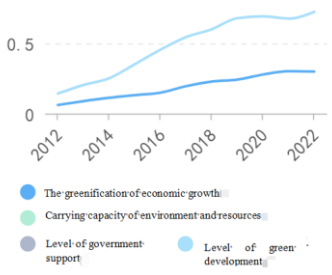

Figure 1. Evolution trend of comprehensive level of green development in Hunan Province from 2012 to 2022

4. Conclusions and Recommendations

4.1. Key Conclusions

This study focuses on the green development in Hunan Province and follows the fundamental principles of constructing an indicator system. By utilizing the entropy method to measure the weights of various indicators of green development in Hunan Province, as well as the comprehensive evaluation scores of green development and its subsystems, the statistical yearbook data from 2012 to 2022 has been examined. The analysis of the computed results indicates the following key findings: (1) The overall green development level in Hunan Province

has shown an upward trend from 2012 to 2022, with relatively insignificant fluctuations. Among them, the economic aspect of green development has a stronger presence, while the levels of government support and environmental carrying capacity remain relatively low. (2) The good greenification index of economic growth serves as an important support for green development in Hunan Province. The level of greenification in economic growth has rapidly increased, but the growth rates of green growth efficiency, greenification in primary, secondary, and tertiary industries within the economic growth greenification system have remained slow. (3) The overall level of environmental carrying capacity has shown an upward trend, providing an essential foundation for green development. Although the development trend has gradually improved from 2012 to 2022, the impact of environmental issues on improving environmental pressure through external adjustments has been relatively slow. Therefore, the environmental pressure curve has shown significant fluctuations, and the improvement in resource abundance has been slow. The current level of resource and environmental carrying capacity remains relatively low. (4) The overall level of government support has shown an upward trend with significant fluctuations, indicating insufficient government support for green development. This is mainly due to the varying annual fiscal investment by the government, which has had no significant impact on the support capacity of infrastructure for green development. As a result, the level of government support for green development has remained low.

4.2. Policy Recommendations

4.2.1. Acceleration of the transition to green development, exemplifying the elegance of sustainable development in Hunan

In order to emphasize the pursuit of high-quality development and prioritize the establishment of “three highlands”, it is recommended to embark on the path of “industrial ecologicalization and ecological industrialization” to continuously elevate the level of sustainability in the industries. Emphasis should be given to promoting structural adjustments and prioritizing energy security, with intensified efforts directed towards the integration of green electricity in Hunan. Additionally, the development of pumped storage projects should be encouraged, harnessing the potential of photovoltaic and wind power generation, tailored to local conditions, in order to construct an advanced and innovative power system. Furthermore, it is crucial to provide full support for the ambitious “Hunan Gasification Project”. Stringent control measures should be imposed on unregulated project expansions that contribute to the issues of excessive emissions and energy consumption. Imposing strict constraints on energy consumption and pollutant emissions will facilitate industrial transformation and upgrading. The strategy of functional areas should be effectively implemented to scientifically plan and organize production spaces, living spaces, and ecological spaces. Moreover, great efforts should be made to promote the development of new energy vehicles and vessels, capitalizing on the strategic significance of the Yueyang section of the Yangtze River as a vital transportation channel. Leveraging the advantages offered by the China-Europe freight train service, endeavors should be made to shift cargo transportation from road to water and rail. Proactive and prudent actions should be taken to achieve carbon peaking and carbon neutrality. The implementation of the “Top Ten Actions for Carbon Peaking” should be pursued, alongside effective coordination of plans for pollution reduction and carbon reduction, with the goal of enabling cities to achieve their peaking targets. Key sectors and industries should be encouraged to commit to peaking targets, and the implementation of pollution reduction and carbon reduction demonstration projects by major enterprises should be facilitated. Furthermore, the certification of low-carbon products and the application of low-carbon technologies should be actively promoted. Climate change actions should be proactively undertaken, with a focus on both the intensity and total control of carbon dioxide emissions. The pilot work on low-carbon cities, low-carbon industrial parks, and climate-adaptive cities should be strengthened. Pilot demonstrations for near-zero carbon emissions and carbon neutrality, as well as for achieving air quality standards and peaking carbon emissions, should be explored. Active participation in the construction of the national carbon market is encouraged. Mechanisms for the transition of the “Two Mountains” concept should be established. The existing advantages in industries such as construction machinery manufacturing should be fully utilized, with a focus on reinforcing the three pillars of “electric power, computing power, and motive power”. The industrial supply chain should be expanded and strengthened, with a vigorous development of new energy vehicles, advanced semiconductors, environmental protection equipment, and green buildings, effectively labeling Hunan's manufacturing as “green production”. Energy-saving and environmental protection industries, environmentally-sensitive industries, and clean energy industries should be cultivated and strengthened. Ecological industries such as eco-tourism and eco-wellness should be developed, leveraging the abundant natural resources. The area of green organic farming and breeding should be expanded, creating more green agricultural brands.

4.2.2. Reinforcing pollution control, manifesting the beauty of environmental harmony in enchanting Hunan

With the improvement of ecological environmental quality at its core, high priority should be given to waging a vigorous battle against pollution, ensuring high-level protection, and promoting high-quality development to create a beautiful Hunan where the air remains fresh, the green mountains endure, and the rivers flow. The campaign to safeguard clear skies should be deeply engaged in by focusing on three key battles: pollution elimination during heavy smog weather, prevention of ozone pollution, and control of diesel truck emissions. Through targeted actions, efforts should be

made to achieve the air quality standards for the urban agglomeration of Changsha, Zhuzhou, and Xiangtan and other areas along the atmospheric transmission corridor. Control measures for key pollutant sources, key sectors, and key industries should be strengthened to combat air pollution. Additionally, joint prevention and control measures, early warning systems, and forecasting capabilities should be strengthened during special periods of severe air pollution to effectively eradicate heavy smog weather. The battle to safeguard clean waters should also be undertaken. Emphasis should be placed on overall coordination of water resources, water environment, water ecology, water security, and water culture. Three key campaigns should be prioritized: the protection and restoration of the Yangtze River, the remediation of urban black and odorous water bodies, and the control of total phosphorus pollution in the Dongting Lake. Pollution prevention and control at the source for the "one river, one lake, and four water systems" should be given special attention, with a focus on reducing total phosphorus in the Dongting Lake. Ensuring the comprehensive guarantee of drinking water source safety is crucial. Furthermore, the battle to safeguard pristine land should be waged. The objective of ensuring the safety of soil environmental quality should be set. Pollution prevention and control at the source should be strengthened, promoting the safe utilization of contaminated farmland, and strictly managing the access of contaminated land for construction purposes. In the fight against agricultural and rural pollution, the treatment of rural domestic sewage and black and odorous water bodies should be advanced, reducing the use of pesticides and fertilizers while increasing their effectiveness, and strengthening the prevention and control of pollution from livestock and aquaculture. Efforts should also be intensified in the control of solid waste and heavy metal pollution, as well as in advancing the construction of "zero-waste cities" in Changsha and Zhangjiajie. The implementation of the key emission permit system for heavy metals and the promotion of comprehensive pollution control in the "manganese triangle" mining area in Huayuan should be prioritized. Furthermore, attention should be given to the treatment of tailings ponds, mine water inflow, and groundwater pollution. Let us unite to sing the melodious "Four Seasons Song". The "Spring Rain Campaign" should be organized to provide services at the grassroots level, thus promoting high-quality development. The "Summer Offensive" should continue to be launched, with a focus on problem-solving. Important tasks assigned by the central government, central inspections, and provincial government initiatives related to people's livelihoods should be incorporated into the task list, with schedules rearranged and strategic approaches adopted. The "Sword Action" should be carried out diligently, aiming to prevent and eliminate significant ecological and environmental risks and safeguarding the bottom line of safety. The specialized "Guarding the Blue Sky" campaign should be organized, focusing on targeted protection periods for air pollution. Strict measures should be implemented to prevent and control heavy pollution weather, thereby ensuring blue skies, clear clouds, and sparkling stars for our citizens.

4.2.3. Strengthening urban and rural environmental governance, manifesting the beauty of livable Hunan

The people should be provided with a splendid living environment and functional spaces, where they can enjoy advanced infrastructure and a clean residential environment while experiencing the charm of the four seasons, getting closer to nature, and cherishing their rural roots. It is imperative that actions be implemented to enhance environmental infrastructure. Focus should be placed on urban renewal initiatives, aiming to expand and improve environmental infrastructure such as sewage treatment and waste management, in order to address urban deficiencies and fill rural gaps. Efforts should be deepened to remediate black and odorous water bodies and promote the upgrading of sewage and rainwater separate systems. Emphasis should be placed on advancing waste sorting to establish a comprehensive waste classification and treatment system in cities at or above the prefectural level. Priority should be given to the construction of waste-to-energy facilities for clean incineration of household waste and to improve the clean incineration rate of household waste. The mechanism for integrated waste management in urban and rural areas should be perfected, aiming to achieve "zero landfill" for untreated household waste. Efforts should be made to enhance the improvement of rural living environments. The rural toilet revolution should be solidly promoted, and a comprehensive system for the collection, transportation, and disposal of rural household waste should be established. Continuous village cleaning campaigns should be carried out, accompanied by strengthened guidance on waste classification and aesthetic guidance, in order to upgrade the overall quality of village appearance. Pilot demonstrations for beauty enhancement should be conducted. In conjunction with the ecological civilization initiative, pilot projects for building a beautiful Hunan should be launched. This involves creating beautiful cities, parks, and factories, as well as exemplary counties, towns, villages, and livable housing complexes, with different levels of beauty and elegance.

4.2.4. Enhancing the mechanism of ecological civilization and promoting the beauty of a beautiful Hunan

It is suggested that the mechanism of ecological civilization be established and enhanced, encompassing the regulatory and policy system, market system, regulatory system, and responsibility system, in order to promote green development. A clear direction, scientific decision-making, effective execution, incentivization, participation of diverse stakeholders, and promotion of positive interactions should shape an environmental governance system. Emphasis should be placed on the dual responsibilities at various levels, including provincial, municipal, and county ecological environment committees, by implementing the *Regulations on the*

Responsibility for Ecological Environment Protection in Hunan Province. Corporate governance responsibility should be strengthened, and public participation should be advocated. The management system for ecological environment should be improved. Moreover, local regulations and standards for the ecological environment should be enhanced, and the revision of standards for environmental quality, pollutant emissions, and other aspects should be organized. Furthermore, it is crucial to strengthen the leading role of the source control system, promote reforms in the management systems of the "Three Lines and One Policy", planning environmental impact assessments, project environmental impact assessments, pollutant discharge permits, supervisory law enforcement, and accountability. Additionally, the credit system for environmental governance should be further developed. The mechanism for realizing the value of ecological products should be improved, and pilot demonstrations should be conducted. A compensation mechanism for the protection of ecological products should be established, and the allocation of transfer payment funds for key ecological functional areas should be perfected. Efforts should be made to enhance the market system. Capital should be guided to participate in investment, construction, and operation of ecological and environmental governance, thereby promoting the growth of the ecological environmental protection industry and establishing a number of specialized environmental protection parks. The implementation of third-party governance for environmental pollution in parks should be expedited, and mechanisms such as "polluter pays" and third-party governance should be established and improved. Additionally, the capacity for governance needs to be enhanced. Reforms in the vertical management system of the ecological environment should be deepened, and comprehensive efforts should be made to strengthen the construction of the cadre team within the ecological environment system. The capacity for ecological environment monitoring should be strengthened, and comprehensive administrative law enforcement reforms should be advanced. The construction of a provincial-level "support platform", "big data center", and "large-scale application system" for co-building and sharing ecological environment protection should be accelerated. The integrated monitoring platform for the "sky and land" should be improved, and efforts should be made to enhance the scientific research capacity of the ecological environment.

4.2.5. Strengthening ecological cultural construction and showcasing the beauty of Hunan humanities

By combining Hunan's "ecological green" with the "Xiangjiang River red" of its revolutionary heritage and traditional Hunan culture, as well as the characteristics of the new era, it is recommended that efforts be made to enhance ecological cultural construction and polish its image, making it a shared value concept in our society. In-depth exploration of ecological values should be conducted, utilizing Hunan's regional characteristics and ethnic culture to create a series of ecological creative works that infuse ecological philosophy and aesthetics. This approach will promote the integration of ecological values and ecological aesthetics. Preserving and protecting traditional ecological culture should be of utmost importance. Strengthened protection and regulation of historical and cultural cities, towns, and villages is necessary to safeguard the traditional landscape of urban and rural areas while promoting the revitalization of historical and cultural heritage. Great importance should also be attached to the protection of historical and cultural legacies, with a focus on highlighting local characteristics and ensuring the inheritance, promotion, development, and protection of ecological values in traditional culture and intangible heritage. Extensive national ecological civilization propaganda and education should be carried out, guiding and encouraging officials to continuously strengthen their belief in prioritizing ecology and green development as a measure of their political achievements. It is essential to implement the *"Beautiful China, I am an Actor" Action Plan* to *Enhance Citizens' Awareness Towards Ecological Civilization from 2021 to 2025*. The inclusion of ecological civilization education in the national education system is crucial, along with actively guiding, encouraging, and supporting community, business, and non-profit organizations to engage in ecological practices and enhance the ecological consciousness of the entire population. We should foster a new trend of green and low-carbon lifestyles. Activities such as promoting green households should be initiated, and a robust incentive mechanism for consuming energy-efficient and environmentally friendly products should be established. Measures must be taken to curb food waste and eradicate the harmful habit of consuming wild animals. A comprehensive effort is required to enhance society-wide awareness of energy conservation, water conservation, and food saving, guiding the public to embrace and practice green, low-carbon, and circular consumption concepts. We should strive to create a distinctive ecological culture brand for the Hunan region. This can be achieved by intensifying media promotion and continuing to host the Hunan Province Tourism Development Conference, thereby enhancing the domestic and international impact of Hunan's ecological civilization tourism. Furthermore, high-profile international exchange activities such as the Asia-Pacific Green Low-Carbon Development Summit and the China-Africa Economic and Trade Cooperation Forum should be held to showcase the new achievements in ecological civilization construction in Hunan and broaden the reach of ecological cultural promotion in the region.

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