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The impact of natural capital utilization on high quality development in Henan Province of China

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Abstract. The evaluation index system for High Quality Development (HQD) in Henan Province of China was constructed and measured based on new development principles. Three-dimensional ecological footprint model was used to evaluate natural capital utilization, and the correlation between natural capital utilization and HQD was deeply explored through correlation analysis and threshold regression model during 2005—2020. The main results were: heterogeneity of HQD and each dimension score in each city was strong, and the northwest Henan was higher than in the southeast. 18 cities had the highest score in coordination dimension (0.09~0.17) and the lowest in innovation dimension (0.00~0.04). The maximum EF_{size} was 1.30×10^6~6.09×10^6 hm^2 in Zhoukou, and the lowest was 1.34×10^5~2.33×10^5 hm^2 in Jiyuan. Cultivated and construction land contributed highly to EF_{size}. The first lag term of HQD had a positive effect on current HQD, and threshold values for the EF_{size} and EF_{depth} were 1.487×10^6 hm^2, and 9.090 respectively. EF_{size} and EF_{depth} had a positive effect on the improvement HQD, indicating a nonlinear trend of strong to weak change. The findings provided theoretical and technical support for policies related to optimizing land use patterns, upgrading industrial structures, and ecological compensation among cities in China.

Keywords: natural capital utilization, high quality development, spatiotemporal evolution, threshold regression model, Henan Province of China

1. Introduction

At present, China's economy has shifted from high-speed growth to a stage of high-quality development. The principal contradiction has transformed into the contradiction between the people’s ever-growing needs for a better life and unbalanced and inadequate development. The green, coordinated, and sustainable development has become a hot topic of concern across all sectors [1, 2]. High Quality Development (HQD) refers to the coordination development of economic structure optimization, resource utilization efficiency, ecological environmental protection, and social fairness and justice while achieving economic growth, which is the embodiment and goal orientation of the rational utilization of natural capital [3]. Natural capital provides resource support for regional economic development, promotes the optimization and upgrading of industrial structure, and drives the high quality development of the regional economy. However, irrational natural capital utilization will lead to ecological environment destruction and resource depletion, thus restricting regional sustainable development [4]. The efficient utilization and management of natural capital are not only the guarantee of ecological security but also the core driving force for enhancing economic competitiveness and social well-being [5]. As the main production area of agricultural products, an important province of mineral resources, and a comprehensive transportation hub in China, Henan province plays an important bridging role in the balanced development of the national economy. In recent years, the ecological footprint of Henan has been continuously expanding, and it is facing prominent problems such as a low carrying capacity of natural resources and unbalanced and inadequate development. Evaluating the natural capital utilization and high quality development and their correlation in Henan Province can provide a more accurate scientific basis for the formulation and implementation of high quality development policies in the Yellow River Basin, which is of great theoretical and practical significance.

Researches on high quality development mainly focus on the evaluation and driving factors. The high quality development of the Yellow River Basin pays more attention to social and ecological aspects [6], and the core characteristics include innovation-driven, green ecology, coordination and sharing, and open cooperation. Based on the new development concept, scholars constructed high quality development index system with different disciplinary characteristics, focusing on dimensions of economy, industry, innovation, coordination, green, institutional, openness, and sharing [7, 8]. The driving factors involved technological innovation [9], industrial structure [10], land transfer [11], and environmental regulation [4]. The coupling and coordination relationship between resource environment and economic development has also attracted attention, which is complex and dynamic, and its driving factors are also spatiotemporal heterogeneous [12, 13]. The main research methods on the relationship between natural resources and high quality development included Geodetector [14], system dynamics model [15], ecological footprint model [16], and coupling model [17]. The impact of footprint size on high quality development shows an inverted "N" shape with two thresholds in the Yangtze River Economic Belt, while footprint depth and high quality development is an inverted “U” curve with a single threshold [18]. The productive lands in ecological footprint theory can represent natural capital and its flow. Using the ecological footprint model to evaluate natural capital utilization in a certain place lays the foundation for evaluating regional high quality development [19]. Supply and demand, flow utilization, and stock occupation of ecological capital are significantly positively correlated with high quality economic development [20]. Selecting comprehensive and accurate indicators can better clarify the relationship between environmental pressure and economic growth [21].

Construction of regional high quality development is mainly based on the theoretical connotation and evaluation system, and the spatiotemporal characteristics and coupling and coordination relationship of its natural, economic, and social aspects are mostly discussed, while there are relatively few empirical studies on its influencing mechanisms. Scholars have carried out the analysis of land resources, water resources use and influencing factors in river basins, but there are few quantitative studies on the relationship between natural capital utilization and high quality development of the economy and society. Therefore, this study selected 18 cities in Henan Province as the research object, constructed a high quality development evaluation index system based on the new development concept and the actual provincial conditions, and measured their spatiotemporal evolution characteristics. Moreover, Ecological Footprint Size (EF_{size}) and Ecological Footprint Depth (EF_{depth}) are used to characterize the natural capital utilization pattern, and the influencing mechanism of natural capital on high quality development is explored. Finally, development suggestions that are tailored to local conditions are put forward.

2. Study area

As a leading province in population, agriculture, and resources, Henan Province has become a pivotal frontier for comprehensively promoting ecological conservation and high-quality development in the Yellow River Basin. Henan administers 18 prefecture-level cities, including Zhengzhou, Kaifeng, Luoyang, Pingdingshan, Anyang, Hebi, Xinxiang, Jiaozuo, Puyang, Xuchang, Luohe, Sanmenxia, Nanyang, Shangqiu, Xinyang, Zhoukou, Zhumadian, and Jiyuan. The total territorial area in Henan is 167, 000 km^2, accounting for 1.73% of the total landmass area of China. Most parts of Henan are located in the warm temperate zone with distinct seasons, concurrent rainfall and heat cycles and ecological diversity. The cultivated land in Henan reaches 7.51 million hectares and average annual total amount of local water resources is 38.92 billion m^3. The permanent resident population was 98.15 million with an urbanization rate of 58.08% in 2023. The regional Gross Domestic Product (GDP) was 6.36 trillion, of which the tertiary industry contributed 3.38 trillion in 2024.

3. Research methods and data sources

3.1. Research methods

3.1.1. Construction and measurement of high quality development index system

The High Quality Development (HQD) level is a critical variable for identifying socioeconomic development status. Based on theoretical analysis of HQD connotations and previous researches [12, 13], As shown in Figure 1, HQD evaluation index system for Henan Province was constructed by selecting 28 indicators across five dimensions (innovation, coordination, green development, openness, and sharing) following principles of scientificity and data accessibility. The entropy method was applied to determine indicator weights, and a linear weighted comprehensive evaluation model was used to analyze spatiotemporal characteristics of HQD level and its dimensions.

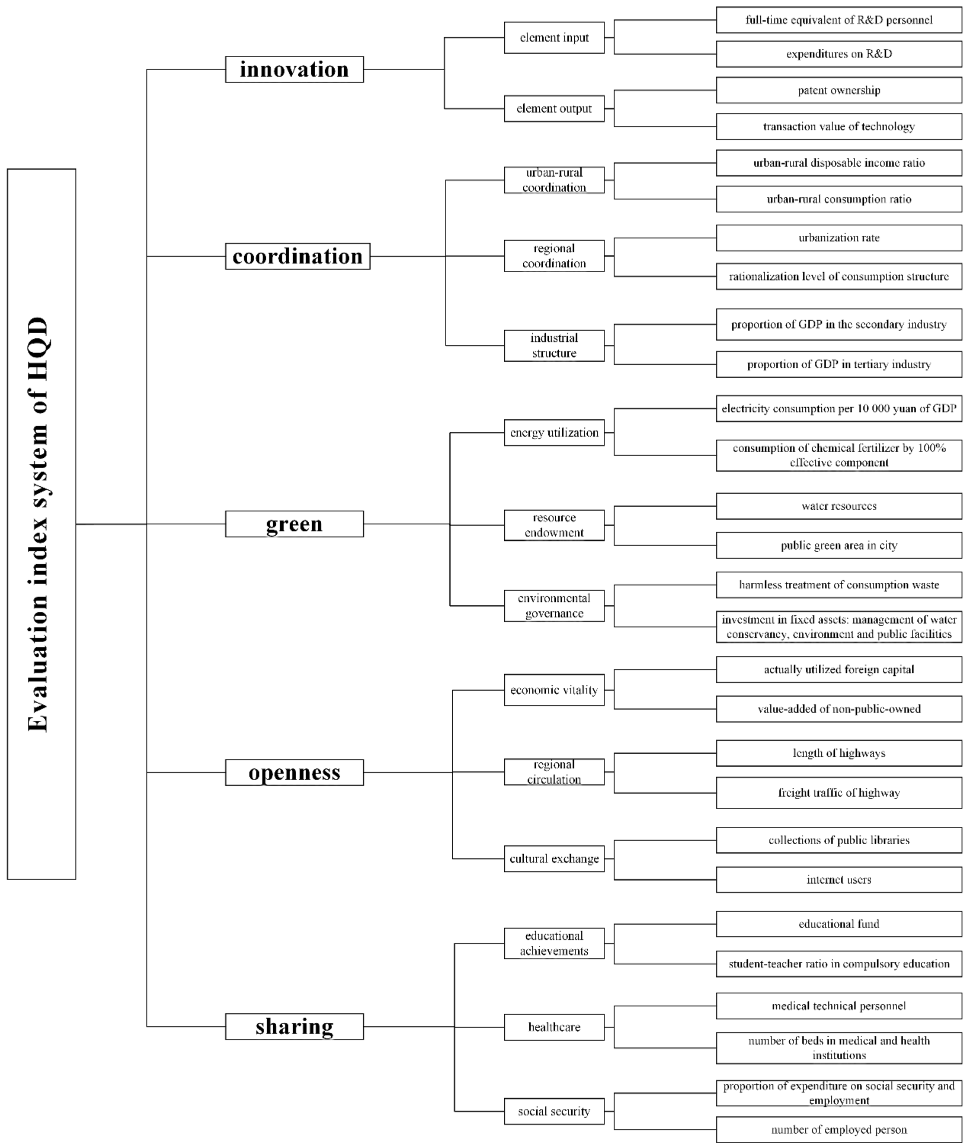

Figure 1. Evaluation index system of HQD in Henan Province

3.1.2. Natural capital utilization assessment

An improved three-dimensional ecological footprint model was employed to evaluate natural capital flows and stocks in Henan. The ecological footprint theory categorizes land into six types: cultivated land, grassland, forest land, water area, fossil energy land, and construction land, which are aggregated into a common unit using equivalence factors and yield factors, and EF_{size} and EF_{depth} are constructed into a three-dimensional ecological footprint model. The specific formulas are as Formulas (1) to (4):

$$ef = \sum_i (ef_i \times r_i) = \sum_i \sum_j \left(\frac{C_{ij}}{P_{ij}} \times r_i \right) \quad (1)$$

$$ec = \sum_i (S_i \times r_i \times y_i) \quad (2)$$

$$EF_{size} = N \times \sum_i \min\{ef_i, ec_i\} \quad (3)$$

$$EF_{depth} = \frac{\sum_i ef_i}{\sum_i ec_i} \quad (4)$$

Where ef, ef_i denote the ecological footprint (hm^2) of the study area and ith land, respectively; r_i is equivalence factor for ith land; C_{ij} is the production or consumption of jth item of ith land ($kg/m^3/kW \cdot h$); P_{ij} is global average production/consumption of jth item of ith land ($kg \cdot hm^{-2}/m^3 \cdot hm^{-2}/kW \cdot h \cdot hm^{-2}$); ec is the ecological carrying capacity of the study area (hm^2); y_i is the yield factor for ith land; S_i is the area of ith land in the study area (hm^2); EF_{size} , EF_{depth} denote the ecological footprint size (hm^2) and ecological footprint depth. $EF_{depth} \leq 1$ indicates that capital flow can meet the economic and social needs while $EF_{depth} > 1$ indicates capital stock needs to be consumed to promote regional development.

3.1.3. Threshold regression model

HQD may exhibit interval effects with different characteristics due to different natural capital utilization patterns in a certain region. To explore nonlinear relationships between HQD and natural capital utilization, dynamic threshold panel models were constructed to identify the "threshold effects" of natural capital utilization on HQD using Formula (5).

$$HQD_t = \alpha_0 HQD_{t-1} + \beta_1 EF_t I\left(EF_t \leq \gamma\right) + \beta_2 EF_t I\left(EF_t > \gamma\right) + \delta_i C_{it} + \varepsilon_t \quad (5)$$

Where: HQD_t , HQD_{t-1} are HQD at year t and $t-1$, α_0 , β_1 , β_2 , δ_i are regression coefficients, EF_{it} represents EF_{size} or EF_{depth} which is both a core explanatory variable and threshold variable, $I(\cdot)$ is the indicator function of the threshold model, γ is the estimated threshold value, C_{it} presents control variables that may influence HQD, ε_t denotes the error term.

To mitigate model endogeneity and align with established methodologies, this study incorporates a suite of control variables including population magnitude, economic productivity, industrial dynamics, urbanization intensity, infrastructure development, and urban gravity. Population magnitude is a direct factor influencing capital utilization and HQD, which is represented by the permanent resident population. Economic productivity is an important embodiment of economic development and is represented by per capita GDP. Industrial dynamics reflects the ability of the market economy to regulate the allocation of resources, thereby improving resource efficiency and total factor productivity, and it is represented by the proportion of employment in the tertiary industry. Urbanization intensity represents the stage of social and economic development in various regions with urbanization rate as a proxy. Infrastructure plays an important role in economic development and is measured by per capita fixed asset investment. Urban gravity characterizes the potential for HQD and is indicated by the growth rate of resident population.

3.2. Data sources

Socioeconomic data were obtained from Henan Statistical Yearbook, Henan Land & Resources Almanac, Henan Forestry Statistical Yearbook, Henan Statistical Yearbook on Science and Technology, Agrotechnical Economics Manual (Revised), Henan Water Resources Bulletin, Food and Agriculture Organization of the United Nations, etc. Taking 18 cities in Henan Province as the research object, the study period spans 2005–2020 to ensure data consistency, with missing values interpolated. Land area data were derived from the Ministry of Natural Resources of China and other global land cover products with appropriate adjustments.

4. Results

4.1. Analysis of high quality development

4.1.1. High quality development of different cities

As shown in Table 1, the average annual values of HQD were ranked as follows: Zhengzhou > Luoyang > Jiyuan > Sanmenxia > Jiaozuo > Hebi > Xuchang > Xinyang > Nanyang > Luohe > Xinxiang > Anyang > Kaifeng > Pingdingshan > Zhumadian > Shangqiu > Zhoukou > Puyang. HQD of each city showed significant spatiotemporal heterogeneity presenting a radial distribution centered on Zhengzhou during 2005—2020. As the provincial capital city, Zhengzhou’s HQD was leading (0.35~0.76), and the lowest value was 0.15~0.45 in Puyang. Generally, the northwestern part of Henan Province was higher than the southeastern Henan. HQD of Zhengzhou increased from 0.35 in 2005 to 0.76 in 2020, which was much larger than that of other cities, with an average annual growth rate of 5.25%, reflecting the advantages of various industries development in the provincial capital city. Both the average value and the growth rate of Luoyang's HQD were among the top, and its ranking rose to second place during 2008—2020. HQD of Puyang increased slowly from 0.15 in 2005 to 0.45 in 2020, and it was at the bottom together with the agricultural cities such as Shangqiu, Zhoukou and Zhumadian. The average annual growth rates of Luoyang (7.27%), Pingdingshan (6.53%) and Sanmenxia (6.46%) were relatively high, reflecting the comparative advantages of industrial cities. HQD of Zhoukou decreased in 2020, which may be deeply affected by COVID-19 pandemic.

Table 1. HQD and rank of each city in Henan Province

City	2005		2010		2015		2020		Rank
	HQD	Rank	HQD	Rank	HQD	Rank	HQD	Rank	
Zhengzhou	0.35	1	0.46	1	0.59	1	0.76	1	1
Kaifeng	0.20	12	0.26	14	0.37	12	0.44	14	13
Luoyang	0.20	11	0.32	3	0.45	2	0.58	2	2
Pingdingshan	0.18	14	0.28	12	0.36	13	0.46	12	14
Anyang	0.19	13	0.27	13	0.36	14	0.43	16	12
Hebi	0.23	3	0.31	6	0.40	6	0.48	7	6
Xinxiang	0.20	10	0.29	10	0.38	10	0.46	11	11
Jiaozuo	0.22	6	0.31	4	0.44	4	0.52	5	5
Puyang	0.15	17	0.21	18	0.34	18	0.45	13	18
Xuchang	0.22	5	0.31	5	0.38	8	0.47	10	7
Luohe	0.21	7	0.28	11	0.38	11	0.47	9	10
Sanmenxia	0.21	8	0.30	8	0.44	3	0.55	3	4
Nanyang	0.21	9	0.29	9	0.38	9	0.48	8	9
Shangqiu	0.14	18	0.24	16	0.36	16	0.43	17	16
Xinyang	0.22	4	0.30	7	0.40	7	0.49	6	8
Zhoukou	0.15	16	0.23	17	0.35	17	0.42	18	17
Zhumadian	0.17	15	0.25	15	0.36	15	0.44	15	15
Jiyuan	0.25	2	0.32	2	0.43	5	0.53	4	3

4.1.2. High quality development of different dimensions

Further analysis of HQD of different dimensions revealed significant heterogeneity among cities. Coordination development dimension was the most divergent dimension in HQD scores. Zhengzhou's HQD score in coordination dimension was 0.14~0.19, while Puyang's was only 0.03~0.16. HQD scores of each city in coordination dimension improved significantly during the research period, reflecting the positive benefits from integrated urban-rural development and industrial structure optimization. The heterogeneity in the sharing dimension was also quite significant. The scores of Zhengzhou (0.09~0.18) and Nanyang (0.06~0.16) were higher than those of other cities, and both showed a large increase during the research period. The difference in HQD scores in the green development dimension was relatively obvious. As a national ecological garden city and forest city, Zhengzhou's HQD score (0.07~0.16) was 1.74~2.78 times that of agricultural city Shangqiu (0.04~0.07). In the openness dimension, Jiyuan and Zhengzhou had the highest scores (0.03~0.13) while agricultural Zhoukou (0.00~0.06) lagged significantly, indicating heterogeneity of regional disparities in trade connectivity, and the gap between regions needed to be narrowed urgently. In the innovation dimension, as the core scientific and technological innovation hub of Henan, Zhengzhou's score (0.01~0.10) exceeded other cities showing an exponential growth trend, highlighting the siphon effect of the national central city.

4.2. Analysis of natural capital utilization

4.2.1. Ecological footprint size

Ecological footprint size (EF_{size}) was calculated based on formulas (1)-(3). High occupation of natural capital flow with large EF_{size} were mainly distributed in cities with abundant cultivated land resources and large populations. While lower values were found in less populated and resource-scarce areas. As shown in Figure 2, the highest EF_{size} was 1.30×10^6~6.09×10^6 hm^2 in Zhoukou and the lowest value was 1.34×10^5~2.33×10^5 hm^2 in Jiyuan. EF_{size} in Zhoukou and Shangqiu showed a gradual downward trend during the research period. EF_{size} in Zhengzhou, Kaifeng, Luoyang, and Xuchang experienced significant fluctuations while the values of other cities remained unchanged. Cities with vast land areas, abundant natural resources, and large populations possessed higher EF_{size} demonstrating stronger renewal and sustainability of natural capital.

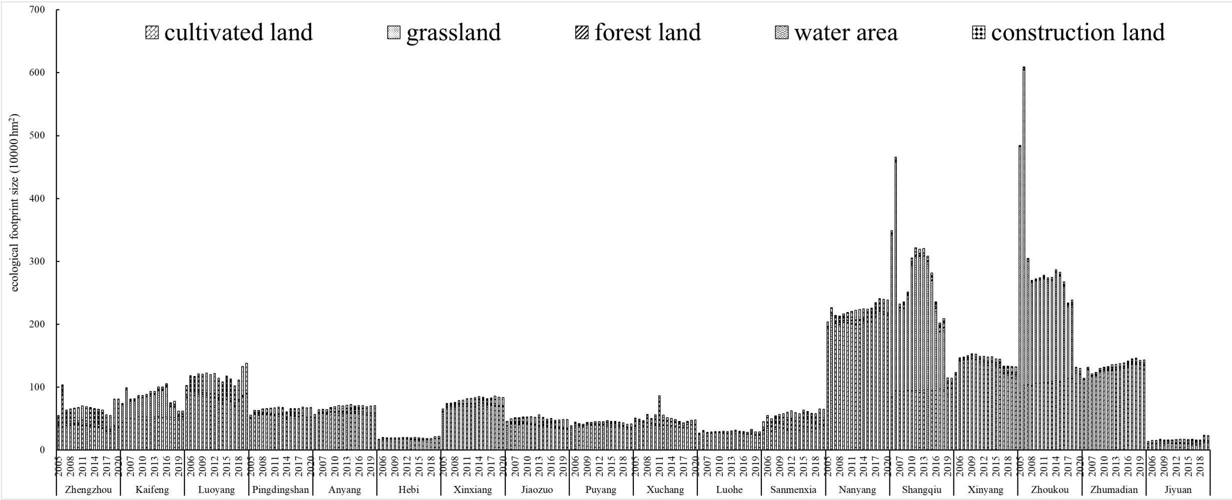

Figure 2. Ecological footprint size (EFsize) of each city in Henan during 2005—2020

The contribution of different EF_{size} components showed significant spatial heterogeneity in each city. Cultivated land and construction land had relatively high contributions to EF_{size}. The proportion of cultivated land exceeded 50% in 16 cities excluding Shangqiu and Zhoukou. The proportions of grassland in Shangqiu and Zhoukou were 54.45%~54.94%, while the grassland in 15 cities accounted for less than 5%. Contribution rates of construction land in Luoyang, Jiyuan, and Zhengzhou were 26.08%~34.36%, and the minimum value was in Zhoukou (1.34%). The higher values of water areas were in Jiyuan (6.71%) and Zhengzhou (5.10%) largely related to adjacent the Yellow River. The contribution rates of cultivated, forest and grassland in most cities slightly decreased during the study period, while the proportion of construction land components increased year by year, especially after the real estate market boomed in 2015.

4.2.2. Ecological footprint depth

Ecological footprint depth (EF_{depth}) was calculated based on Formulas (1)-(4).The natural capital stock represented by EF_{depth} were higher than the original length of 1.00 in each city, indicating that capital stock was in a state of continuous consumption. There was significant spatial heterogeneity among cities. The highest value of EF_{depth} in Xuchang reached 5.24~11.40, especially capital stock consumption exceeded the capital flow by more than ten times during the 12th Five-Year Plan period. Xinyang owned the lowest EF_{depth} (3.37~4.41), and its capital flow was less than 30% of the demand. EF_{depth} in most cities presented an inverted "U" shaped curve during the research period, closely related to the industrial transformation and green development policies. The annual average growth rates of EF_{depth} in Luohe, Xinyang, and Sanmenxia were 1.83%, 0.67%, and 0.15% respectively while other cities showed a certain decline. The degree of natural capital consumption had been alleviated under the background of ecological protection and a low-carbon economy.

Further analysis of different land EF_{depth} was conducted. As shown in Figure 3, cultivated land and grassland EF_{depth} in most cities occupied an absolute high position, followed by water areas and forest land, with the construction land accounting for the smallest proportion. Contribution of grassland components to the total EF_{depth} in Xinyang, Puyang, and Anyang reached 63.51%~62.05%. Cultivated land components in Zhengzhou, Jiyuan, and Luoyang accounted for the largest proportion (46.25%~42.83%). EF_{depth} of construction land components in Jiyuan was the highest(0.74~1.99), and those in relatively developed cities such as Sanmenxia, Luoyang, and Zhengzhou reached 1.15~1.05, presenting an inverted "U" shaped curve during the research period. Furthermore, the occupation of cultivated land also presented certain positive externalities, indicating that each city currently possessed a considerable potential for construction land, demonstrating stronger sustainability compared to other land types.

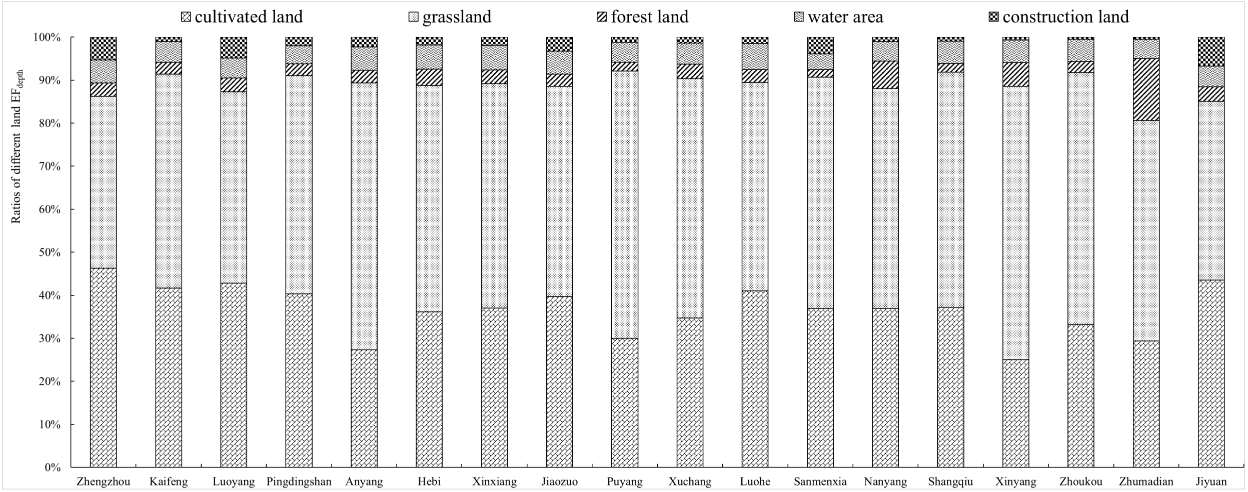

Figure 3. Ratio of different land ecological footprint depth (EFdepth) of each city in Henan

4.3. Relationship between high quality development and natural capital utilization

4.3.1. Correlation analysis between high quality development and natural capital utilization

An in-depth exploration of the relationship between HQD and EF_{size} of various cities found that the variations presented an inverted "U"-shaped Kuznets curve except for 2005—2006, with an inflection point of 0.428 for multi-year average values. The inflection points in different years were inconsistent, expanding from 0.305 in 2007 to 0.649 in 2020, with the determination coefficient R^2 of the fitting curve increasing year by year (0.188~0.698). With the continuous development of the social economy, the efficiency of natural capital utilization significantly improved, and the quality of the ecological environment was expected to be further enhanced. The phenomenon of a "pollution haven" may occur due to the transfer of ecological pressure, reflecting the imbalance and insufficiency of development in various regions.

4.3.2. Threshold effect of natural capital utilization on high quality development

Dynamic threshold panel regression model was constructed for in-depth analysis at the urban scale using Formula (5). Models (1) and (2) used EF_{size} and EF_{depth} as threshold variables respectively. The results showed that regardless of whether control variables were included, both EF_{size} and EF_{depth} had a significant impact on HQD at the 1% level. As shown in Table 2, the first-order lag term of HQD and threshold regression coefficients were all extremely significant, indicating that the previous period's HQD had a positive effect on the current period's HQD. The regression coefficient (0.901) showed that a change of one unit in the previous period's HQD increased to 0.901 units in the current HQD, demonstrating a high correlation and continuous effect between the previous and current HQD. In Model (2), the previous period's HQD had a positive effect on the current HQD, and the regression coefficient was 0.918 larger than that in Model (1).

The threshold values of EF_{size} and EF_{depth} were 1.487×10^6 hm² and 9.090. The regression coefficients indicated a positive effect of both EF_{size} and EF_{depth} on improving HQD, but the degree of impact decreased after reaching the threshold, exhibiting a nonlinear transition trend from strong to weak. Attention should be paid to improving the phenomenon of the diminishing marginal utility of natural capital utilization efficiency on HQD. Regression coefficients of population size and economic output among the control variables were all positive promoting the enhancement of HQD in both models. Regression coefficient of urban gravitational force was negative, indicating that an increase in the growth rate of permanent population would suppress HQD enhancement. It was necessary to promote the transformation from scale expansion to connotation improvement and strictly control excessive population agglomeration. The rapid social economy development relied on more resources to promote production and living standards, thus continuously increasing both EF_{size} and EF_{depth}. The increase in population size led to EF rise from both the expansion of living demand and production capacity, and through urban expansion occupying natural capital, thereby weakening regional ecological carrying capacity.

Table 2. Dynamic threshold regression results of natural capital utilization and high quality development

variables	Model (1) EF_{size}	Model (2) EF_{depth}
L.HQD	0.901***	0.918***
	(-22.17)	(-24.62)
$EF_{size}(EF_{size} \leq \gamma)$	1.923×10^{-8}***	
	(-3.69)	
$EF_{size}(EF_{size} > \gamma)$	1.186×10^{-8}***	
	(-3.81)	
$EF_{depth}(EF_{depth} \leq \gamma)$		0.003***
		(-5.79)
$EF_{depth}(EF_{depth} > \gamma)$		0.001**
		(-2.51)
population magnitude	3.975×10^{-5}***	5.528×10^{-5}***
	(-2.72)	(-4.73)
economic productivity	6.068×10^{-7}**	4.454×10^{-7}**
	(-2.5)	(-1.97)
industrial dynamics	-4.036×10^{-4}***	-2.503×10^{-4}
	(-2.63)	(-1.35)
urbanization intensity	0.092**	0.059
	(-2.09)	(-1.36)
infrastructure development	-3.163×10^{-7}	-1.858×10^{-7}
	(-1.55)	(-1.12)
urban gravity	-0.001***	-0.001**
	(-2.63)	(-2.33)
constant	-0.034**	-0.040***
	(-2.36)	(-3.27)
sample	288	288

Note: *, **, *** denoted significance at the 10%, 5%, and 1% levels respectively; values in parentheses represented robust standard errors.

5. Conclusion and policy suggestions

5.1. Conclusion

High EF_{size} were concentrated in cities with abundant cultivated land resources and larger populations while low-value were distributed in regions with fewer inhabitants and scarce land resources. Cultivated land and construction land had a relatively high contribution to EF_{size}, followed by grassland and forest land. EF_{depth} in agricultural cities such as Shangqiu and Zhoukou was second only to that in Xuchang and Zhengzhou. EF_{depth} presented an inverted "U" shaped curve with varying degrees of decline in most cities during the research period. EF_{depth} of cultivated land and grassland were high, while those of forest land, water areas, and construction land were relatively low in most cities.

There were strong temporal and spatial differences in total score of HQD and each dimension exhibited a growth trend in Henan during 2005—2020. There was a notable heterogeneity in HQD among cities with a radial distribution centered around Zhengzhou. HQD of different dimensions among cities varied considerably, with the maximum scores in coordination development dimension, innovation development dimension scored the lowest. Zhengzhou possessed the highest HQD, while Puyang owned the lowest. Temporally, the growth rate of Zhengzhou's HQD was significantly higher than that of other cities. Hebi had the lowest annual growth rate, and there was a decline in the HQD of Zhoukou in 2020.

EF_{size} showed an inverted "U" shaped Kuznets curve with HQD in various cities. The inflection point gradually expanded during research period, and the determination coefficient of the fitted curve increased year by year. EF_{size} and EF_{depth} had significant impacts on HQD at the 1% level. The first-order lag term of HQD and the threshold regression coefficients were all extremely significant. EF_{size} and EF_{depth} exerted positive effects on enhancing HQD while the degree of positive effects diminished after reaching the threshold, showing a nonlinear change trend from strong to weak in the effect on HQD.

5.2. Policy suggestions

Strengthen the awareness of natural capital. Natural capital, along with physical capital, human capital, and financial capital, has profound impacts on economic and social development. Henan needs to further establish a value orientation towards natural capital, jointly maintain the rich natural resources in the Yellow River Basin, delimit the three zones and three lines in a coordinated manner, and promote the accumulation of natural capital within the basin.

Improve the regional linkage mechanism. Promote the unification of regional natural capital accounting standards to avoid "ecological dumping". Leveraging the cumulative effect of policy dividends such as the ecological protection and high-quality development of the Yellow River Basin, strengthen the linkage between Henan and other provinces and municipalities, enhance the influence scope and radiation capacity of core cities such as Zhengzhou and Luoyang.

Adhere to green development and scientific and technological innovation. Develop circular economy and green technologies to reduce the intensity of resource consumption. Promote eco-agriculture, eco-industry, and eco-services; improve the utilization efficiency of resources such as land, labor and technology to achieve efficient and reasonable resource allocation of the Yellow River. Deepen cooperation among cities and with other provinces in innovation elements, and establish a collaborative innovation mechanism for Henan Province to build a national innovation highland.

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Conflicts of interest

The authors declare no conflict of interest.

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