Relationship Characteristics of Human Development and Its Footprint in the Loess Plateau Based on Decoupling Model

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Abstract. With the rapid economic and social development of the Loess Plateau, the human development index has continued to improve while the ecological footprint of human beings has continued to increase. This paper aims to understand the feedbacks between the HDI and ecological footprint, and to analyse the changes in the correlation patterns between the two driven by economic development, in order to provide theoretical support for the synergistic pathways between human development and ecological conservation on the Loess Plateau. Based on quantitative analysis of the spatial and temporal changes in the ecological footprint, ecological carrying capacity, and human development index of the Loess Plateau from 2000 to 2020, this paper applies a decoupling model to reveal the decoupling relationship and patterns between the ecological footprint and the human development index. The results show that: (1) the ecological carrying capacity of the Loess Plateau is smaller than the ecological footprint (i.e., in an ecological deficit) from 2000 to 2020, with the deficit increasing from 0.18ghm^2/person in 2000 to 0.66ghm^2/person in 2020, and the overall ecological deficit of the hinterland of the Loess Plateau is significantly smaller than that of the northwest and southeast. (2) The human development index of the Loess Plateau increased from 0.54 to 0.75 from 2000 to 2020, with rapid progress in human society and a higher level of human development in the hinterland than in the surrounding areas. (3) The relationship between the ecological footprint of the Loess Plateau and the Human Development Index has undergone a transformation process from "expansionary negative decoupling - weak decoupling - strong decoupling". That is, the ecological resources consumed are less to support a higher level of human development, and the ecological pressure on human social development tends to decrease. The pressure on human and social development tends to decrease, and the two tend to maintain a "strong decoupling".

1. Introduction

The earth provides the environment and resource base for human survival, while human development in turn affects the natural system, forming an inevitable mutual feedback relationship. How to use resources and environment sustainably and realize the synergy between human social development and ecological resources protection is the necessary way for human ecological civilization development, and is also a focal issue in the transition period of social development. Some studies have shown that in the early stage of social development, high speed economic development is often accompanied by prominent environmental pollution and ecological damage problems, and with the development of science and technology and the improvement of ecological and economic benefits, ecological protection and high quality development present a new stage of interpenetration, interaction and integrated development [1], showing the characteristics of Kuznets environmental curve.

Ecological resources are the material basis for social and economic development, and the increasing human occupation of ecological resources (i.e., human footprint) is exerting a certain pressure on nature and inducing ecological security risks [2]. The ecological footprint is an effective indicator of human occupation of ecosystems [3], which measures ecological risks from a global perspective; the human development index (HDI) is the most widely used category among several human well-being indices and assessment indicator systems [4], which recognizes the level of human development from a three-dimensional perspective of income, education and health. With the in-depth study of ecological footprint theory, some scholars found some shortcomings, the core view that ecological footprint is a static model that does not focus on intergenerational equity in sustainable development [5], and the ecological footprint theory only focuses on the supply and demand of ecological resources and services in the environmental system, but ignores the analysis of human social system, and the system studied has a single nature. In order to make up for the shortage of such indicators, some studies have combined the human development index and ecological footprint, for example, Zhang Shuai et al [6] combined human development index and ecological footprint to empirically study the

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sustainable development status and ecological well-being of 82 countries, and the results showed that almost all developed countries have a "high welfare, high consumption" type development model. The results show that almost all developed countries have a "high welfare, high consumption" development model. For example, human development in western China consumes a lot of natural environment, and the ecological footprint exceeds the ecological carrying capacity and the ecological deficit is obvious [7], Huang and Qing et al [8] found that the ecological deficit existed in the Loess Plateau region in 1991, and the ecological pressure and risk of the Loess Plateau was generally alleviated through ecological construction [9].

Decoupling theory is mostly applied to explore the relationship between economic development and resource consumption, and nowadays, decoupling theory and models have become an effective analytical method to measure regional sustainable development because of its proper explanation of the relationship between economic growth and resources and environment [10], and the research has been extended to the fields of energy and environment, circular economy, water resources, agricultural environment and policy [11-17], but in general, there are not many studies exploring the relationship between human development and ecological resources on the Loess Plateau in combination with ecological footprint and human development index, and there is an overall lack of understanding of the reciprocal feedbacks patterns between development and ecological risks in ecologically fragile areas. In this paper, from the relationship between human development and its footprint on the Loess Plateau, the Tapio decoupling model is used to study the decoupling pattern and dynamics of ecological footprint and human development, with the objectives of (1) revealing the spatial and temporal characteristics of human development index and ecological footprint on the Loess Plateau; (2) analyzing the evolution process and characteristics of the decoupling relationship between human development and its footprint. On this basis, we will determine whether the development of economy, health and education in the Loess Plateau region is ecologically sustainable, and then provide some new insights into ecological conservation and human development in the Loess Plateau region, and provide theoretical references for the realization of synergistic development of human well-being and ecological environment.

2. Materials and methods

2.1. Study area

The Loess Plateau is located between 100°54′~114°33′E, 33°43′~41°16′N, mainly including all of Shanxi province and Ningxia province, central Gansu province, central and northern Shaanxi province, eastern Qinghai province, southern Inner Mongolia, and western Henan province [18] (Figure 1), a total of 44 cities (states) in seven provinces (autonomous regions), with a total area of about 648,700 km^2, accounting for the total area of arable land in 2020 is about 193,300 km^2, accounting for 29.79% of the total area; the area of forest land is about 96,100 km^2, accounting for 14.81% of the total area; and the area of grassland is about 258,400 km^2, accounting for 39.83% of the total area. The total annual food production is about 50,020,000t, with a growth rate of about 57.33% compared with 2000. the total resident population of the whole region reaches 129.25 million at the end of 2020, with an increase of 17.2 million compared with 2000, with an average annual natural growth rate of 0.72%.

The Loess Plateau has favorable conditions for agriculture, animal husbandry and forestry, and is particularly rich in mineral, energy and natural resources. It is located in the transition zone from the semi humid climate zone to the arid and semi-arid climate zone, and belongs to the temperate monsoon climate as a whole. It is sensitive to climate change, with severe wind sand hazards and soil erosion, and the ecological environment is very fragile [8, 19].

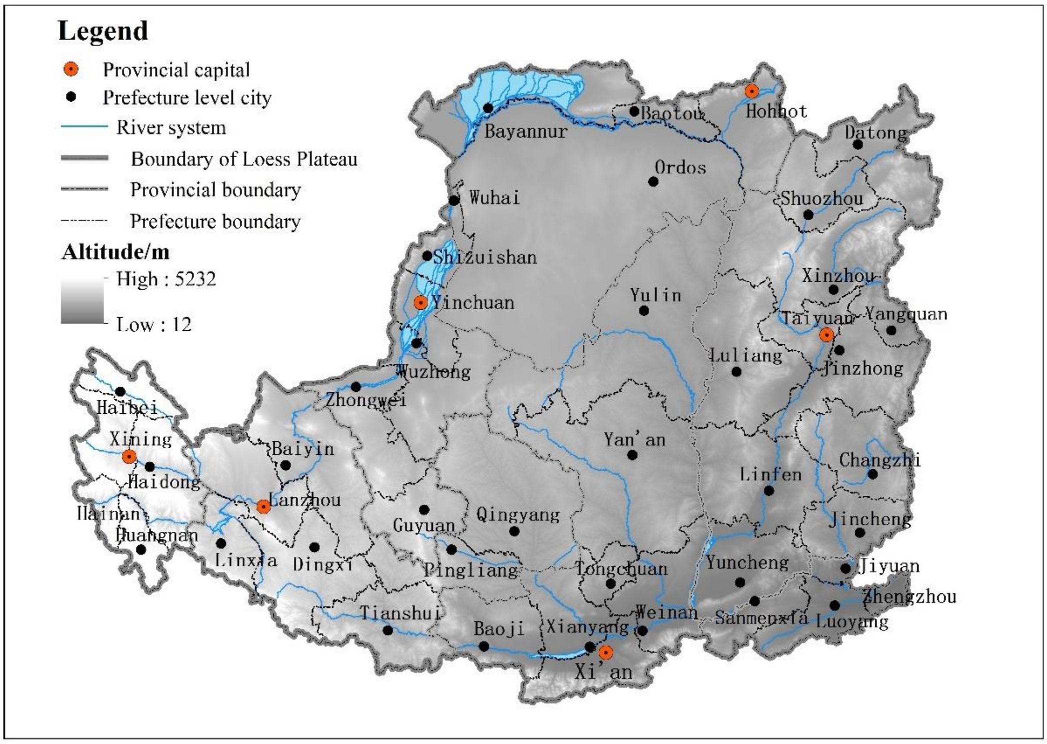

Fig 1. Location of the Loess Plateau.

2.2. Research methods and data sources

2.2.1. Ecological footprint

The calculation formula of ecological footprint(EF) is:

$$EF = N \cdot ef = \sum_{i=1}^{n} r_i \times A_i = r_i \times \frac{c_i}{Y_i} \qquad (1)$$

$$ef = \frac{EF}{N} \qquad (2)$$

Where: EF is the total ecological footprint of a region (ghm^2); N is the total population of the region; ef is the per capita ecological footprint of the region (ghm^2); i is a type of consumption item; r_i is the equilibrium factor of type i biological productive land; A_i is the area of biological productive land occupied by the per capita consumption items of category i (hm^2); c_i is the per capita consumption of the ith consumption item; Y_i is the world average yield per unit area of bio productive land corresponding to the ith consumption item.

The calculation formula of ecological carrying capacity(EC) is:

$$EC = \sum_{i=1}^{n} r_i \times y_i \times a_i \qquad (3)$$

$$ec = EC/N \qquad (4)$$

Where: EC is the total ecological carrying capacity of a region (ghm^2); r_i is the equilibrium factor of type i biological productive land; y_i is the production factor of type i biological productive land; a_i is the area of the ith biological productive land in a region; ec is the per capita ecological carrying capacity (ghm^2) of the region. The equilibrium factor and production factor refer to existing studies [20, 21].

The calculation formula of ecological deficit/surplus is:

$$ED = EC - EF \qquad (5)$$

Where: ED is ecological deficit or ecological surplus. ED >0 is ecological surplus, and ED <0 is ecological deficit.

2.2.2. Human Development Index

The HDI is a weighted composite of the Education, Income, and Health indices; the closer the HDI is to 1, the higher the human development level of the region; the closer the HDI is to 0, the lower the human development level of the region. According to the United Nations Development Program (UNDP), HDI above 0.800 is classified as very high human development; between 0.700 and 0.799 is classified as high human development; between 0.550 and 0.699 is classified as medium human development; and below 0.550 is classified as low human development. The education index, income index, and health index are calculated by the following formulae [22].

$$\text{Education index} = \frac{(\text{Average years of education} + \text{Expected years of education})}{2} \qquad (6)$$

$$\text{Income index} = \frac{\ln(\text{Real per capita disposable income}) - \ln(\text{Minimum per capita disposable income})}{\ln(\text{Maximum per capita disposable income}) - \ln(\text{Minimum per capita disposable income})} \qquad (7)$$

$$\text{Health index} = \frac{\text{Actual value of average expected life} - \text{Minimum average life expectancy}}{\text{Maximum average life expectancy} - \text{Minimum average life expectancy}} \qquad (8)$$

$$HDI = \sqrt[3]{(Education\ index \times Income\ index \times Health\ index)} \qquad (9)$$

Tab 1. Indicators and Their Maximum and Minimum (Threshold) Ranges During HDI Calculation.

Target layer	Domain level	Indicator (variable)	Maximum	Minimum
HDI	Education	Expected years of education /Year	18	0
		Average years of education /Year	15	0
	Income	Per capita disposable income /RMB	264300	352.4
	Health	Average life expectancy / Age	85	25

2.2.3. Decoupling bomb model

Based on Tapio decoupling model [23], the decoupling elastic equation between ecological footprint and human development index is constructed to measure the decoupling elastic relationship between ecological footprint and human development level, and analyze the trend of decoupling between them over time in the Loess Plateau from 2000 to 2020. The decoupling elasticity index is divided into systems (Table 2), and the calculation formula is:

$$\beta_{EF,HDI} = \frac{(EF_i - EF_{i-1})/EF_{i-1}}{(HDI_i - HDI_{i-1})/HDI_{i-1}} \quad (10)$$

Where: $\beta_{EF,HDI}$ is the decoupling elasticity index; EF_i、EF_{i-1} Ecological footprint when i and $i-1$ respectively; HDI_i、HDI_{i-1} is the human development index when i, $i-1$.

Tab 2. Decoupling State Division System.

State	Type	ΔEF	ΔHDI	$\beta_{EF,HDI}$	Meaning
Decoupling	Strong decoupling	＜0	＞0	＜0	HDI increased rapidly and EF decreased gradually
	Weak decoupling	＞0	＞0	0-0.8	HDI grew rapidly, EF grew slowly
	Declining decoupling	＜0	＜0	＞1.2	HDI decreases gradually and EF decreases rapidly
Negative decoupling	Strong negative decoupling	＞0	＜0	＜0	HDI decreases gradually and EF gradually increases
	Weak negative decoupling	＜0	＜0	0-0.8	HDI decreases gradually, EF decreases slowly
	Expansive negative decoupling	＞0	＞0	＞1.2	HDI grew slowly, EF grew rapidly
Connect	Expansive connection	＞0	＞0	0.8-1.2	HDI and EF increase simultaneously
	Fading Connections	＜0	＜0	0.8-1.2	HDI and EF decrease simultaneously

2.2.4. Data sources

The data involved in the calculation of ecological footprint, ecological carrying capacity and human development index of Loess Plateau mainly include land use data, socio-economic data. Land use data are obtained from the Resource and Environment Science and Data Center of the Institute of Geographical Sciences and Resources, Chinese Academy of Sciences (https://www.resdc.cn/), including land use data for 2000, 2005, 2010, 2015 and 2020, with a spatial resolution of 1000m×1000m. Socio-economic data of each region of the Loess Plateau are obtained through provincial , city and county-level statistical yearbooks, statistical bulletins, and the National Population Census Bulletin, including total population, per capita disposable income, life expectancy, agricultural products, and livestock products in 2000, 2005, 2010, 2015, and 2020.

To facilitate the study of the relationship between human development on the Loess Plateau and its resulting footprint, the ecological footprint account does not consider the energy consumption account. In the calculation process the biologically productive land is divided into four categories: arable land, forest land, pasture land, and water, and the consumption of biological resources is divided into four main categories: agricultural products, forest products, livestock products, and aquatic products, and the following categories are processed according to the information: agricultural products: wheat, rice, corn, sorghum, soybeans, potatoes, vegetables, cotton, oilseeds, sugar beets, and melons, forest products: timber, garden fruits, livestock products. Pork, beef, mutton, milk, wool, poultry eggs, and aquatic products.

3. Results and discussion

3.1. Temporal and spatial changes of ecological footprint

From the structural analysis of the ecological footprint of the Loess Plateau, the size of the productive land footprint of various organisms from 2000 to 2020 is as follows: arable land > pastureland > forest land > watershed (Figure 2), with the largest proportion of the footprint of arable land, accounting for 79.92% and 50.43% in 2000 and 2020, respectively, and decreasing in 2020. In 2000, the per capita footprints of cropland, forest land, pasture land and water area were 0.81ghm^2, 0.04ghm^2, 0.14ghm^2 and 0.02ghm^2 respectively, and the per capita footprints of cropland and pasture land accounted for 93.82% of the total, while in 2020, the per capita footprints of cropland, forest land, pasture land and water area were 0.72ghm^2, 0.11ghm^2, 0.49ghm^2 and 0.11ghm^2 respectively, and the per capita footprints of cropland and pasture land accounted for 84.97% of the total. This shows that the Loess Plateau is a typical area dominated by agriculture and animal husbandry, and the consumption of grain, meat, eggs and milk is the main part.

The per capita ecological footprint of the Loess Plateau is generally on the rise, with a rapid growth period of 31.64% from 2000 to 2005 and a relatively stable period from 2005 to 2020. Ecological carrying capacity decreases year by year from 2000-2015 and increases slowly from 2015-2020 (Figure 3). The Loess Plateau is in a state of ecological deficit in general, and the maximum ecological deficit per capita is 0.70 ghm^2 in 2015, which shows that the consumption of ecological resources in the Loess Plateau region is in a higher risk state.

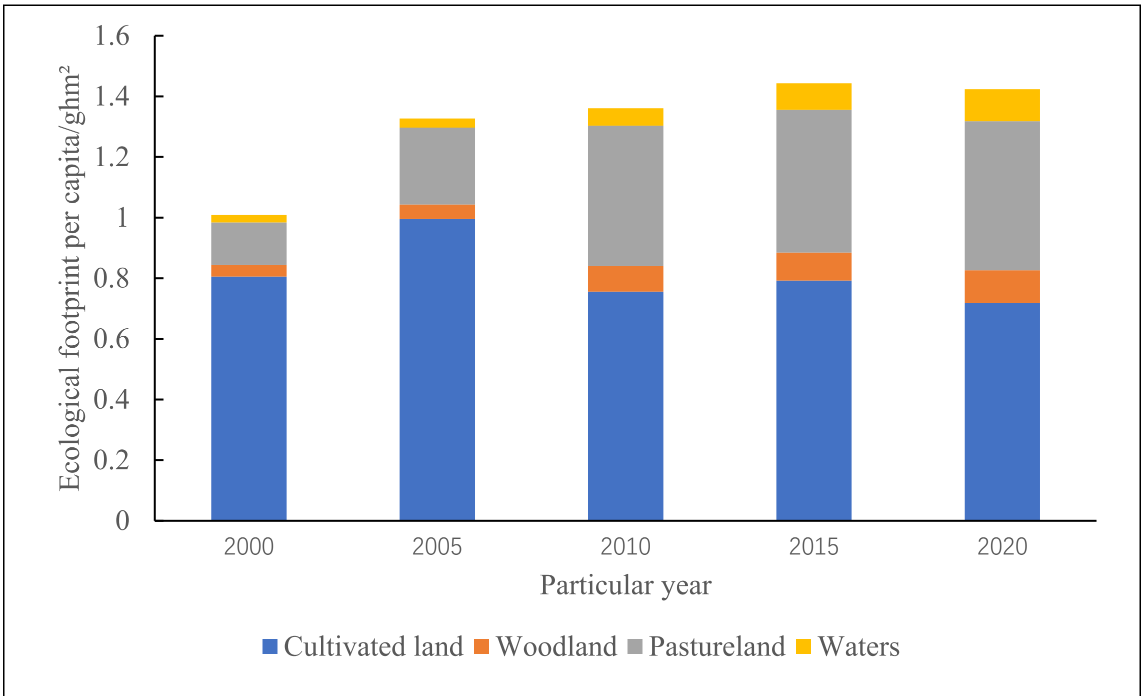

Fig 2. Components of per capita Ecological Footprint on the Loess Plateau from 2000 to 2020.

From 2000 to 2020, the per capita ecological footprint in the central part of the Loess Plateau has changed significantly, mainly in Inner Mongolia, Shaanxi, Ningxia and Qinghai. The spatial distribution of ecological footprint per capita in general shows the trend of "increasing from north to south", i.e., taking Inner Mongolia Autonomous Region in the north as the origin and extending southward in a radial pattern. Compared with 2000, the per capita ecological footprint of the Loess Plateau region will increase by 0.42ghm^2 in 2020, among which the per capita ecological footprint of Bayannur League, Haibei Tibetan Autonomous Prefecture, Hainan Tibetan Autonomous Prefecture and Huangnan Tibetan Autonomous Prefecture has been in a higher state. The ecological carrying capacity did not fluctuate significantly during 2000-2020, and the spatial distribution state remained basically stable. The ecological footprint contrasts with the spatial and temporal changes in ecological carrying capacity, and shows an obvious imbalance in space.

In 2020, Shanxi, Shaanxi, Gansu, and Henan have the highest arable footprints, Qinghai and Inner Mongolia have the highest grassland footprints, and Ningxia has equal arable and pasture footprints, which coincides with their geographical locations and the scale of their agricultural and animal husbandry industries. The total grain production of Shanxi, Gansu, Shaanxi and Henan exceeds more than 37 million tons, their population accounts for 82.56% of the total population of the entire Loess Plateau, and the arable land area accounts for 79.84% of the total area of the Loess Plateau, so the production and consumption demand of arable products such as grain and oilseeds is high and the agricultural share is large. Inner Mongolia and Ningxia are located in the northern agricultural and pastoral interlacing zone, Qinghai is located in the grassland pastoral area, the arable land area is reduced, the grassland area is large, the scale of animal husbandry is large, and the production and consumption demand of animal husbandry products is high. since the implementation of the project of returning farmland to forest and grass on the Loess Plateau in 2000, the arable land area is reduced and the forest and grass area is increased, but the production pattern of the Loess Plateau area, which is mainly plantation, has not changed substantially, and the forest and grass resources The utilization rate is low, resulting in a slow increase in carrying capacity and low ecological benefits of forest and grassland vegetation, resulting in a waste of resources.

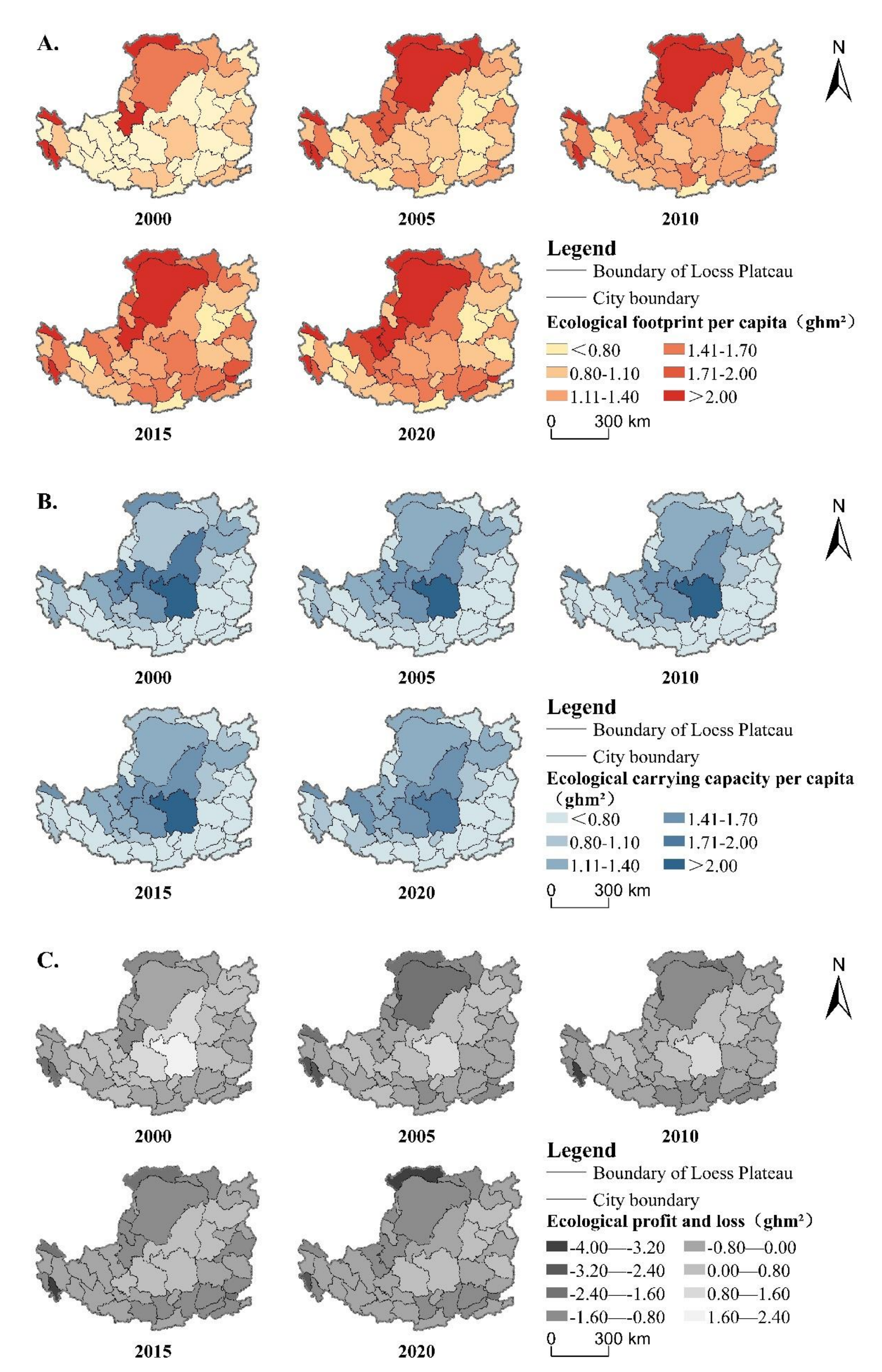

Fig 3. Spatial and Temporal Distribution Patterns of Ecological Footprint(A), Ecological Carrying Capacity(B) and Ecological Profit and Loss(C) by Cities on the Loess Plateau, 2000-2020.

The number of areas in ecological surplus on the Loess Plateau from 2000 to 2020 is decreasing year by year (Figure 3). 18 areas were in ecological surplus in 2000, accounting for 40.91%, and 7 areas were in ecological surplus in 2020, accounting for 15.91%. In terms of spatial and temporal distribution, the central part of the Loess

Plateau showed ecological surplus in 2000, and ecological deficits appeared to different degrees in the north and south, among which the ecological deficit in Qinghai Province was relatively high. 2000-2020, the spatial and temporal distribution pattern of ecological deficits mainly showed a gradual increase around to the abdomen area of the Loess Plateau, with the northern urban areas represented by Erdos City and Bayannur City, and the northern urban areas represented by Xi'an City and Weinan city as the southern urban areas, and the western urban areas represented by Hainan Tibetan Autonomous Prefecture and Huangnan Tibetan Autonomous Prefecture have obvious ecological deficits.

3.2. Dynamic analysis of human development index

The HDI of the Loess Plateau region shows a steady growth trend (Figure 4), which is consistent with the trends of the education index, income index, and health index. The HDI grew from 0.54 in 2000 to 0.75 in 2020, with a growth rate of 39.32%, and the income index grew the fastest among the three indices, from 0.41 in 2000 to 0.76 in 2020, with a growth rate of 85.29%. The education index increased from 0.52 in 2000 to 0.65 in 2020, with a growth rate of 24.73%, and the health index increased from 0.75 in 2020 to 0.87 in 2020, with a growth rate of 15.40%.

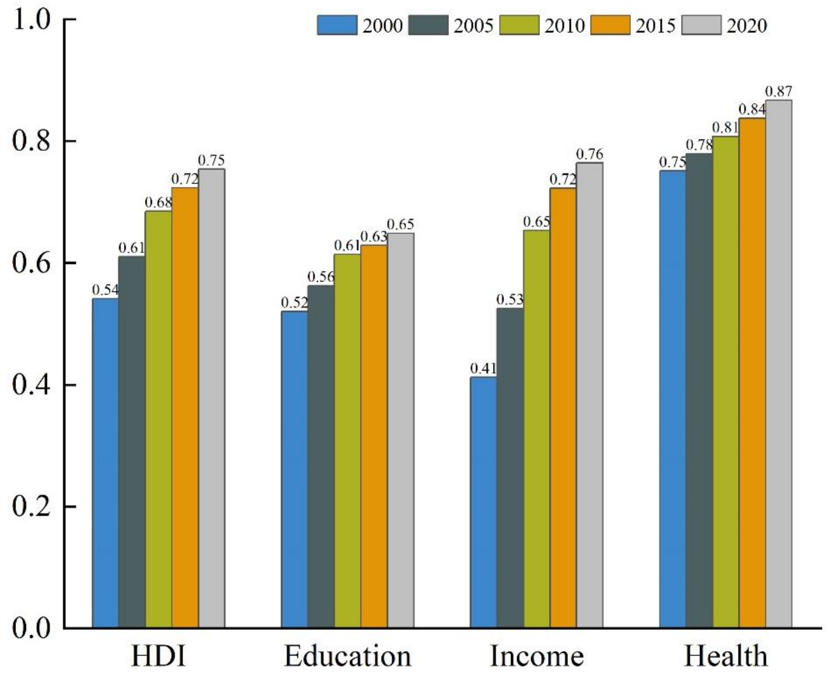

Fig 4. Dynamic Changes of HDI and Indices in the Loess Plateau, 2000 to 2020.

The HDI in the central and eastern regions of the Loess Plateau increased faster from 2000 to 2020 (Figure 5), with the most significant increase in Shaanxi Province, which increased from 0.55 in 2000 to 0.80 in 2020, with a growth rate of 44.50%. This is followed by Gansu Province and Ningxia Hui Autonomous Region, with increases of 0.224 and 0.219, respectively. 21 areas in the Loess Plateau region were at low HDI in 2000, accounting for 47.73%, while the rest were at medium HDI; by 2020, Xi'an, Baoji, Yan'an, Yulin, and Ordos reached very high HDI, with HDI of 0.811, 0.803, 0.804, 0.828, and 0.816.

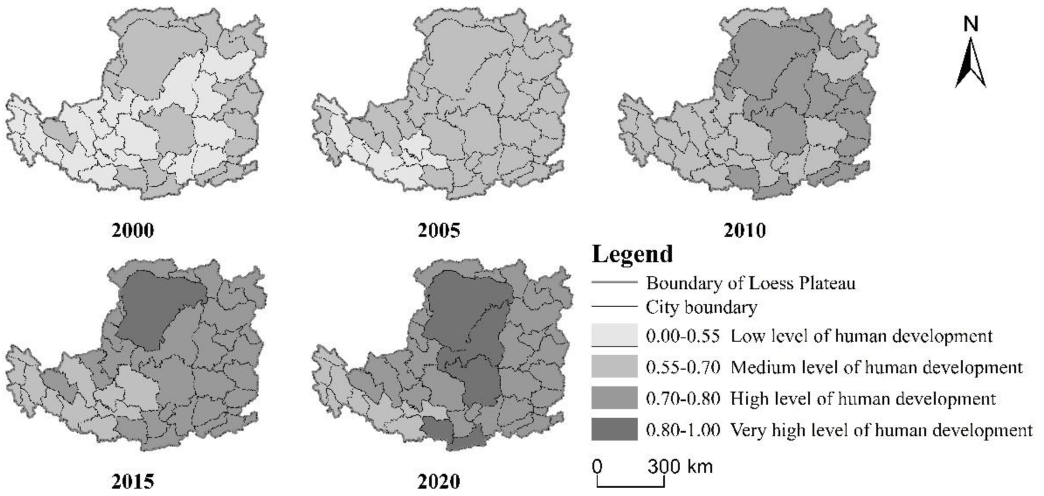

Fig 5. Horizontal Spatial Pattern of Human Development Index on the Loess Plateau, 2000 to 2020.

Among the three types of indices, the income index has the largest growth rate and the health index is stable. However, the education index has been rising at a low level, pulling down the level of human development, which has not yet reached the advanced level in the world, and more attention needs to be paid to the balanced development of education in the future [24, 25]. Compared with the world average, the life expectancy index of Loess Plateau is slightly higher than the world average. The implementation of China's basic medical and health service policy has promoted the improvement of people's health and the increase of life expectancy per capita.

The HDI in the hinterland of the Loess Plateau is significantly higher than that in other regions, and the level of human development is uneven across regions spatially. Comparing the geography of the Loess Plateau, it can be found that the eastern region has more superior natural conditions than the western region, and has a concentrated population, rapid urbanization, and rapid economic development, while the western region has poorer natural conditions, more fragile ecology, lower population density, a single income structure, and slow economic development, and geographic factors affect the development of the western region of the Loess Plateau [26]. 2000-2020 The gap between the human development indices of the regions of the Loess Plateau is gradually decreasing, which is mainly due to the rapid development of the urban and rural economies and the improvement of the quality of life, the overall achievement of poverty eradication in poor areas, and the overall construction of a moderately prosperous society, all of which have positively contributed to human development [22, 27].

3.3. Decoupling relationship between ecological footprint and human development index

There are four types of decoupling between ecological footprint and HDI in Loess Plateau from 2000 to 2020 (Table 3), including expansive negative decoupling, weak decoupling, strong decoupling, and expansive linkage, with the frequencies of 28.57%, 21.43%, 28.57%, and 21.43%, respectively.

In the state of "expansive negative decoupling", the human development index of the region increases slowly, but the ecological footprint increases significantly, so this state is not ideal. In the state of "weak decoupling", the human development index of the region increases faster and the ecological footprint increases slowly; in the state of "strong decoupling", the human development index of the region increases faster and the ecological footprint decreases significantly, which is the ideal state.

Tab 3. Types of Decoupling Models in the Loess Plateau,2005 to 2020.

	2000-2005 Decoupling Typr	2005-2010 Decoupling Typr	2010-2015 Decoupling Typr	2015-2020 Decoupling Typr
Shanxi	Expansive connection	Expansive connection	Expansive negative decoupling	Strong decoupling
Qinghai	Expansive connection	Strong decoupling	Weak decoupling	Strong decoupling
Gansu	Expansive negative decoupling	Weak decoupling	Expansive negative decoupling	Strong decoupling
Shaanxi	Expansive connection	Expansive connection	Weak decoupling	Strong decoupling
Ningxia	Expansive connection	Weak decoupling	Weak decoupling	Expansive negative decoupling
Inner Mongolia	Expansive negative decoupling	Strong decoupling	Strong decoupling	Expansive negative decoupling
Henan	Expansive negative decoupling	Weak decoupling	Expansive negative decoupling	Strong decoupling
The Loess Plateau	Expansive negative decoupling	Weak decoupling	Weak decoupling	Strong decoupling

From 2000 to 2005, Gansu, Inner Mongolia, and Henan provinces showed "expansive negative decoupling", and Shanxi, Qinghai, Shanxi, and Ningxia provinces showed "expansive linkage", in the early stage of rapid economic development, the human development pattern was at the expense of In the early stage of rapid economic development, the human development pattern was at the expense of the ecological environment, resulting in a faster growth of ecological footprint; from 2005 to 2015, Qinghai, Shanxi, Ningxia and other places appear "weak decoupling", the growth rate of human development index is greater than the growth rate of ecological footprint, human development gradually reduces the impact on the ecological environment, and the decoupling relationship between the two gradually strengthens; from 2015 to 2020, many places appear "weak decoupling". From 2015 to 2020, the state of "strong decoupling" appears in many places, the ecological pressure caused by human development is low, and the ecological cost of human development is small; from 2000 to 2020, the state of decoupling experiences a change from "expansive negative decoupling" to "weak decoupling" and then "weak decoupling". The decoupling status from 2000 to 2020 has undergone a process of change from "weak decoupling" to "strong decoupling", and the ΔHDI is greater than 0 during the whole study period, indicating that the decoupling relationship between the ecological footprint and human development index of the Loess Plateau has been optimized, and human development has gradually come out of the pattern of greater ecological pressure, but The Loess Plateau is still in ecological deficit and still faces severe ecological pressure and risk. With the continuous social progress, economic development, urbanization level, transformation of traditional economic development model, optimization of industrial structure, and initial results of ecological management [28], coupled with strict control of development scope and intensity, human development is faster and ecological pressure becomes less, and the initial synergy between human development and ecological protection is achieved[29].

4. Conclusions and suggestions

4.1. Research conclusion

(1) During 2000-2020, the ecological footprint of the Loess Plateau increased and the human development index increased, but the ecological footprint and human development index in many places showed a significant "strong decoupling", and the impact of human development on ecological resources was weakened.

(2) From 2000 to 2020, the ecological footprint of the Loess Plateau is larger than the ecological carrying capacity due to the decrease of arable land and the increase of population, resulting in an obvious ecological deficit. However, the level of human development progresses rapidly, among which the income index increases the most by 85.29%, and the socio-economics improves significantly, the sustainability of economic and social development increases, and the ecological risk decreases.

(3) The relationship between human development and its footprint has undergone a transformation from "expansive negative decoupling - weak decoupling - strong decoupling", i.e., the Loess Plateau region has achieved greater human development with less ecological resource consumption. With social development, the relationship between the two has the development trend of maintaining "strong decoupling".

4.2. Countermeasures and suggestions

To make human development and ecological environment in the Loess Plateau sustainable, and to realize the value transformation from "green mountains" to "golden mountains", it is necessary to effectively reduce the ecological footprint, reduce the ecological deficit and ecological risk, and improve human development at the same time. Based on the results of the study and the current development status of the Loess Plateau, the following countermeasures are proposed.

(1) Rational development and utilization of land resources to improve ecological carrying capacity. Implement China's basic ecological protection policy, adhere to the priority of ecological protection, consolidate the policy of returning farmland to forest and grass, and strive to build an ecological barrier in the ecologically fragile areas of the Loess Plateau. Increase investment in science and technology, such as applying cutting-edge science and technology to develop land appropriately and use construction land intensively and economically; scientifically supervise the quality of arable land, soil environment and fertilizer ratios; improve land utilization rate, increase land reclamation and arable land re-cultivation, etc.

(2) Give full play to regional advantages, change the development mode, and further optimize the industrial structure. Gradually transform the economic growth model and take the path of intensive, refined and sustainable development. At the same time, adjust the structure of energy utilization, increase the input of renewable energy and improve the utilization rate of energy. For example, vigorously develop low energy consumption and high output industries; rely on scientific and technological progress and actively explore the circular economy model, etc.

(3) Control the number of population and improve the quality of population as well as the quality of life. In the era of rapid economic development, more attention should be paid to the overall development of human beings, and the government should strengthen investment in education, health care and medical care in the Loess Plateau region to improve the quality of the population. Taking advantage of the unique local humanities and history and culture, the government should promote tourism with local characteristics in combination with market demand and vigorously promote cultural confidence. Steadily promote rural revitalization, strengthen rural infrastructure construction, and enhance the rural living environment.

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