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High-quality development in China: Measurement system, spatial pattern, and improvement paths☆

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ABSTRACT

Improving the quality of economic and social development is the common goal of all countries. Since China is at the inflection point shifting from high-speed development to high-quality development (HQD), a systematic study on China's HQD evaluation system is crucial. This research elaborated the connotation of HQD in the context of China and established a five dimension indicator system of HQD at the prefecture-city level. Then, we calculated the HQD indexes of 301 prefectures and explored the spatial pattern and development lagging regions. The results show that significant regional differences exist in the HQD comprehensive index, the coordination index, and the proposed five dimension indexes. The average values of people's livelihood and innovation efficiency are relatively low, which are the weak aspects of HQD. Economic scale, urban land scale, and urban population scale are positively correlated with the HQD comprehensive index. One hundred sixty prefectures with problems in HQD are identified. The implications for accelerating HQD involve improving the incentive mechanism, adopting pertinent strategies that fit the regional conditions, and prioritizing the Yellow River Basin, Northeast China, and Yunnan-Guangxi region.

1. Introduction

The 17 sustainable development goals proposed in the 2030 Agenda of the United Nations are different from those previously focused on the economy or another single field. These 17 goals contain many potentially diverging policy goals in economy, society, environment, and ecology, which means that comprehensive consideration of economic development, environmental protection, and people's wellbeing has become the general trend of global sustainable development (Kroll, Warchold, & Pradhan, 2019). In this regard, the EU proposed a package of circular economy plans and announced the *European Green Deal* at the end of 2019, with the realization of carbon neutrality in 2050 as the core strategic goal, to build a competitive modern economic system with decoupling of economic growth and resource consumption (Sanyé-Mengual, Secchi, Corrado, Beylot, & Sala, 2019). In 2006, The United States developed *The America 2050 Strategy*, providing a guiding framework for promoting integrated investment in mobility, environment, and economic development (Georgeson & Maslin, 2019).

The People's Republic of China made an ambitious statement of high-quality development (HQD) in October 2017, marking a new era for China's economy. HQD is in stark contrast to China's previous high-speed economic growth after its economic reform. It requires changing the old development mode of pursuing economic growth (Guo, Liu, Wen, & Li, 2014; Lu et al., 2019). And it emphasizes putting quality first and prioritizing efficiency, fostering new drivers of growth. Moreover, it aims for resource conservation, environmental protection, and letting nature restore itself (Liu & Xu, 2016; Lu et al., 2015). In general, HQD is an efficient, fair, and sustainable development that stimulates society's creativity and vitality as a whole.

Currently, the studies on HQD can be roughly divided into three aspects: the study of the scientific connotation of HQD, the construction of index systems, and the empirical evaluation. The study of the connotation of HQD is mainly concerned about the principal contradiction of Chinese society, the new vision for development, the

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modernized economy, supply-side structural reform, and better quality, higher efficiency, and more robust drivers of economic growth through reform (Geng, Sarkis, & Ulgiati, 2013; Zhang et al., 2018). The essence of HQD is the transformation from quantity focusing to efficiency improvement, scale expansion to structural optimization, input & investment-driven to innovation-driven (Mohanty, Vivekanandhan, Pin, & Misra, 2018; Bain et al., 2019), and treatment after pollution to green development (Geng, Sarkis, & Ulgiati, 2013; Schiller, Reid, & Tamásy, 2018). Thus, the rich connotation of HQD suggests that its evaluation index system is multi-dimensional and complex.

Based on the understanding of the connotation of HQD, different studies have constructed various evaluation systems along with standards and indicators according to their purposes and regions (Xu et al., 2020). To date, there has been no unified indicator system yet. Still, the primary indicators usually include the following five aspects: (1) Economic indicators, such as GDP per capita, the proportion of the tertiary industry, and openness to foreign capital, etc., which focus on economic structure and opening up (Bleys, 2012; Mi & Coffman, 2019). (2) Innovation indicators, such as investment in scientific research funding, patent per capita, etc., focus on capital and human resources (Siyanbola, Adeyeye, Olaopa, & Hassan, 2016; Hausken & Moxnes, 2019). (3) Environmental indicators, such as the three wastes discharge and green total factor productivity. Environmental factors are included in the calculation based on total factor productivity (Ege & Ege, 2019; Sanyé-Mengual et al., 2019). (4) Ecological indicators, such as green covered area of completed area, forest coverage, ecological footprint, biodiversity index, etc (Wible, 2012; Lin, Monga, & Standaert, 2019). (5) Livelihood indicators, such as per capita income and consumption expenditure, social security, and public services (Haq & Zia, 2013; Xu, Deng, Guo, & Liu, 2019). However, the index systems adopt more economic indicators than ecological or social indicators. It is insufficient to reflect the multi-dimensional connotation of HQD.

Most of the empirical analysis on the evaluation of HQD in China are at the provincial-level(Chen & Lu, 2009; Shi & Ren, 2018) or the city-level in typical regions such as the Yangtze River Economic Belt(Cai et al., 2019), the Yangtze River Delta (Xu et al., 2019), and Western China (Huang et al., 2019). A national-scale empirical evaluation of HQD at the prefecture-city level is scant.

The prefecture-level cities (PLCs) usually include city-district and county-level administrative units, with cities and villages. There are considerable differences within provincial-level regions, while county-level regions always lack data. In contrast, PLCs are more suitable for reflecting regional and urban-rural development status (Li, Wang, Liu, & Long, 2014; Lin, Wu, & etal., 2018).

Therefore, this study intends to establish an index system and then conducts quantitative empirical research based on multi-source data of China's PLCs in 2016 to reveal the spatial pattern of HQD and further identify those development lagging regions. Accordingly, a corresponding path is proposed to improve the development quality of different regions in the new era. We make two differences in HQD evaluation: first, we collect multi-source data depicting ecological and social aspects. And second, we evaluate HQD at the prefecture-level administrative units, which can help obtain a more nuanced insight. The results of this study can also be used as a baseline benchmark to compare with the 2020 end value to evaluate the effectiveness of HQD during the 13th Five-Year Plan period of China.

2. Theoretical analysis

China's central government has initiated the transition of China's economy from a high-speed growth stage to an HQD stage, providing an action guide for China's development in the new era. HQD is the development that reflects the new vision for development, that is, innovative, coordinated, green, and open development that is for everyone (Lu et al., 2019). In combination with relevant national requirements and the existing interpretation of HQD, this study divided the connotation of HQD into five dimensions (Fig. 1): economic development, innovation efficiency, environmental impact, ecological services, and people's livelihood.

(1) HQD means that the economy is changing from high-speed growth to medium-speed growth, but it cannot fall into the "middle-income trap" of low or even negative growth (Sachs & Schmidt-Traub, 2017). Therefore, economic growth is still an important dimension in measuring development quality and plays a primary role. Besides, more attention should be paid to improving the economic structure, including industrial structure, consumption structure, import & export structure, etc. (Hartig & Kahn, 2016). The measurement of economic development could also incorporate the extent of openness to facilitate HQD with a high-level opening.

(2) Improving economic structure depends on innovation. The improvement of innovation efficiency provides an essential engine for improving the quality and level of development (Maradana et al., 2019). Technological innovation's contribution needs to be increased (Li, Wei, Miao, & Chen, 2019) since the development brought about by capital accumulation and factor inputs is limited. Shortly, we can divide innovation efficiency into two parts: innovation input and output. Innovation requires sufficient capital and human capital input to drive high-quality R&D of technology and enhance economic vitality and competitiveness (Cinnirella & Streb, 2017).

(3) Environment security is the natural background for HQD, providing necessary material conditions (Ota, 2017; Polezer et al., 2019). Since HQD means protecting the environment and saving resources, the resource and environmental costs of development must be considered (Zhang et al., 2018). Therefore, how to reduce environmental pollution and achieve effective governance are essential criteria for judging HQD.

(4) HQD is green and sustainable development. HQD focuses on the function and value of ecological services, including supply, modulation, support, and cultural services (Xu et al., 2020). HQD depends on a series of services provided by the ecosystem, which need to be maintained and enhanced to realize the coordination of economic, social, and ecological benefits (Yang & Ma, 2009).

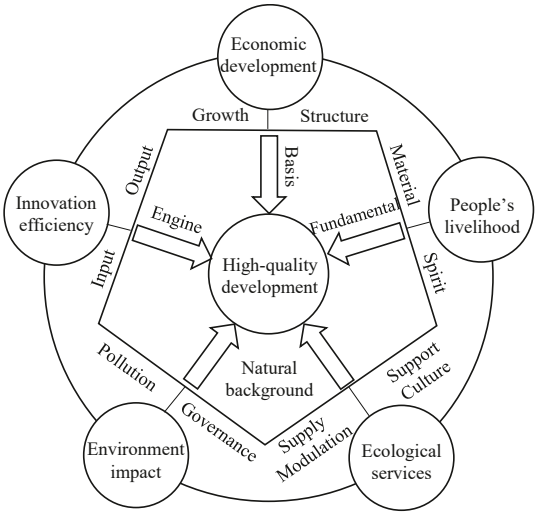

Fig. 1. The connotation of high-quality development.

(5) People-oriented development is the fundamental requirement, given that the core purpose of development is to eradicate poverty and improve national welfare (Long, Zou, Pykett&Y, & Li, 2011). In this way, the achievement of development should be shared by all citizens and meet the people's new aspirations for a better life (Plummer, Tonts, & Argent, 2018). On the premise that people-oriented development can be quantitatively described, people's livelihood embodies the coordination between material and spiritual life (Haseeb, Suryanto, Hartani, & Jermsittiparsert, 2019). The material life includes income, expenditure, and the coverage of basic social security such as education, medical care, and elderly care. And the spiritual life can be reflected in the spread of information and culture.

3. Methodology

3.1. Data sources and pre-processing

The socio-economic data required for this study are mainly from the *China City Statistical Yearbook (2017)*. The data of Beijing, Tianjin, Shanghai, and Chongqing are the aggregate data of each city, not subdivided into districts and counties. The data of Hainan Province include only Haikou City and Sanya City. The data of Hong Kong, Macao, Taiwan, Tibet Autonomous Region, Xinjiang Autonomous Region, and some autonomous PLCs in Yunnan Province have not been included because of the lack of needed data for this study. To address missing individual indicator data in a few cities, we use the relevant provincial and municipal statistical yearbooks and statistical bulletin data to complete it or use interpolation methods based on data from neighboring cities and years. For example, public financial expenditure data of PLCs in Qinghai Province comes from the *Qinghai Statistical Yearbook (2017)*. And the ratio of waste water centralized treated of sewage work, the ratio of consumption wastes treated in Heilongjiang and Sichuan province come from their *National Economy and Society Developed Statistical Bulletin*. The data obtained in this study includes 301 PLCs, which cover administrative regions with concentrated population distribution and active socio-economic activities in China, and are highly representative for HQD analysis.

3.2. Indicators and method for measuring HQD

Based on the connotation of HQD and the measurement logic of development quality, this paper builds an evaluation index system consisting of 29 indicators in 5 dimensions: economic development, innovation efficiency, environmental impact, ecological services, and people's livelihood. And the weight of each indicator is determined through Delphi Method by inviting seven experts in the domain of regional development research (Table 1). The construction of the index system has referred to the relevant evaluation index systems at home and abroad (Ogle et al., 2017; Martínez et al., 2020) while considering data availability. The specific indicators are as follows:

(1) Economic development. We selected the GDP per capita to measure the economic strength of the region, selected the tertiary industry proportion to reflect the advanced level of the industry, and measured the economic benefits of the primary and secondary industries with the labor productivity of agricultural and profit rate of above-scale enterprise's output value. In addition, foreign investment openness and the household consumption contribution rate were used to evaluate economic vitality.
(2) Innovation efficiency. We measured innovation input with capital and human resources and evaluated innovation output with the productivity of capital, labor, and construction land.
(3) Environmental impact. The discharge of wastewater, exhaust gas, and soot per unit of GDP were used to reflect the degree of environmental pollution caused by economic growth, while the

Table 1
Index system for evaluating the level of HQD.

Primary indicators	Secondary indicators	Calculation methods	Weights
Economic development	GDP per capita	Obtained directly from the statistical yearbook (10 thousand yuan per person)	0.157
	Tertiary industry proportion	Added value of tertiary industry/Regional GDP (%)	0.166
	Labor productivity of agricultural	Added value of the primary industry/ Employed persons of primary industry (10 thousand yuan)	0.167
	Profit rate of above-scale enterprise's output value	Total profits of industrial enterprises above designed size/ Gross industrial output value (%)	0.160
	Foreign investment openness	Amount of foreign capital actually utilized/Investment in fixed assets (%)	0.181
	Household consumption contribution rate	Total retail sales of customer goods/GDP (%)	0.169
Innovation efficiency	Science and technology expenditure input intensity	Expenditure for science and technology/GDP (%)	0.203
	Researcher investment	Number of researchers/ Total of employed persons (%)	0.201
	Capital productivity	GDP/Investment in fixed assets (%)	0.207
	Labor productivity	GDP/Total of employed persons (10 thousand yuan per person)	0.195
	Productivity of construction land	Secondary and tertiary industry as percentage to GDP/Area of construction land (10 thousand yuan per km^2)	0.194
Environment impact	Wastewater discharge per unit of GDP	Volume of industrial waste water discharged/GDP (tons per yuan), negative indicator	0.174
	Exhaust gas emissions per unit of GDP	Volume of sulphur dioxide emission/GDP (tons per 10 thousand yuan), negative indicator	0.165
	Soot emissions per unit of GDP	Volume of industrial soot produced/GDP (tons per yuan), negative indicator	0.158
	Ratio of industrial solid wastes comprehensively utilized	Obtained directly from the statistical yearbook (%)	0.176
	Ratio of waste water centralized treated of sewage work	Obtained directly from the statistical yearbook (%)	0.171
	Ratio of consumption wastes treated	Obtained directly from the statistical yearbook (%)	0.156
Ecological services	Green covered area of completed area	Obtained directly from the statistical yearbook (%)	0.178
	Green area per capita	Area of green land/ Average population (hectares per 10 thousand persons)	0.171
	Water production	Calculated based on the water production	0.160

(*continued on next page*)

Table 1 (*continued*)

Primary indicators	Secondary indicators	Calculation methods	Weights
		module in the InVEST model (Xu et al., 2020)	
	Habitat quality	Calculation based on InVEST habitat quality model (Xu et al., 2020)	0.168
	Soil and water conservation	Calculation based on SDR module in InVEST model (Xu et al., 2020)	0.161
	Net primary productivity	The rate at which all the plants in an ecosystem produce net useful chemical energy. The data is extracted from remote sensing production	0.162
People's livelihood	Average wage of employed staff and workers	Obtained directly from the statistical yearbook (yuan)	0.176
	Consumption expenditure per capita	Total retail sales of customer goods/ Average population (yuan per person)	0.175
	Numbers of beds of hospitals and health centers per thousand persons	Numbers of beds of hospitals and health centers/Average population (bed/ thousand persons)	0.160
	Pension insurance coverage	Numbers of employees joining urban basic pension insurance/ Average number of employed staff and workers (%)	0.157
	Internet coverage	Numbers of subscribers of Internet services/ Average population (%)	0.168
	Collections of public Libraries per Capita	Total collections of public libraries/ Average population (pieces per person)	0.164

ratio of industrial solid wastes comprehensively utilized, the ratio of waste water centralized treated of sewage work, and the ratio of consumption waste treated were used to reflect the validity of resources and pollution control.

(4) Ecological services. The green covered area of completed area, green area per capita were used to reflect cultural services; water production was used to reflect ecosystem supply services, habitat quality, soil and water conservation, and net primary productivity were used to reflect ecosystem modulation and support services.

(5) People's livelihood. We used livelihood and cultural indicators to reflect the extent to which economic development has benefited people's wellbeing, including average wage of employed staff and workers, social security such as education, medical care, and elderly care, as well as Internet coverage and collections of public libraries.

The calculation methods of these indicators are shown in Table 1. Among them, seven of the indicators can be directly obtained from the statistical yearbook, including GDP per capita, tertiary industry proportion, the ratio of industrial solid wastes comprehensively utilized, the ratio of waste water centralized treated of sewage work, the ratio of consumption waste treated, green covered area of completed area, and average wage of employed staff and workers. Furthermore, the net primary productivity data are from the MOD16A3 and MOD17A3H series of USGS.

The initial data were standardized using the range-method, and then Economic Development Index (EDI), Innovation Efficiency Index (IEI), Environmental Impact Index (EII), Ecological Service Index (ESI), and People's Livelihood Index (PLI) were obtained by weighted calculation. Accordingly, the indexes of all dimensions are summed to obtain an HQD comprehensive index (CI) (Li et al., 2014). To further measure the degree of coordinated development in the five dimensions, the fifth root square of the product of the five indexes is used as the HQD coordination index (CoI). It can reflect both the disparity of the five indexes and their absolute value. While considering the respective development levels of the five dimensions, the coordination index also pays attention to the coordination degree of the development of the five dimensions.

4. Results

4.1. Spatial pattern of HQD comprehensive index

To reveal the spatial characteristic in the development quality of PLCs in China, we used ArcGIS to visualize the comprehensive index, coordination index, and indexes of five dimensions and used Natural Breaks (Jenks) to classify it (Fig. 2). The method of Natural Breaks (Jenks) can group the similar values most appropriately to ensure that the differences between groups are significant and within groups are small (Sameen et al., 2020). (1) The comprehensive index is composed of the five dimensions of economic development, innovation efficiency, environmental impact, ecological services, and people's livelihood (Fig. 2a), with a mean value of 0.390, a standard deviation of 0.058, and a coefficient of variation of 0.147. High-value areas are mainly distributed in the southeast coastal region, the Bohai Gulf, the Sichuan Basin, and provincial capitals such as Xi'an, Wuhan, and Changsha city. Low-value areas are located in the northwest, the Loess Plateau, and the northeast. The value of the northwest area of the *Hu Huanyong Line* is significantly lower. (2) The coordination index is obtained by multiplying EDI, IEI, EII, ESI, and PLI and then calculating its fifth root squares (Fig. 2b), with a mean value of 0.330, a standard deviation of 0.193, and a coefficient is 0.190. On the whole, the coordination index of the southeast region of the *Hu Huanyong Line* is higher than that of the northwest region. The PLCs with a high degree of development coordination are concentrated in the Yangtze River Delta and the Pearl River Delta. PLCs with relatively unbalanced development are distributed in the northwest, the northeast, and central China. Generally speaking, the development quality of the eastern region is relatively high and coordinated. In contrast, the development quality of the northwest, northeast, and Central China is relatively low and unbalanced.

4.2. Analysis of each dimension

The indexes of the five dimensions of HQD show different distribution characteristics (Fig. 3). Specifically: (1) The mean value of EDI is 0.342, and the coefficient of variation is 0.234. The regions with higher EDI are mostly provincial capital cities, while those with lower EDI are distributed in the northwest, northeast, southwest, and Western Loess Plateau. (2) The mean value of IEI is 0.220, and the coefficient of variation is 0.320. The high-value areas of the IEI are distributed in the eastern coastal areas and provincial capitals, while the low-value areas are concentrated in the northwest, the Qinghai-Tibet Plateau, and Eastern Loess Plateau. (3) The mean value of EII is 0.847, and the coefficient of variation is 0.117. The high-value area of EII is roughly distributed to the east of the *Hu Huanyong Line*, while the low-value area is distributed to the west of the *Hu Huanyong Line*. (4) The mean value of ESI is 0.336, and the coefficient of variation is 0.267. The high-value area of EII is distributed in the southeastern hilly areas and the southwestern mountainous regions. The areas with lower mean values are distributed in northern areas, showing an apparent North-South differentiation pattern. (5) The mean value of PLI is 0.207, and the coefficient of variation is 0.444. The regions with a higher PLI are mainly distributed in the Yangtze River Delta, the Pearl River Delta, the Bohai Gulf, and large cities in the central and western regions. The regions with a

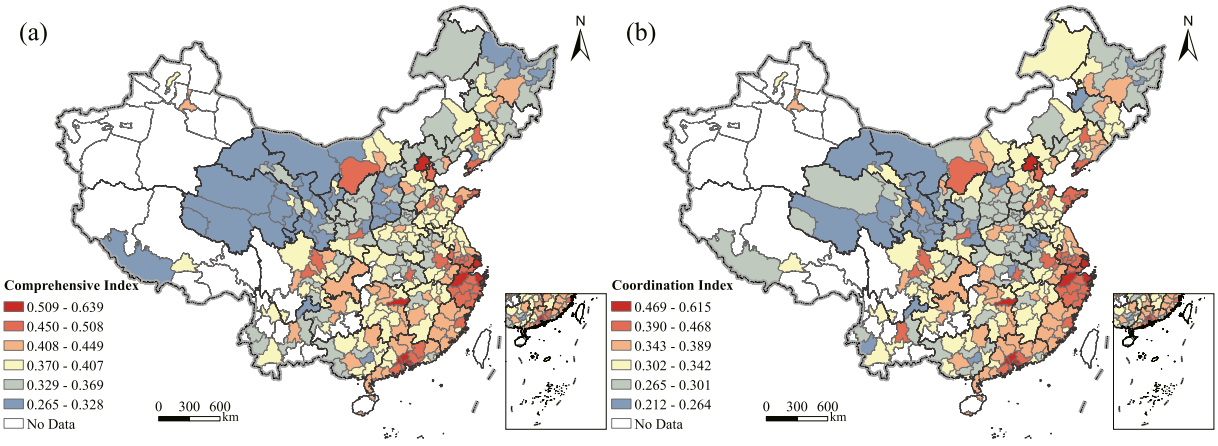

Fig. 2. Spatial difference of HQD comprehensive index and coordination index.

lower PLI are distributed in the southwest, the Loess Plateau, and Central China. Overall, the mean values of the PLI and the IEI are relatively small, and the coefficient of variation is large, which reflects the regional differences in people's living standards and innovation ability across the country.

4.3. The correlation characteristics of the indexes

4.3.1. The correlation among the indexes

We use SPSS software to test the correlation between the five dimensions of data in each region and explore the relationship between EDI, IEI, EII, ESI, PLI, and CI. Table 2 shows that the correlation between the five dimensions of HQD is strong. EDI, IEI, EII, and PLI show a strong positive correlation in pairs; ESI has a weak positive correlation with EII and PLI, respectively. The correlations between the five dimensions and the comprehensive index have passed the significance test, but in terms of the size of the correlation coefficient, the order is EDI (0.771), PLI (0.758), IEI (0.731), EII (0.675), ESI (0.426). In general, the three dimensions of economic development, people's livelihood, and innovation efficiency have relatively strong correlations with the comprehensive index and other dimensions. Hence these three dimensions are prominent indicators that affect the level of the HQD comprehensive index. Given the low average values of PLI and EII (0.207 and 0.220, respectively), this shows that improving people's livelihood and making innovation a driving force are the key to improving development quality.

Furthermore, we calculate the correlation coefficients between each secondary indicator and the HQD comprehensive index to evaluate the importance of the indicators. According to the previous studies (Li et al., 2014) and our data distribution, we identify the PLCs with indicator scores lower than 60% of the national average as development lagging PLCs. And we calculate the number of development lagging PLCs for each indicator to evaluate the weak indicators. As Table 3 shows, the average value of the seven indicators of GDP per capita, foreign investment openness, science and technology expenditure input intensity, the average wage of employed staff and workers, consumption expenditure per capita, number of medical beds per thousand people, Internet coverage, and public library collections per capita is low. Their correlation coefficients with the HQD comprehensive index are large, indicating they are crucial to HQD. However, the numbers of development lagging PLCs for these indicators are large, suggesting that many cities have great potential to improve their development quality in these aspects. If these indicators' scores increase, the overall HQD will be significantly improved.

4.3.2. Correlation with typical socio-economic indicators

We chose typical socio-economic indicators that reflect the economic scale, population scale, construction land scale, and farmers' living standard to do correlation analysis with the HQD index. Table 4 shows that the correlations between typical socio-economic indicators and the EDI, IEI, EII, and CI all passed the significance test ($p < 0.01$). Their correlations with PLI also mostly passed the significance test, except for the indicators that reflect PLCs' population size. Most of their correlations with ESI have not passed the significance test, or the correlation is low, and many of them are negative. Therefore, it is well suggested to pay attention to the negative impact of population size growth and land use scale on the ecological environment.

In contrast, the correlations of socio-economic indicators with the CI are listed in descending order as follows: disposable income per capita and consumption expenditure of farmers, GDP size, urban built-up area, urban construction land area, registered population in municipal districts, and registered population of the prefecture. It is worth noting that farmers' living standards correlate highly with a given PLC's HQD. Meanwhile, these data suggest that regional economic scale, urban land scale, and urban population scale are significantly related to a PLC's HQD. Economic development, land use, and population size are important foundations for HQD, but sustainable development should emphasize the shift from scale growth to higher-quality development.

4.4. Comparison of typical regions

To explore the different characteristics of HQD levels in major regions of China, we further calculated the mean value and coefficient of variation of different dimensions of HQD index in specific regions of China, including East, Central, West, and Northeast China, as well as the Yangtze and Yellow River basins (Table 5). Then, they were compared to the national average level to reveal different characteristics:

(1) East China's comprehensive index and the mean of each dimension are higher than the national average, showing obvious development superiority, but the coefficient of variation of the PLI is a little higher (0.465), reflecting a particular imbalance in people's livelihood in this region.
(2) The comprehensive indexes of the Central and Western regions and the Northeastern region are lower than the national average. The Central region has the lowest PLI, only 0.168, which equals 81.15% of the national average.
(3) The disadvantages of West China are mainly reflected in the two dimensions of economic development and innovation efficiency: 84.80% and 89.09% of the national average.
(4) The comprehensive index in Northeast China is the same as that in the Western region, but the shortcomings in development are different. The development in Northeast China mainly falls short

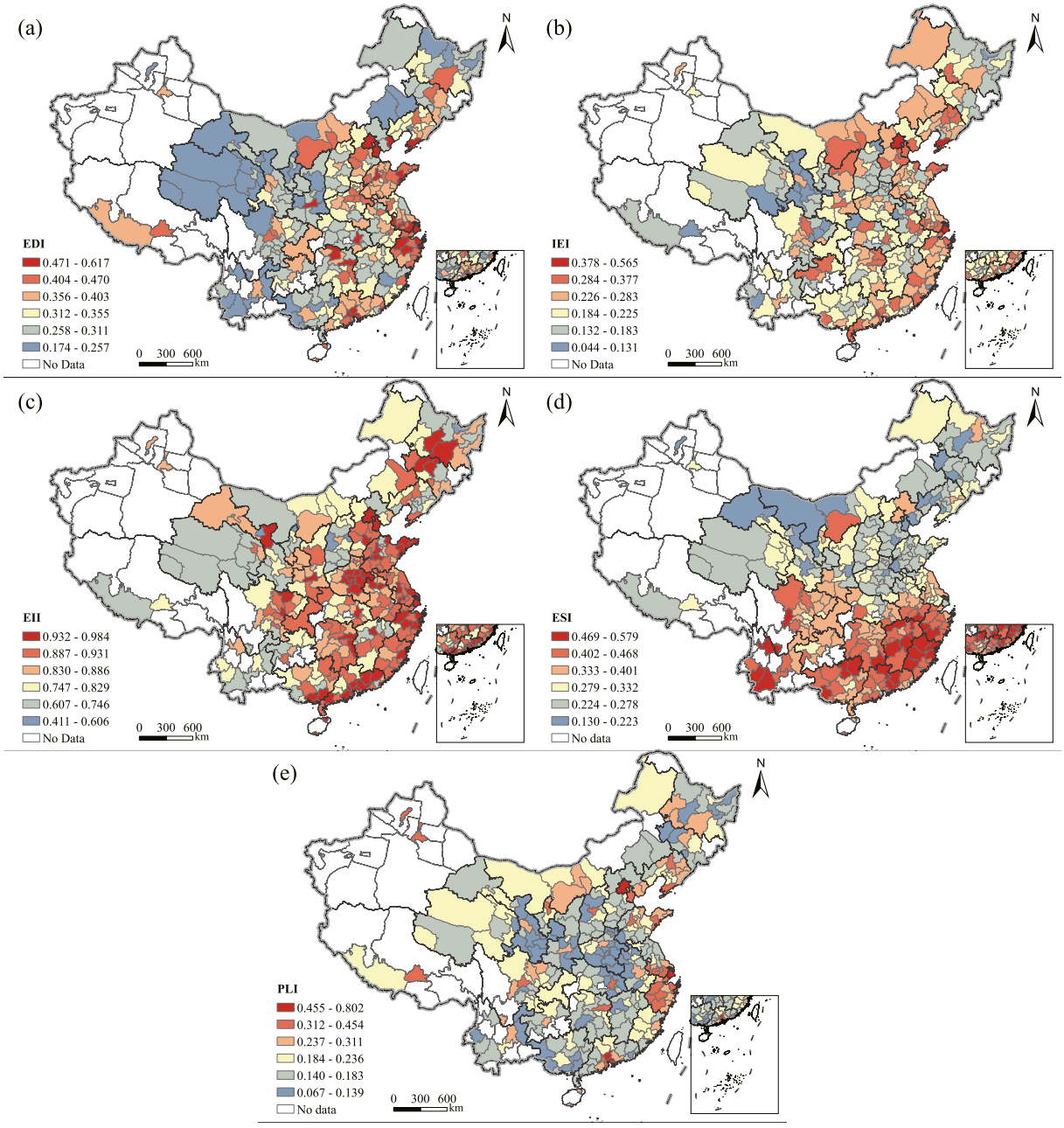

Fig. 3. Spatial differences in different dimensions of HQD.

Table 2
Correlation coefficients for different dimensions of HQD.

	EDI	IEI	EII	ESI	PLI	CI
EDI	1	0.516**	0.477**	−0.001	0.637**	0.771**
IEI		1	0.337**	0.107	0.606**	0.731**
EII			1	0.145*	0.220**	0.675**
ESI				1	0.120*	0.426**
PLI					1	0.758**
CI						1

Note: ** significant at the 0.01 level; * significant at the 0.05 level.

of ecological challenges, with ESI being only 78.27% of the national average.

(5) The comprehensive index in the Yangtze River Basin and the indexes in all dimensions are higher than the national average, especially ESI, which reached 0.391, 16.37% higher than the national average. Moreover, the coefficient of variation of all indexes in the Yangtze River Basin is generally lower than that of the whole country with one exception that only the coefficient of variation of the PLI is slightly higher than the national level, which reflects the overall relatively balanced development quality of the Yangtze River Basin.

(6) The overall development quality of the Yellow River basin is relatively low. The comprehensive index is 0.355, which equals 91.03% of the national average. The indexes in all dimensions are lower than the national average. In particular, IEI and ESI are only 89.55% and 81.25% of the national average, indicating a relatively serious challenge in HQD.

Overall, there are significant regional differences in development quality in China, which entails classified guidance and exploration of improvement paths that are aligned with local conditions (Wei, 2015).

Table 3
Basic statistics of various indicators in each dimension.

Indicators	Correlation coefficients	Mean value	Number of development lagging PLCs
EDI	**0.771****	**0.342**	**7**
GDP per capita	0.644**	0.204	115
Tertiary industry proportion	0.411**	0.379	36
Labor productivity of agricultural	0.282**	0.188	158
Profit rate of above-scale enterprise's output value	0.356**	0.658	7
Foreign investment openness	0.566**	0.117	148
Household consumption contribution rate	0.149**	0.530	26
IEI	**0.731****	**0.220**	**22**
Science and technology expenditure input intensity	0.559**	0.121	135
Researcher investment	0.268**	0.182	99
Capital productivity	0.354**	0.179	111
Labor productivity	0.238**	0.317	53
Productivity of construction land	0.334**	0.310	69
EII	**0.675****	**0.847**	**1**
Wastewater discharge per unit of GDP	0.313**	0.882	4
Exhaust gas emissions per unit of GDP	0.522**	0.814	22
Soot emissions per unit of GDP	0.447**	0.841	21
Ratio of industrial solid wastes comprehensively utilized	0.357**	0.772	45
Ratio of waste water centralized treated of sewage work	0.224**	0.865	14
Ratio of consumption waste treated	0.349**	0.914	16
ESI	**0.426****	**0.336**	**11**
Green covered area of completed area	0.432**	0.487	26
Green area per capita	0.337**	0.151	71
Water production	0.518**	0.087	168
Habitat quality	−0.353**	0.339	145
Soil and water conservation	0.105	0.384	52
Net primary productivity	0.267**	0.552	24
PLI	**0.758****	**0.207**	**31**
Average wage of employed staff and workers	0.574**	0.261	60
Consumption expenditure per capita	0.763**	0.154	108
Number of beds per thousand medical institutions	0.428**	0.297	49
Pension insurance coverage	0.383**	0.355	61
Internet coverage	0.555**	0.117	108
Public library collections per capita	0.575**	0.066	163

Note: ** significant at the 0.01 level; * significant at the 0.05 level.

4.5. Identification of development lagging regions

This study identified the development lagging regions based on the previous studies (Li et al., 2014) and the data distribution of HQD indexes. A PLC is defined as a development lagging region if it meets one of these criteria: (1) the comprehensive index is lower than 75% of the national average; (2) the coordination index is lower than 75% of the national average; (3) EDI is lower than 75% of the national average; (4) IEI is lower than 75% of the national average; (5) EII is lower than 75% of the national average; (6) ESI is lower than 75% of the national average; (7) PLI is lower than 75% of the national average.

We used Spatial Query Tool in ArcGIS to extract data and then carried out overlay analysis according to the above seven criteria. We found that there are six PLCs with low comprehensive indexes that meet the criteria (1), 11 PLCs with low coordination indexes that meet the criteria (2), and 40 PLCs with low EDI that meet the criteria (3). There are 55 PLCs with low IEI that meet the criteria (4), 10 PLCs with low EII that meet the criteria (5), and 50 PLCs with low ESI that meet the criteria (6). There are 88 PLCs with low PLI that meet the criteria (7). Given that the seven types partially overlap in space, the actual number of development lagging regions is 160. The development lagging regions can be roughly divided into eight categories through comprehensive analysis (Fig. 4):

(1) Category I: ecological lagged type, involving 16 PLCs located in the Northeast China Plain and North China Plain, are relatively economically less-developed PLCs with low ESI performance.
(2) Category II: environmental and ecological lagged type, involving a total of 19 PLCs, distributed in the Northeast Plain, North China Plain, and Qinghai-Tibet Plateau, showing low EII and ESI.
(3) Category III: ecological and people's livelihood lagged type, involving a total of 17 PLCs, mainly distributed in the middle and lower reaches of the Yellow River, manifested as low ESI and PLI.
(4) Category Ⅳ: people's livelihood lagged type, involving a total of 16 PLCs, mainly distributed in the upper and middle reaches of the Yellow River and southern Henan, manifested as low PLI performance.
(5) Category Ⅴ: economy and people's livelihood lagged type, involving a total of 21 PLCs mainly distributed in Yunnan and Guangxi, showing low EDI and PLI.
(6) Category Ⅵ: innovation and people's livelihood lagged type, involving a total of 18 PLCs, mainly distributed in the Central and Western regions. The distribution is relatively scattered, characterized by low IEI and PLI.
(7) Category Ⅶ: economy and innovation lagged type, involving a total of 17 PLCs, concentrated in the upper and middle reaches of the Yellow River, Southwest China, and Northeast China, showing low EDI and IEI.
(8) Category Ⅷ: comprehensive lagged type, including 36 PLCs, mainly concentrated in the upper reaches of the Yellow River and northeast China, which manifested as the low comprehensive index caused by the low performance on multiple dimensions. The Yellow River Basin, Northeast China, and Yunnan-Guangxi

Table 4
Correlation between HQD index and typical socio-economic indicators.

Indicators	EDI	IEI	EII	ESI	PLI	CI
GDP	0.657**	0.648**	0.363**	0.016	0.695**	0.693**
Registered population of the city	0.351**	0.251**	0.311**	−0.043	0.072	0.275**
Registered population in municipal districts	0.498**	0.378**	0.285**	−0.056	0.457**	0.462**
Urban construction land area	0.513**	0.439**	0.231**	0.016	0.612**	0.530**
Urban built-up area	0.617**	0.513**	0.286**	−0.011	0.700**	0.621**
Per capita disposable income of farmers	0.646**	0.543**	0.377**	0.144*	0.732**	0.719**
Per capita consumption expenditure of farmers	0.580**	0.550**	0.322**	0.172**	0.725**	0.690**

Note: ** significant at the 0.01 level; * significant at the 0.05 level.

Table 5
Comparison of HQD levels in typical areas.

Statistics	Regions	EDI	IEI	EII	ESI	PLI	Comprehensive index	Coordination index
Mean value	Nationwide	0.342	0.220	0.847	0.336	0.207	0.390	0.330
	East	0.405	0.262	0.904	0.351	0.264	0.437	0.381
	Central	0.345	0.204	0.856	0.344	0.168	0.383	0.317
	West	0.290	0.196	0.804	0.340	0.189	0.364	0.304
	Northeast	0.326	0.221	0.805	0.263	0.205	0.364	0.311
	Yangtze River Basin	0.344	0.223	0.867	0.391	0.212	0.407	0.346
	Yellow River Basin	0.321	0.197	0.797	0.273	0.188	0.355	0.298
Coefficient of variation	Nationwide	0.234	0.320	0.117	0.267	0.444	0.147	0.190
	East	0.193	0.299	0.065	0.263	0.465	0.135	0.178
	Central	0.151	0.272	0.108	0.246	0.344	0.110	0.146
	West	0.224	0.308	0.131	0.272	0.335	0.125	0.161
	Northeast	0.204	0.273	0.125	0.158	0.312	0.117	0.150
	Yangtze River Basin	0.235	0.312	0.083	0.191	0.449	0.129	0.181
	Yellow River Basin	0.240	0.309	0.140	0.180	0.329	0.130	0.164

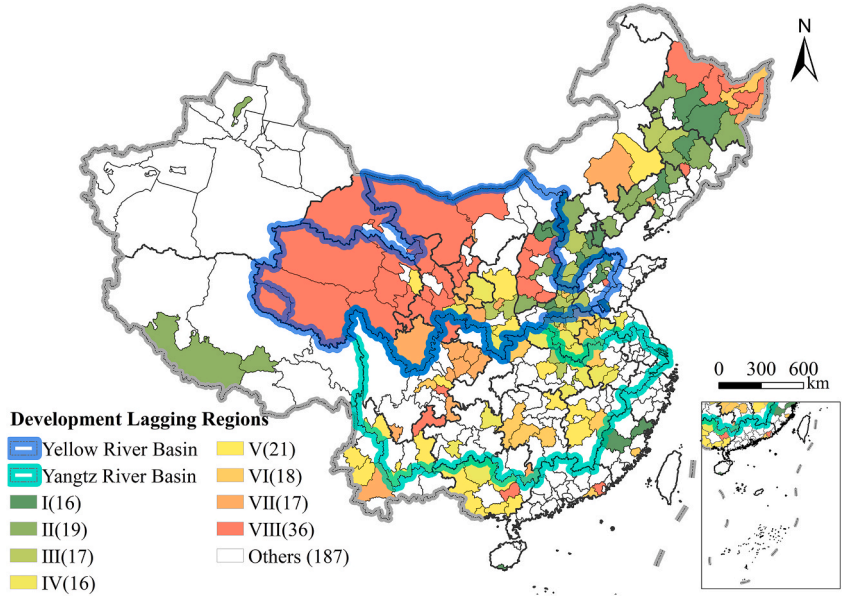

Fig. 4. The types and patterns of development lagging regions.

region are concentrated development lagging regions with 51, 24, and 16 development lagging PLCs, respectively.

5. Discussion: the paths of pursuing high-quality development

This study discussed the scientific connotation of HQD, established a comprehensive evaluation index system to measure the quality of development, revealed its spatial pattern. And then, we analyzed the correlation of different dimensions, identified the development lagging regions, and finally drew some empirical analysis-based conclusions. It could help us better understand the overall characteristics, regional pattern, and main problems of China's current HQD. To continuously improve and strengthen the level of HQD, we put forward suggestions focusing on three aspects based upon our empirical research.

5.1. Focus on improving the incentive mechanism around the HQD connotation and assessment systematically

HQD has gradually become the strategic development goal, but this acknowledgment is not enough to ensure that it is well implemented in practice. Therefore, it is necessary to further form a unified cognition on HQD, establish and improve the evaluation index system and improvement mechanism as soon as possible. To do that, we suggest to focus on improving the incentive mechanism for different regions to guide the regional government to establish a multi-dimensional comprehensive goal, including economic development, innovation, environmental quality, ecological services, and people's livelihood, etc. So that governments at all levels strive for HQD instead of high-speed development.

5.2. At the national level, identify weak links and low-value indicators and make pinpoint efforts on these areas

Given innovation efficiency and people's livelihood are the weak links in HQD. Therefore, these two areas shall be prioritized. More specifically, first, the governments should continue increasing innovation investment to create a healthy and encouraging environment for innovation, entrepreneurship, and business to promote industrial upgrading through scientific and technological innovation and thus ultimately build a modern industrial system. Second, policymakers should adhere to the open door strategy, improve the utilization of foreign capital, deepen the international division of labor and cooperation, enhance the competitiveness of our products in the global market, and promote innovative and open development. Third, the governments shall adhere to shared development, provide more employment opportunities and better work remuneration, improve infrastructure construction, build a sound public service system and social security system, and continuously improve the quality of people's livelihood. In addition, it is necessary to make great efforts in ecological and environmental

protection.

5.3. At the specific regional level, focus on those key development lagging regions and make improvements aligned with local conditions

We suggest to clarify the improvement path according to the development characteristics, main shortcomings, and causal mechanisms for the eight types of development lagging regions. In particular, the governments should focus on the three development lagging regions concentrated in the Yellow River Basin, Northeast China, and Yunnan-Guangxi region:

The problems of the Yellow River Basin are complex and need to be analyzed in sections. The level of development in the Yellow River's upper reaches is low. The comprehensive index is lower than 91.36% of the national average. The PLI is 82.87% of the national average, and the ESI is 79.00%. In the middle reaches, soil erosion is severe, with the amount of soil and water conservation being 77.36% of the national average; the comprehensive management of soil erosion is still a long way to go. Meanwhile, the middle reaches' economic development is still overly dependent on energy and chemical industries. The scores of waste gas emissions and soot emissions per unit of GDP are lower than 80% of the national average. Whereas in the downstream areas, the intensity of economic activities is high, which incurs the major challenge between population and resources. In addition, the ecosystem is seriously degraded. The habitat quality is only 66.63% of the national average. Since the Yellow River Basin is an organic whole, it is necessary to form an overall long-term HQD plan. The plan needs to factor in the differences in the resource endowments and development status of the upper, middle, and lower reaches to gradually realize the comprehensive development of the whole basin. In particular, the upstream areas should strengthen the maintenance function of the ecosystem and improve people's livelihood. The middle reaches should strengthen water and soil conservation, energy conservation, emission reduction, and environmental protection. And the downstream areas should support ecological restoration to improve the quality of habitat.

Northeast China is mainly puzzled by its ecological problems and industrial development problems. The Northeast region is an essential commodity grain base in China. However, soil erosion and soil degradation in black soil areas are prominent due to improper development and utilization. In terms of industrial development, the comprehensive industrial efficiency is low, the profit rate of above-scale enterprise's output value is 80.56% of the national average. The productivity of construction land is 60.68% of the national average. The investment in scientific and technological innovation is insufficient, and the scientific and technical expenditure is only 27.00% of the national average. In addition, the average salary of employees is low, only 61.40% of the national average. Taken together, Northeast China should strengthen soil erosion control, black soil resource protection, improve engineering construction and management, establish and perfect a comprehensive system of soil and water conservation, and guarantee ecological security. At the same time, more efforts should be made to improve the business environment, strengthen talent strategy and promote innovation-driven development to transform the pattern of economic growth, improve the development quality, and continuously enhance people's livelihood.

Yunnan-Guangxi region faces a severe relative poverty problem. Its EDI is 71.65% of the national average. Its ability to attract foreign investment is weak, and its openness to foreign investment is only 13.87% of the national average. The consumption level and the popularization of the Internet are too low. Medical care and old-age security conditions lag far behind, and the people's livelihood needs to be improved with its PLI only reaches 67.63% of the national average. Therefore, the focus of HQD in this region is to leverage its natural resources, cultural resources, and ecological environment. More specifically, this region is well suggested to 1) promote economic growth and improve people's livelihood by developing distinctive tourism, improving infrastructure, and supporting service facilities; 2) stimulate consumption by providing high-quality products and services; and 3) coordinate "bringing in" and "going out" and design preferential policies to attract foreign investment. More pertinent to this exploration, this region shall cooperate with "The Belt and Road" strategy to build an international economic cooperation corridor and enlarge its opening. However, it is necessary to balance the relationship between economic growth and ecological protection so that this region can promote sustainable and healthy economic development without destroying its ecology.

6. Conclusion

This study revealed the regional pattern and development lagging regions of HQD at the prefecture level in China based on a comprehensive evaluation method, and proposed paths for improving HQD accordingly.

It was found that the HQD comprehensive index, coordination index, EDI, IEI, EII, ESI, PLI show apparent regional differences. The HQD level in the eastern region is relatively high, and its development is fairly coordinated. The three dimensions of economic development, people's livelihood, and innovation efficiency have strong correlations with other dimensions and the comprehensive indexes.

The correlation analysis between the HQD index and typical socioeconomic indicators shows that the living standards of farmers are often higher ($p < 0.01$) in regions where the HQD comprehensive index is higher. This finding corroborates our argument that emphasizing HQD is positive for improving the farmers' living quality. The scale factors such as the regional economy scale, the urban land use scale, and the urban population scale still have a significant correlation with the level of HQD, indicating that these factors are important foundations of HQD. Still, sustainable development should emphasize the shift from scale growth to HQD.

We established the judgment criteria of development lagging regions. Further, We identified the eight categories of 160 problem PLCs, involving ecological lagged type (16), environmental and ecological lagged type (19), ecological and people's livelihood lagged type (17), people's livelihood lagged type (16), economy and people's livelihood lagged type (21), innovation and people's livelihood lagged type (18), economy and innovation lagged type (17), comprehensive lagged type (36). The development lagging regions are mainly distributed in the Yellow River Basin (51), Northeast China (24), and Yunnan-Guangxi region (16), with issues such as insufficient innovation efficiency and lagging behind people's living standards.

To continuously improve the level of HQD, we put forward suggestions focusing on three aspects based upon our empirical research. From a systematic viewpoint, the governments need to establish an evaluation system based on a unified cognition of HQD. To do that, efforts should be made to improve the top-level design, form an effective coordination and incentive mechanism. At the national level, identify the weaknesses, improve innovation efficiency and people's livelihood. At the specific regional level, focus on key development lagging regions, especially the Yellow River Basin, Northeast China, and Yunnan-Guangxi region.

Overall, this study enhanced our knowledge of high-quality development in recent China at the prefecture level and may improve China's regional policies. However, this study also has some limitations. More attention should be paid to: firstly, better assessing the rural regional system and its revitalization state (Li, Long, & Liu, 2015; Liu, Zang, & Yang, 2020; Long, Zhang, & Tu, 2019), the development quality of urbanization (Long, Liu, Hou, Li, & Li, 2014), the coordinated development of urban and rural areas, the internal structure of the tertiary industry, and the regional environmental quality (Liu, Zhou, & Lu, 2020), among others. Secondly, further clarifying the threshold of various indicators for different kinds of regions and giving a more accurate evaluation of HQD level. Thirdly, enhancing our understanding of the mechanism of HQD based on case studies and revealing the dynamics of HQD based on panel data.

Author statement

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