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The spatial and temporal evolution of coordinated ecological and socioeconomic development in the provinces along the Silk Road Economic Belt in China

Yi Yang*, Na Hu

School of Economics and Management, Xi'an University of Technology, Xi'an, 710054, China

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ABSTRACT

The ecological and socioeconomic conditions of the provinces along the Silk Road Economic Belt (SREB) in China are quite different. Current research lacks a scientific analysis of the spatial and temporal evolution of the coordinated ecological and socioeconomic development in this region. Based on the ecological footprint and the *Comprehensive Development Index* (CDI), an evaluation indicator system for coordinated ecological and socio-economic development was constructed. The weights of the indicators were determined by the entropy method. Using data from 2005 to 2016, the coupling coordination degree model was used to evaluate the coordination level between the ecological and socioeconomic subsystems. The results showed a decreasing trend in the comprehensive evaluation function score of the ecological subsystem. The socioeconomic subsystem scores and coupling coordination degree fluctuated slightly in 2014 and 2015, but they increased in general. The co-ordinated development improved, and the spatial differences were obvious. Ecological degradation gradually exhibits a restrictive effect on socioeconomic subsystem, further restricting the improvement of the coordinated development. This study can provide a basis for scientific evaluation of the coordinated development level of ecological and socioeconomic conditions, and is conducive to improving the regional cooperation mechanism.

1. Introduction

Limited by factors such as terrain and landscape, the provinces along the Silk Road Economic Belt (SREB) in China have fragile ecologies (Yang, Li, Pei, Qiao, & Wu, 2018) and prominent environmental problems. Thus, this area has always confronted the issue of protecting the ecological environment while ensuring socioeconomic development. In the past 40 years, profit-seeking behaviour has created many development challenges, such as environmental pollution and ecological degradation. The encroachment of urban construction on environmentally sensitive land, the destruction of local nature reserves (Ma, Cai, Zheng, & Wen, 2019), the presence of the heavy chemical industry, the increase in air pollution (Liu, Chen, Wu, & Li, 2018) and other issues. Issues include the illegal construction of villas in Xi'an at the northern foot of Qin Ling (People's Government of Shaanxi Province, 2018) and wharfs, wooden trestles and other facilities in the Wetland Nature Reserve in the middle and lower reaches of the Yarkant River in Xinjiang (The Xinjiang Production & Construction Corps, 2018). Given these types of environmental problems, exploring green development patterns, accelerating coordinated ecological and socioeconomic development has become particularly important.

The geopolitical resource endowment and cultural origin of the provinces along the route determine their core regional action in the construction of the SREB. In seizing the opportunities presented by the implementation of the SREB, these provinces need to optimize their socioeconomic development model, increase the carrying capacity of their environmental resources, and achieve coordinated ecological and socioeconomic development are the major problems that the region currently faces.

Therefore, to explore the ecological processes in these provinces, the ecological status was characterized by the change in the per capita ecological footprint of the biological resources account, pollution discharge account and energy consumption account. Indicators such as per capita expenditure on basic public services and per capita GDP were used to characterize the socioeconomic conditions. On this basis, the coupling degree and coordination degree between ecological and socioeconomic subsystems were measured, and the relationship between them was discussed. This work will lay a scientific foundation for evaluating the policy and implementation effect of regional ecological construction (Shen, 2014; Xu et al., 2018) and socioeconomic planning,

* Corresponding author.
E-mail address: yangyi_nwpu@163.com (Y. Yang).

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provide a theoretical basis for exploring the mode of coordinated development.

Most of the existing research results were based on the theory behind the coupling coordination degree model. Different evaluation indicator systems of ecological and socioeconomic subsystems were established by synthesizing the results of the existing research on the construction of evaluation indicator system. A more scientific and reasonable method to construct the evaluation indicator system is lacking. However, the ecological footprint offers a scientific method for measuring the regional ecological situation (Miao, Sun, & Yang, 2016), thereby providing a theoretical basis for analysing ecological and socioeconomic coordination, legal and evolutionary mechanisms (Lai, Zhou, Xiao, Gong, & Chen, 2006). Furthermore, this metric guarantees a scientific evaluation of the spatial and temporal evolution of the coordination between the environment and the economy (Chun, Zhu, Pan, & Zhou, 2018). Therefore, using the ecological footprint method, combining the *Comprehensive Development Index (CDI)* and the *Statistical Monitoring Scheme for Building a Well-off Society in an All-round Way*, an evaluation indicator system for coordinated ecological and socioeconomic development was constructed. This method can not only provide a scientific and rigorous basis for the construction of the evaluation indicator system for coordinated ecological and socioeconomic development, but also be a more targeted approach with which to study the temporal and spatial evolution of regional coordinated development.

2. Literature review

Existing research has adopted many methods, including the ecological footprint (Pan, Zhuang, Geng, Wu, & Dong, 2019; Zhang, Dzakpasu, Chen, & Wang, 2017), evaluation indicator system construction (Ma, Cheng, & Qi, 2018; Wang, Wei, & Guo, 2018; Zhang, Liu, Wu, & Wang, 2018) and stochastic dynamics (Santos, Silva, Bastos, Carvalho, & Cabral, 2018), to evaluate regional ecological quality. The ecological footprint is a quantitative method to measure human utilization of natural resources. It refers to the area of land with biological productivity needed to produce all the resources consumed by humans or to absorb the waste discharged by humans (Rees, 1992). Ecological footprint has been used to study many systems at different scales (Fan, Qiao, Xian, Xiao, & Fang, 2017). It can uncover the state of human-ecosystem interactions and the spatial features of ecosystem appropriation (Pan et al., 2019). On the one hand, ecological footprint is a tool used to assess the impact of regional socioeconomic activities on ecosystems (Uddin, Salahuddin, Alam, & Gow, 2017). On the other hand, ecological footprint is an indicator suitable for regional ecological environments. Because it can reveal the impact of human activities on the air, soil and water in a region (Charfeddine & Mrabet, 2017). Ecological footprint has been used to scientifically evaluate regional ecological quality (Miao et al., 2016) and ecological pressure (Luo, Bai, Jing, Liu, & Xu, 2018). Therefore, ecological footprint is a scientific way to characterize ecological status.

In view of the fragile ecological characteristics of the western region of China where the provinces along the SREB are located. Some research has adopted ecological footprint methods to evaluate the level of ecological quality. Zhang, Xu, Cheng, and Chen (2001) investigated the per capita ecological footprint of biological resources. The per capita ecological footprint deficit of the provinces in Western China was 83% in 1999. Zhang and Ren (2013) investigated the ecological footprint of energy consumption, and the whole ecosystem of Western China was found to be unsafe. A study by Chen and Xia (2012) found that the high dependence of economic development on fossil energy in Western China resulted in widespread ecological deficits and poor ecological sustainability in 2008. Evidence from the above studies shows that under rapid socioeconomic development, ecological environment quality is declining. Although the provinces along the SREB in China have taken active measures to cope with the deterioration of the ecological environment (Belt & Road Network of China, 2017), the recovery ability of ecologically fragile areas is weak compared with those of other areas (Li, Chen, & Zheng, 2014).

Ecological and socioeconomic subsystems constrain and promote each other (Du & Zhang, 2015). The related constraints are manifested in two sides: socioeconomic stress on the ecology and ecological environment constraints on the socioeconomic subsystem (Zhao, Liu, & Zhao, 2014). The evolution of the ecological environment is affected by socioeconomic factors including economic activity, lifestyle, urbanization trends and land use change (Arto et al., 2019). Human activities meet the increasing requirements of socioeconomic development through resource utilization (Bekun, Alola, & Sarkodie, 2019; Chen, Li, Liu, Zhang, & Huang, 2019). This leads to the destruction of ecosystem functions and the ability to provide ecosystem services (Lawler et al., 2014). On the other hand, over-exploitation and exhaustion of natural resources will cause serious damage to the ecological environment, and ultimately hinder socioeconomic development (Xing, Xue, & Hu, 2019). Mutual promotion is manifested in two sides: the support of the ecology for socioeconomic development, and the protection of the ecological environment by increased socioeconomic development (Yang, Xi, & Li, 2012). The ecological environment provides a material basis for human survival and socioeconomic development (Zhang & Zhang, 2014). Moreover, a strong ecological environment can promote the coordinated development of ecological and socioeconomic subsystems (Chen, Peng, & Xiong, 2013). On the other hand, industrial structure is gradually optimized, science and technology are constantly developing, and higher socioeconomic status guarantees the protection and improvement of the ecology (Arzu, Liu, & Wang, 2015). For example, the continuous development of the socioeconomic sector has resulted in the development of technology. Satellite remote sensing technology has been widely used in environmental protection in China and used to monitor ecological environmental pollution in atmospheric, water and soil environments (Zhao et al., 2017). In addition, stringent environmental policies, stricter laws and regulations on the cleaner environment are enforced as socioeconomic development increases, leading to a progressive decline in environmental degradation (Sarkodie & Strezov, 2018).

Current studies have discussed the coupling and coordination of these systems from different points of view. In the area of study, scholars have mainly studied river basins (Du & Zhang, 2015), regions (Wang, Cheng, Zhu, & Lu, 2017), cities (He, Wang, Liu, Ma, & Liu, 2017) and counties (Wei, Shi, Wei, Zhou, & Xie, 2018). With the help of the entropy weight method (Arzu et al., 2015), objective weighting method, evaluation indicator method and comprehensive evaluation method (He et al., 2017), scholars have mainly used the coupling degree model and the coordinated development degree model to calculate the degree of coupling and coordination between ecological and socioeconomic subsystems, and to evaluate the coordination level of ecological and socioeconomic development. Although previous studies have differences in the methods used, the models established and the research targets, their coordination evaluation results show that the status of ecological and socioeconomic subsystems in most regions was improving, and the coupling coordination degree also showed an upward trend towards coordinate development (Liu, Chen et al., 2018, Liu, Liu, Xia, & Da, 2018; Yi & Fang, 2014). These results have laid a solid foundation for scientifically evaluating the ecological and socioeconomic coordination of the provinces along the SREB in China.

3. Materials and methods

3.1. Study area

The SREB in China covers the five northwestern provinces of Shaanxi Province (Shaanxi), Gansu Province (Gansu), Qinghai Province (Qinghai), Ningxia Hui Autonomous Region (Ningxia), Xinjiang Uygur Autonomous Region (Xinjiang), and the four southwestern provinces of

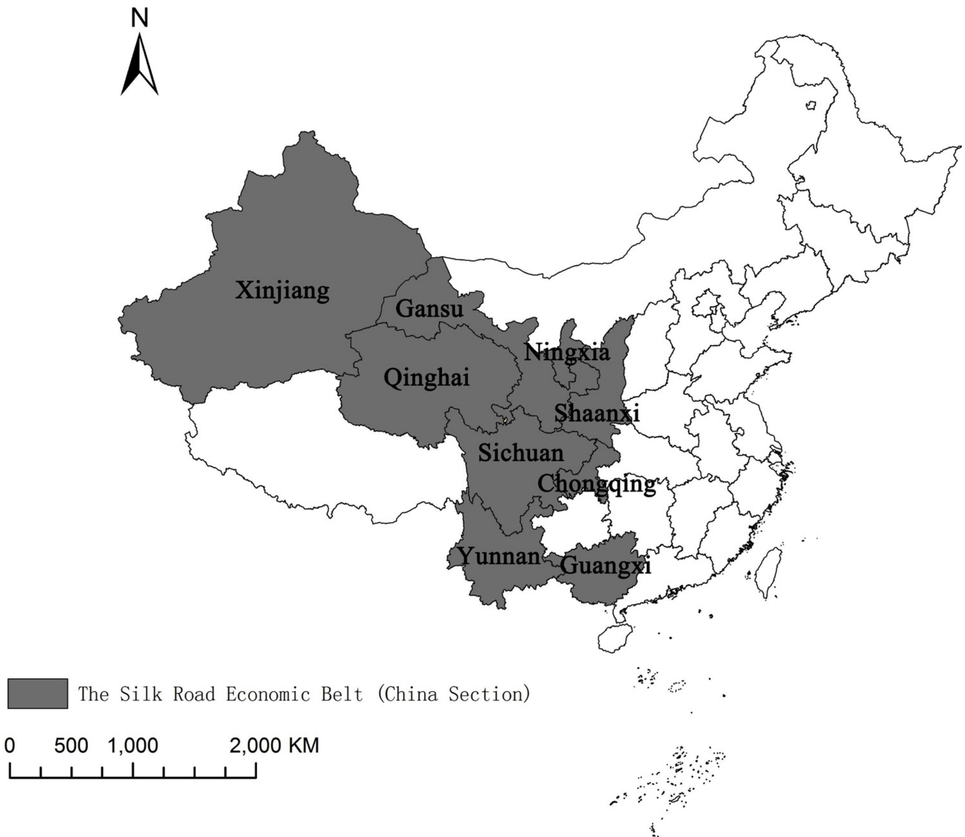

Fig. 1. Location of the provinces along the SREB of China.

Chongqing Municipal (Chongqing), Sichuan Province (Sichuan), Yunnan Province (Yunnan), Guangxi Zhuang Autonomous Region (Guangxi) (Fig. 1). It is an area that crosses administrative divisions. This region covers a vast area of 4.25 million km^2 and accounts for 44.32% of China's total land area (National Bureau of Statistics of China, 2017). In 2017, the population of these provinces was 312,487 million, accounting for 22.5% of China's total population, whereas their combined GDP is 20.74 billion USD and accounts for 16.9% of China's total GDP (National Bureau of Statistics of China, 2018). China first put forward the "Belt and Road Initiative" in 2013 (Central Government Portal of China, 2014). The construction of the SREB is an important part of this strategy. Provinces along the SREB in China are also actively promoting the implementation of the strategy. The provinces vigorously carry out cooperation and exchange in socioeconomic (Central Government Portal of China, 2014) and ecological fields (Belt & Road Network of China, 2017), such as culture, education, scientific research, tourism and environmental protection. Taking the provinces along the SREB as the research area, it has a certain policy basis. However, the provinces along the SREB in China are typical ecologically fragile areas (Li, Liu, & Yang, 2012). This condition is due to the topographic and geomorphological characteristics of Western China (Huang, Ai, Yao, & Luo, 2003; Zhang et al., 2015). If the ecosystem of the provinces along the SREB in China is destroyed, its recovery rate will be much lower than those of other parts of China. To better guide the coordinated development of ecological and socioeconomic subsystems in ecologically fragile areas, it is necessary to take this region as a sample.

The geological structure in this region is complex and dynamic, and the terrain has a wide range of clearly differentiated high and low areas. Furthermore, the region is characterized by scarce precipitation due to a dry climate, a widespread desert with sand and high winds, and a fragile ecology. The geological structure in the region is complex and dynamic, due to the collision between the Indian plate and the Eurasian plate and the subsequent northward subduction and compression of the Indian plate (Song et al., 2014). The initial collision time is approximately 65 Ma, around the transition from the Late Cretaceous to the Palaeocene (Wu, Zhang, & Han, 2002; Yang et al., 2018). The five northwestern provinces are mainly located in the Loess Plateau and the western upstream reaches of the Yellow River. The natural landscape can be divided into the Loess Plateau, the Gobi Beach, desert steppe and the Gobi Desert, each forming a large area from east to west. For example, desertification land area accounts for 64.31% of the autonomous region in Xinjiang (China Forestry Network, 2016), which hosts the most widely distributed and largest desertification area in China. The desertification land area of Gansu accounts for 45.8% (Gansu Daily, 2018) of the total land area of Gansu and is distributed to the centre, north and east of the Yellow River. Most of the western region includes inland rivers, of which the Tarim River is the largest inland river in China. In 2017, the forest coverage rates of the five northwestern provinces of Shaanxi, Ningxia, Gansu, Qinghai and Xinjiang were 41.42%, 11.89%, 11.28%, 5.63% and 4.24%, respectively (National Bureau of Statistics of China, 2018). The four southwestern provinces are located at the southwest frontier of China, southeast of the Qinghai-Tibet Plateau, and the distribution of various geomorphic forms is widely balanced. There are many large rivers in southwestern China. The central and northern areas include the Yangtze River basin, while the southern and western areas include the Pearl River, Yuanjiang River, Lancang River and Irrawaddy River basins. The forest coverage of the four southwestern provinces is significantly higher than that of the northwest region: in 2017, the forest coverage rates of Guangxi, Yunnan, Chongqing and Sichuan were 56.51%, 50.03%, 38.43% and 35.22%, respectively (National Bureau of Statistics of China, 2018). The provinces have rich natural, mineral, land and tourism resources, of which the coal reserves in the northwest account for 30% of the total coal reserves in China (National Bureau of Statistics of China, 2017).

Table 1
Per capita GDP and per capita disposable income of residents of the provinces along the SREB of China in 2005 and 2016.

The province	Per capita GDP (USD)		Per capita disposable income of residents (USD)	
	2005	2016	2005	2016
Shaanxi	1208.669	7682.982	1010.012	2842.425
Gansu	912.8851	4163.102	987.3993	2209.383
Qinghai	1226.464	6555.873	983.8706	2605.693
Ningxia	1250.183	7107.53	988.2295	2836.19
Xinjiang	1600.488	6109.036	975.6044	2764.262
Chongqing	1340.904	8810.542	1250.733	3318.389
Sichuan	1106.227	6024.548	1023.932	2832.575
Yunnan	956.6545	4682.681	1131.368	2518.057
Guangxi	1072.983	5726.958	1133.907	2756.792

The southwestern region has many types of mineral resources and large stocks, among which non-ferrous metal reserves account for approximately 40% of China's total (National Bureau of Statistics of China, 2017). The region has a long history, rich and colourful cultural tourism resources. Religious and cultural tourism is prominent, as this area serves as not only a trade route but also an area of cultural exchange.

Considering the per capita GDP, the per capita disposable income of residents (Table 1), the perinatal death rate, the proportion of rural residents receiving subsistence allowances, the urbanization rate, the GDP ratio of financial revenue (Figs. 2 and 3) and other indicators, the social and economic development of Chongqing and Shaanxi are better than that of the other provinces in this region. In 2005, the perinatal death rate in Gansu, Ningxia, Chongqing, Yunnan and Guangxi were less than 1%, which could not be directly shown in Fig. 2. The provinces have strong production capacity in areas including energy, steel, chemicals, and general equipment manufacturing. The construction of the SREB will establish a platform for industrial structure upgrading and cooperative regional development.

As the social and economic development of the provinces continues, resource exploitation and consumption are accelerating, which leads to serious ecological problems in some areas. The government provides insufficient economic development and environmental protection overall, and the construction of basic pollution control facilities has lagged. Few centralized sewage treatment facilities have been built or are under construction, incompatible sewage collection networks and inadequate construction. Some industrial and domestic wastewater is discharged directly into rivers without treatment (Central Government Portal of China, 2018). Some nature reserves are experiencing serious ecological damage (People's Government of Guangxi Autonomous Region, 2018). Illegal mining of ores and illegal processing of mining licences for enterprises occurs, and the restoration of the ecological environment surrounding mines is lagging (People's Government of Shaanxi Province, 2017). Atmospheric and water problems have become increasingly prominent, driving implementation of air pollution prevention and control measures. Serious problems such as unorganized and excessive discharge has occurred, and the treatment of black and odorous bodies of water has seriously lagged (People's Government of Shaanxi Province, 2017). For example, in 2017, the proportion of good air quality days in Shaanxi and Xinjiang averaged 65.3% and 69%, which is lower than the average level of 78% in China (National Bureau of Statistics of China, 2018). The water quality of the main stream of the Nanliujiang River in Guangxi has declined seriously due to extensive aquaculture and the direct discharge of domestic sewage (People's Government of Guangxi Autonomous Region, 2018).

3.2. Data sources

The original data needed for ecological subsystem measurement, including the outputs of agricultural, forest, grass and aquatic products, the environmental pollution, the energy consumption and other relevant data for the provinces of the SREB in China, were extracted from the *Statistical Yearbook of China* and the *Statistical Yearbooks* for the provinces of the SREB in China from 2006 to 2017. The equilibrium factors were obtained from the Global Footprint Network's *Working Guidebook to the National Footprint Accounts* for 2017, among these, cultivated and building land is 2.52, woodland and fossil energy land is 1.28, grassland is 0.43, and water area is 0.35. Assuming that any soil that absorbs pollution has less biological production capacity, its equilibrium factor is set to 1.0 (Yang & Jia, 2015). The raw data needed for the socioeconomic subsystem are extracted from the *Statistical Yearbook of China*, the *Science and Technology Statistics Yearbook of China*, the *Statistical Yearbook of Chinese Cultural Relics*, the *Health Statistics Yearbook of China* and the *Statistical Yearbooks* for the provinces of the SREB in China. The raw data are processed by extremely poor

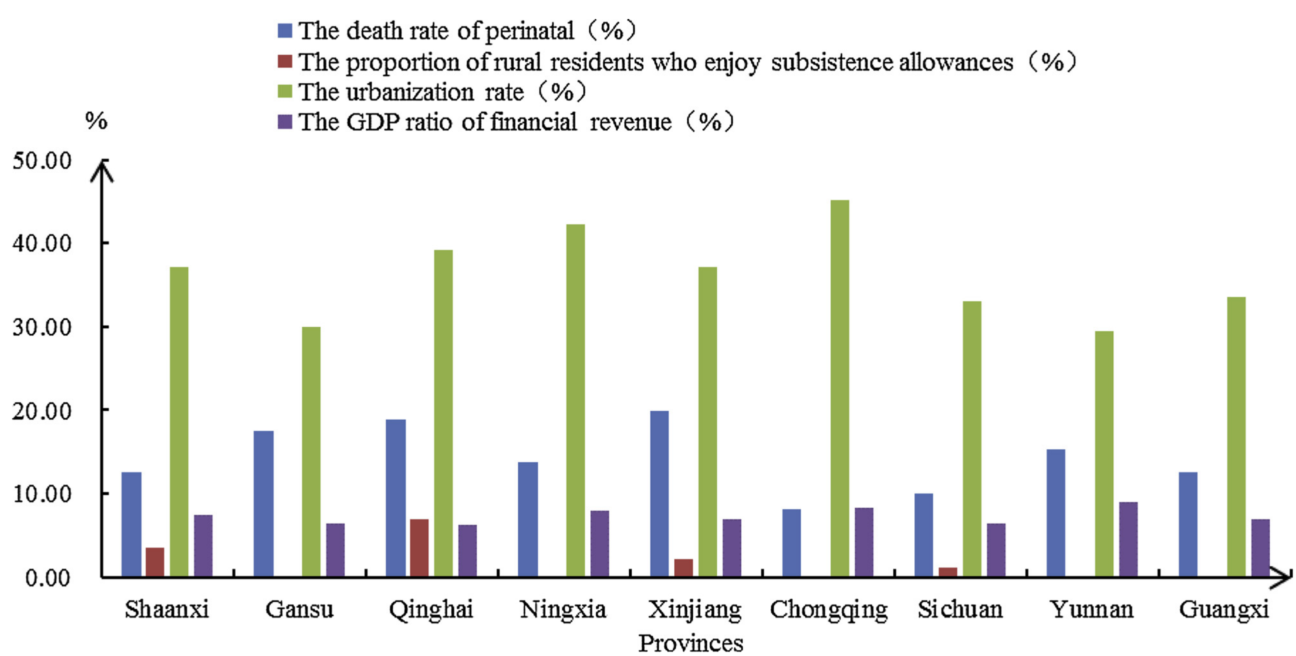

Fig. 2. The development of socioeconomic in the provinces along the SREB of China in 2005.

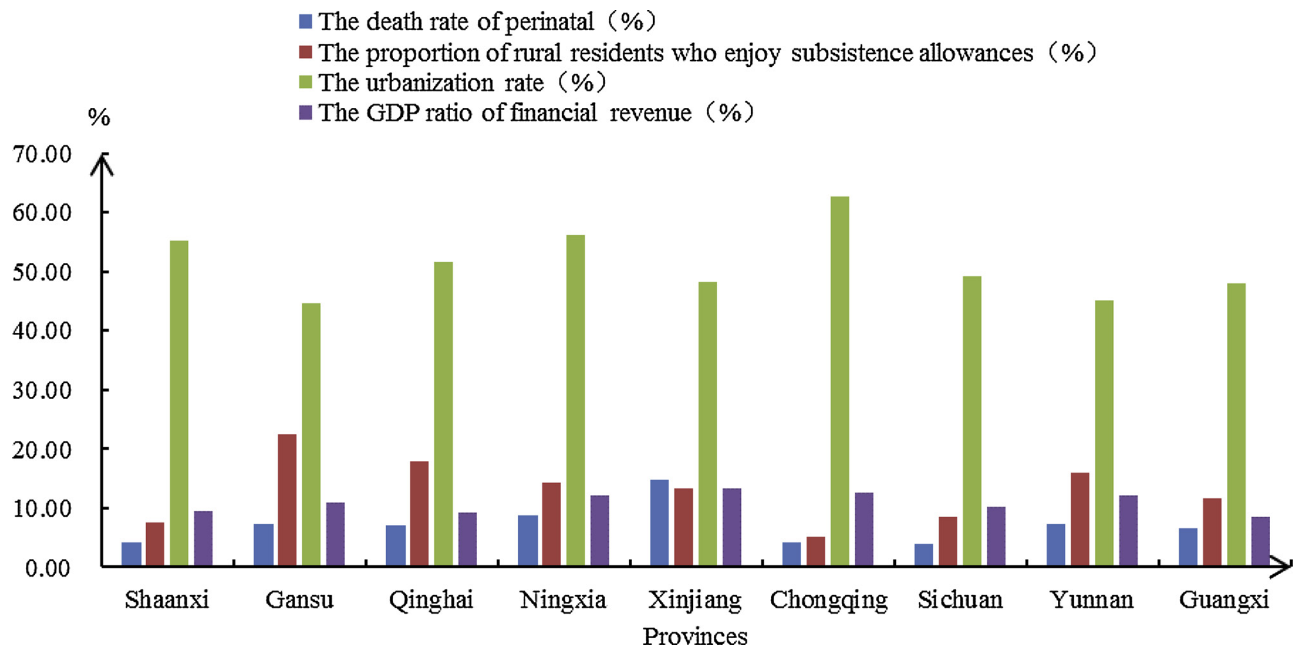

Fig. 3. The development of socioeconomic in the provinces along the SREB of China in 2016.

standardization to render them dimensionless.

3.3. Methods

3.3.1. Construction of the indicator system

There is no unified evaluation standard for the relationship between ecological and socioeconomic development. Ecological footprint can measure the consumption of natural resources, energy and the discharge of polluted wastes by human activities in a region. It is used to evaluate the quality of the ecological environment and to measure ecological pressure. Therefore, the ecological footprint was chosen as an indicator of ecological status. Research on the *CDI* (The Statistical Society of China, 2013), and *Statistical Monitoring Scheme for Building a Well-off Society in an All-round Way* (The National Bureau of Statistics of China, 2009) were used as data sources. Based on the data available, indicators were selected to represent the level of socioeconomic development to construct the evaluation indicator system for coordinated ecological and socioeconomic development (Table 2).

The social development includes public service expenditure, cultural education, health and social security. Public service expenditures are represented by the per capita expenditure of the basic public service and expenditure on basic public services accounted for a proportion of total expenditure in the fiscal expenditure. Cultural education is represented by cultural undertakings accounted for a proportion of fiscal expenditure, and the illiterate population accounted for a proportion of the population aged 15 and over. Health and wellness are characterized by the death rate of perinatal. Social security is represented by the number of people covered by basic endowment insurance, the number of people covered by basic medical insurance, the proportion of rural residents who receive subsistence allowances, and the proportion of urban residents who receive subsistence allowances.

The economic development includes economic growth, structural optimization and development quality. Per capital GDP and index of GDP. The economic structure optimization is represented by added

Table 2
The evaluation indicator system for coordinated ecological and socioeconomic development.

First-grade Indicator	Second-grade Indicator	Unit
Ecological subsystem X	The per capita ecological footprint of the biological resource account (X_1)	ha/cap
	The per capita ecological footprint of the energy consumption account (X_2)	ha/cap
	The per capita ecological footprint of the pollution discharge account (X_3)	ha/cap
Socioeconomic subsystem Y	The per capita expenditure of the basic public service (Y_1)	RMB yuan per person
	Expenditure on public services accounted for a proportion of total expenditure in the public budget (Y_2)	%
	Cultural undertakings accounted for a proportion of fiscal expenditure (Y_3)	%
	The illiterate population accounted for a proportion of the population aged 15 and over (Y_4)	%
	The death rate of perinatal (Y_5)	%
	The number of people covered by basic endowment insurance (Y_6)	Ten thousand persons
	The number of people covered by basic medical insurance (Y_7)	Ten thousand persons
	The proportion of rural residents who receive subsistence allowances (Y_8)	%
	The proportion of urban residents who receive subsistence allowances (Y_9)	%
	Per capital GDP (Y_{10})	RMB yuan
	Index of GDP (Y_{11})	–
	Added value of the tertiary industry accounted for a proportion of GDP (Y_{12})	%
	Household consumption expenditure accounted for a proportion of GDP (Y_{13})	%
	R&D expenditure accounted for a proportion of GDP (Y_{14})	%
	The urbanization rate (Y_{15})	%
	The GDP ratio of financial revenue (Y_{16})	%
	Labor productivity of the society(Y_{17})	RMB yuan per person

Note: Indicators in the table were evaluated from 2005 to 2016. Y_1 to Y_9 are indicators of social development, Y_{10} to Y_{17} are indicators of economic development.

value of the tertiary industry accounted for a proportion of GDP, household consumption expenditure accounted for a proportion of GDP, R&D expenditure accounted for a proportion of GDP and the urbanization rate. The quality of economic development is represented by the GDP ratio of financial revenue and labor productivity of the society.

3.3.2. Entropy method

In addition to establishing an evaluation indicator system for the coordinated development of ecological and socioeconomic subsystems, assigning a weight to each indicator according to its relative effects on the degree of the coordinated development is another important task for evaluating such a coordinated development. The methods of calculating weights are mainly divided into subjective and objective methods. The subjective weighting method calculates the weight according to researchers' subjective cognition. The results are greatly influenced by the ability and knowledge of the researchers. The analytic hierarchy process is one of the most commonly used subjective weighting methods (Aryafar, Yousefi, & Doulati Ardejani, 2013). The objective weighting method calculates the weights of influencing factors using statistical methods based on raw data, such as principal component analysis and the entropy method. Although principal component analysis is a combination of qualitative and quantitative analyses some information will be deleted in the process of selecting the principal components, ultimately affecting the results (Shao, Sun, Tao, Xiang, & Xian, 2015). The entropy method calculates the weight according to the information provided by the raw data of each indicator. Using the entropy method to calculate the weight can avoid subjectivity by considering the raw data. This method has been applied in many research fields (Zhao, Ji, Tian, Chen, & Wang, 2018). Therefore, the weights of ecological and socioeconomic subsystems were calculated by the entropy method. The formula is as follows (Yang & Sun, 2015):

$$\omega_{\mathrm{i}} = \frac{G_{\mathrm{i}}}{\sum_{\mathrm{i}=1}^{\mathrm{m}} G_{\mathrm{i}}} \tag{1}$$

where ω_{i} is the weight of indicator i, $i = 1, 2, 3\ldots,\mathrm{m}$, $m = 3$ in the ecological subsystem, and $m = 17$ in the socioeconomic subsystem. G_{i} is the information utility value of indicator i.

$$G_{\mathrm{i}} = 1 - E_{\mathrm{i}} \tag{2}$$

where E_{i} is the entropy of indicator i.

$$E_{\mathrm{i}} = -\mathrm{k}\sum_{j=1}^{n} \sum_{t=1}^{r} P_{ij} \ln P_{ij} \tag{3}$$

where k is constant, and k= $\ln(\mathrm{rn})$. j is the number of evaluation objects, $j = 1, 2, 3\ldots,\mathrm{n}$, there are nine provinces along the SREB in China, so $n = 9$. In addition, t is the number of evaluation years, t= 1, 2, 3…,r, the time range of the evaluation is from 2005 to 2016, so $r = 12$. $\mathrm{P_{ij}}$ is the proportion of the value of each indicator.

$$P_{\mathrm{ij}} = \frac{\mathrm{v_{ij}}}{\sum_{\mathrm{t}=1}^{\mathrm{r}} \mathrm{v_{ij}}} \tag{4}$$

where $\mathrm{v_{ij}}$ is the standardized value of each indicator.

3.3.3. Ecological footprint

The ecological footprint was proposed by Rees and was completed and improved by Wackernagel et al. (1999). The ecological footprint refers to the sum of all resources consumed by a population and the area of biologically productive land needed to absorb all the waste generated by the corresponding region. The ecological footprint was divided into biological resources, energy consumption and pollution discharge accounts (Table 3).

The formula of the ecological footprint is as follows (Yang & Jia, 2015):

$$EF = N \times ef = N \times \sum \left(\frac{C_i}{P_i} \times r_i\right) \tag{5}$$

where EF is the ecological footprint, N is the population of the provinces along the SREB in China, ef is the per capita ecological footprint. i is the product category, C_i is the per capita consumption of product i, but C_i is the discharge of pollutant i in the pollution discharge account. P_i is the global average production of product i, which is the ability of land to absorb pollution emissions in the pollution discharge account. r_i is the balance factor, which is also the ratio of the productive land of a species to the average productivity of all productive land in the region.

3.3.4. Coupling coordination degree model

Coupling, which originates from the physical science, is a phenomenon in which two different systems influence each other through various interactions at a certain time (Li, Li, Zhou, Shi, & Zhu, 2012). In recent years, this concept has often been used in ecological and socioeconomic studies. By using the capacity coupling coefficient model from physics and the coefficient of variation from statistics, the coupling degree model for the ecological and socioeconomic subsystems is established. The formula is as follows (Kong, Ren, Wang, & Liu, 2016):

$$C = \left\{\frac{f(EE) \times g(SE)}{\left(\frac{f(EE)+g(SE)}{2}\right)^2}\right\}^{1/2} \tag{6}$$

where C is the coupling degree between the ecological and socioeconomic subsystems, $0 \le C \le 1$. When C is higher, and the degree of interaction between the ecological and socioeconomic subsystems is greater. $\mathrm{f}(EE)$ is the function of ecological comprehensive evaluation, when $\mathrm{f}(EE)$ is higher, the ecological quality is better. $\mathrm{g}(SE)$ is the function of the socioeconomic comprehensive evaluation, when $\mathrm{g}(SE)$ is higher, the level of socioeconomic development is higher.

$$\mathrm{f}(EE) = \sum_{\mathrm{j}=1}^{\mathrm{n}} \sum_{\mathrm{t}=1}^{\mathrm{r}} \omega_{EE} \times \mathrm{v}_{EE} \tag{7}$$

$$g(SE) = \sum_{\mathrm{j}=1}^{\mathrm{n}} \sum_{\mathrm{t}=1}^{\mathrm{r}} \omega_{SE} \times \mathrm{v}_{SE} \tag{8}$$

where ω_{EE} is the weight of each indicator of the ecological subsystem. ω_{SE} is the weight of each indicator of the socioeconomic subsystem. j is the number of evaluation objects, $j = 1, 2, 3\ldots,\mathrm{n}$, there are nine provinces along the SREB in China, so $n = 9$. t is the number of evaluation years, t= 1, 2, 3…,r, the time range of evaluation is from 2005 to 2016, so $r = 12$. v_{EE} is the standardized value of each indicator in the ecological subsystem. v_{SE} is the standardization value of each indicator in the socioeconomic subsystem.

The coupling degree plays an important role in evaluating the coupling between the ecological and socioeconomic subsystems at a specific time and space. However, it is difficult for the coupling degree to show the level of coordinated development between two systems (Niu & Wang, 2017). Therefore, the coupling coordination degree model is used to reflect the degree of coordinated development of ecological and socioeconomic subsystems, including the degree of coupling and coordination. The formula is as follows (Kong et al., 2016):

$$D = \sqrt{C \times T} \tag{9}$$

$$T = \alpha \times f(EE) + \beta \times g(SE) \tag{10}$$

where D is the coupling coordination degree between the ecological and socioeconomic subsystems, $0 \le D \le 1$, when D is higher, the level of coordinated development of the ecological and socioeconomic subsystems is higher. T is the comprehensive evaluation index for the coordinated development between the ecological and socioeconomic subsystems. α and β represent the contributions of ecological and

Table 3
Composition of ecological footprint account in the provinces of the SREB in China.

Account	The first level subjects	The second level subjects	Units of the second level subjects
Biological resources account	Agricultural products	Wheat, rice, corn, soybean, cotton, tobacco, oilseeds, vegetables, hemp, sugar, silkworm cocoon, tubers, beet, alfalfa	Ten thousand tons
	Forest products	Walnut, Chinese chestnut, raw lacquer, fruits, tea, pepper, tung oil seed, five times seed, palm sheet	
	Grass products	Pork, beef, mutton, dairy, eggs, horse meat, camel meat, rabbit meat, poultry	
	Aquatic products	–	
Energy consumption account	–	Coal products	Ten thousand tons of standard coal
	–	Oils	
	–	Natural gas	
	–	Hydropower, wind power and other energy generation	
Pollution discharge account	Water pollution	Industrial waste water, discharge of chemical oxygen demand (COD), domestic sewage	Ten thousand tons
	Air pollution	SO_2, smoke and dust	
	Solid waste pollution	Industrial solid waste, domestic garbage	

socioeconomic subsystems, and $\alpha + \beta = 1$. Assuming that each subsystem is equally important to the coordinated ecological and socioeconomic development, $\alpha = \beta = 0.5$.

Referring to the research results of He et al. (2017), the results for the coupling coordination degree results were divided into four levels (Table 4).

4. Results and discussion

4.1. Results analysis of the ecological subsystem

The standardized value of the per capita ecological footprint and the indicator weight were used to calculate the comprehensive evaluation function score of the ecological subsystem. From 2005 to 2016, the comprehensive evaluation function score of the ecological subsystem in the provinces along the SREB showed a downward trend (Table 5), from 0.838 to 0.705, with a decrease of 15.87%. However, the decline rate and decline range of the provinces along the SREB in China were different, with obvious spatial differences.

The scores of Xinjiang and Ningxia decreased from 0.553 to 0.360 and from 0.696 to 0.452 during this time, respectively, these scores were lower than the scores of other provinces. The yield of characteristic agricultural products such as corn, beets and other high quality forest products such as fruits and walnuts in Xinjiang was higher than those in other provinces. The main support of economic growth in Xinjiang is the heavy industry supported by coal, iron and steel, chemical industries, the energy consumption was growing faster (Xu et al., 2017). The characteristic agricultural and energy products in Xinjiang play a key role in the construction of the SREB and the “Belt and Road Initiative”. The increase in the per capita ecological footprint of the biological resources and the energy consumption account was the main reason for the decline in the score over this period. Although the pollution discharge and energy consumption in Ningxia were not the highest among the provinces, its population was relatively small, which lead the per capita ecological footprint of pollution discharge and energy consumption to be higher than those in other provinces. The increase in coal and natural gas consumption in Ningxia over the study period was the main reason for the decline in its score.

Table 4
Classification of coordination levels between ecological and socioeconomic subsystems.

Coordination level	Seriously unbalanced	Slightly unbalanced	Barely balanced	Highly balanced
Coordination degree	(0,0.3]	(0.3,0.5]	(0.5,0.7]	(0.7,1.0]

The score of Qinghai was higher than those of Xinjiang and Ningxia but lower than those of the other provinces. The score decreased from 0.871 to 0.472, the range of decrease was 45.81% and an average annual increase of 5.73%. The contribution rate of the pollution discharge account was 61.42%. The increase in solid waste pollution was the main reason for the decline of the score. The solid waste mainly came from the mining, electric power, chemical industry and ferrous metal smelting industries (Wu, Lu, Li, Min, & Luo, 2018). The antiquated production technology and outdated equipment have resulted in extensive industrial development mode. From 2010 to 2011, the output of industrial solid waste increased from 17.83 million tons (National Bureau of Statistics of China, 2011) to 12.17 million tons (National Bureau of Statistics of China, 2012), which lead to an increase in the per capita ecological footprint of solid waste pollution from 0.33 ha/cap to 2.09 ha/cap, correspondingly, the score of Qinghai dropped sharply.

The scores of Yunnan, Gansu, Shaanxi, Chongqing, Sichuan and Guangxi all showed a downward trend. The respective decreases from 2005 to 2016 were 10.63%, 9.50%, 8.61%, 4.51%, 4.68% and 1.58%. The per capita ecological footprint of the energy consumption accounts in Guangxi and Chongqing contributed greatly to the decreases of 132.40% and 111.34%, respectively. Although the per capita ecological footprint of solid waste pollution increased slightly, Guangxi and Chongqing have centralized the management of seriously polluting enterprises. The discharge of industrial wastewater, SO_2, smoke and dust in the pollution discharge account have decreased, leading the per capita ecological footprint of the pollution discharge account to decrease each year. The high energy-consuming industries, such as papermaking and smelting in Guangxi, steel and cement in Chongqing, account for a high proportion of the industries above the scale. Compared with hydropower and wind power, coal consumption remains relatively high (Sun, Li, & Wang, 2018). The sharp increase in coal and oil consumption was the main reason for the decline in the scores of Guangxi and Chongqing. The per capita ecological footprints of Shaanxi, Sichuan and Gansu contributed significantly to the declines in their scores, but the contribution rate of the per capita ecological footprint of the energy consumption account was higher than that of the biological resources or pollution discharge account, which were 94.71%, 81.04% and 51.75%, respectively. The consumption of coal, oil, natural gas, hydropower, wind power and other types of energy have increased to varying degrees, which is the main factor leading to the decline in these scores. To grasp the strategic opportunities in the construction of the SREB and the “Belt and Road Initiative”, it is essential to strengthen cooperation in energy infrastructure construction, energy technology, energy-saving and emission-reduction fields.

The contribution rates of the per capita ecological footprint of biological resources, pollution emissions and energy consumption accounting for the decline in the score of Yunnan were 76.21%, 4.74%

Table 5
The dynamic change of the comprehensive evaluation function score of the ecological subsystem in the provinces along the SREB in China from 2005 to 2016.

Year		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Northwest	Shaanxi	0.918	0.920	0.909	0.895	0.892	0.877	0.867	0.854	0.846	0.835	0.826	0.839
	Gansu	0.937	0.924	0.921	0.914	0.911	0.895	0.865	0.857	0.853	0.845	0.846	0.848
	Qinghai	0.871	0.859	0.837	0.821	0.816	0.815	0.588	0.562	0.551	0.551	0.485	0.472
	Ningxia	0.696	0.660	0.636	0.625	0.615	0.556	0.489	0.484	0.462	0.447	0.432	0.452
	Xinjiang	0.553	0.570	0.587	0.642	0.625	0.627	0.574	0.504	0.414	0.385	0.390	0.360
Southwest	Chongqing	0.909	0.914	0.905	0.900	0.895	0.888	0.878	0.875	0.862	0.861	0.860	0.868
	Sichuan	0.898	0.919	0.909	0.903	0.898	0.880	0.882	0.865	0.857	0.859	0.856	0.856
	Yunnan	0.941	0.926	0.940	0.938	0.931	0.884	0.857	0.840	0.836	0.836	0.840	0.841
	Guangxi	0.823	0.840	0.815	0.807	0.807	0.806	0.809	0.796	0.782	0.794	0.804	0.810
The region		0.838	0.837	0.829	0.827	0.821	0.803	0.756	0.737	0.718	0.713	0.704	0.705

and 19.05%, respectively. Among them, the per capita ecological footprint of the biological resources account increased from 0.95 ha/cap to 1.72 ha/cap over the study period. The main reason was that tea, fruit and other characteristic products had a high yield, plateau ecological pasture and standardized scale breeding were more developed. The rapid growth of agricultural products, forest products, grass products and aquatic products was the main factor leading to the decline in the score of Yunnan.

4.2. Results analysis of the socioeconomic subsystem

The comprehensive evaluation function score of the socioeconomic subsystem is calculated. by the standardized value and weight of the indicator. The results of the comprehensive evaluation function scores of the socioeconomic subsystem in the provinces along the SREB in China from 2005 to 2016 (Table 6) showed an overall increase, from 0.284 to 0.471, increasing by 65.85%. The score of the social comprehensive evaluation function was higher than that of the economic comprehensive evaluation function, due to the promulgation and implementation of the *Social Pension Service System Construction Plan* (Central Government Portal of China, 2011) and the *National New Urbanization Plan* (Central Government Portal of China, 2014). The provinces along the SREB in China attached great importance to social development, optimized the allocation of public service resources and improved the public service capacity, social security system and social security service capacity. Indicators such as the per capita expenditure on the basic public services, the number of people covered by basic medical insurance, R&D expenditure accounted for a proportion of GDP have been increasing year by year, and economic development lagged social development.

The comprehensive evaluation function score of the socioeconomic subsystem in Chongqing was higher than those in other provinces, the economic growth, structural optimization and development quality were also higher. Overall, the score increased from 0.334 to 0.566, with the largest rate of increase of 69.46%. In 2009, cultural undertakings accounted for a proportion of fiscal expenditures, and the GDP ratio of financial revenue in Chongqing decreased, which lead to a decline in the comprehensive evaluation function score of the socioeconomic subsystem. However, as the local government increased its cultural investments, the score gradually rebounded and continued to increase (Cultural & Tourism Development Committee of Chongqing, 2017). The score of the comprehensive evaluation function of the socioeconomic subsystem in Sichuan was lower than that in Chongqing but higher than those of other provinces along the SREB in China, changing from 0.229 to 0.526, an increase of 129.69% over the study period. In Gansu and Yunnan, increases in the comprehensive evaluation function score of the socioeconomic subsystem were high in the provinces along the SREB in China, changing from 0.252 to 0.482 and 0.244 to 0.475, increases of 91.27% and 94.67%, respectively. Indicators such as the per capita expenditure on basic public services, the number of people covered by basic endowment insurance, per capita GDP, and the added value of the tertiary industry accounted for a proportion of GDP have increased. The comprehensive economic strengths and public service systems have been continuously improved. The comprehensive evaluation function score of the socioeconomic subsystem in Guangxi increased from 0.299 to 0.405, with a small increase of 35.45%. The socioeconomic comprehensive evaluation function scores of Shaanxi, Ningxia, Qinghai and Xinjiang increased by 51.77%, 56.96%, 60.41% and 69.12%, respectively, over the study period.

4.3. Results analysis of coupling coordination degree

The calculation results for the coupling coordination degree in the provinces along the SREB in China (Fig. 4) showed that the fluctuation between the ecological and socioeconomic subsystems was relatively small from 2005 to 2016. The coupling coordination degree generally increased from 0.699 to 0.759, while the coordination level improved from barely balanced to highly balanced. From 2005 to 2013, emphasizing development and neglecting protection lead to the improvement of socioeconomic development and the acceleration of ecological deterioration. This finding indicates that, the economy was extensive, and that ecological pressure increased steadily. The socioeconomic development improved faster than the ecological deterioration, and the coupling coordination degree increased continuously. From 2013 to

Table 6
The dynamic change of the comprehensive evaluation function score of the socioeconomic subsystem in the provinces along the SREB in China from 2005 to 2016.

Year		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Northwest	Shaanxi	0.311	0.301	0.348	0.363	0.389	0.423	0.458	0.479	0.487	0.480	0.487	0.472
	Gansu	0.252	0.241	0.272	0.310	0.326	0.357	0.401	0.438	0.452	0.462	0.467	0.482
	Qinghai	0.288	0.302	0.314	0.320	0.340	0.369	0.366	0.398	0.413	0.433	0.434	0.462
	Ningxia	0.309	0.317	0.335	0.367	0.363	0.384	0.407	0.429	0.431	0.445	0.469	0.485
	Xinjiang	0.285	0.273	0.286	0.321	0.337	0.366	0.402	0.453	0.462	0.473	0.482	0.482
Southwest	Chongqing	0.334	0.362	0.415	0.446	0.410	0.458	0.494	0.521	0.520	0.543	0.560	0.566
	Sichuan	0.299	0.308	0.334	0.312	0.365	0.401	0.438	0.470	0.475	0.486	0.510	0.526
	Yunnan	0.244	0.285	0.300	0.307	0.334	0.370	0.410	0.438	0.518	0.452	0.469	0.475
	Guangxi	0.299	0.306	0.306	0.307	0.346	0.357	0.354	0.394	0.406	0.408	0.365	0.405
The region		0.284	0.290	0.296	0.322	0.332	0.354	0.383	0.430	0.463	0.423	0.409	0.471

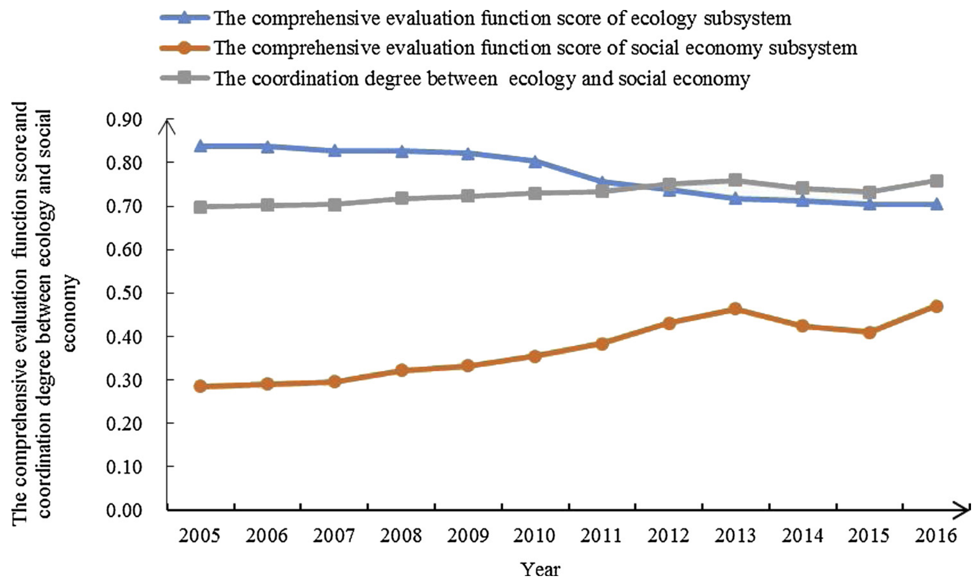

Fig. 4. The dynamic change of comprehensive evaluation function score and coordination degree between ecological and socioeconomic subsystems in the provinces along the SREB in China from 2005 to 2016.

2016, the socioeconomic development level was slightly lower than it was before, and the previously increasingly accelerated process of socioeconomic development was constrained by resources, causing the socioeconomic development to fluctuate. The construction of an ecological civilization has recently received increasing attention. With the slowing of ecological deterioration, the provinces along the SREB in China gradually embarked on the road of highly coordinated between ecological and socioeconomic development. Therefore, the deterioration of the ecological environment not only restricts the development of the social economy, but also profoundly affects the level of coordinated development (Xing et al., 2019).

The scores of the comprehensive evaluation function of the ecological and socioeconomic subsystems were calculated according to formula (7) and formula (8). According to the average values of the provinces for the ecological subsystem in 2005 and 2016, the coordinate axes were divided into four quadrants (Fig. 5). There were cross-quadrant fluctuations in only Qinghai, Yunnan, Guangxi and Gansu, among the provinces along the SREB in China. The Qinghai scores fluctuated from “high ecological and high socioeconomic scores” in 2005 to “low ecological and low socioeconomic scores” in 2016. The Yunnan scores fluctuated from “high ecological and low socioeconomic scores” in 2005 to “high ecological and high socioeconomic scores” in 2016. The Guangxi scores fluctuated from “low ecological and high socioeconomic scores” in 2005 to “high ecological and low socioeconomic scores” in 2016. In addition, the Gansu scores fluctuated from “high ecological and low socioeconomic scores” in 2005 to “high ecological and high socioeconomic scores” in 2016.

Due to the differences in resource endowment and socioeconomic

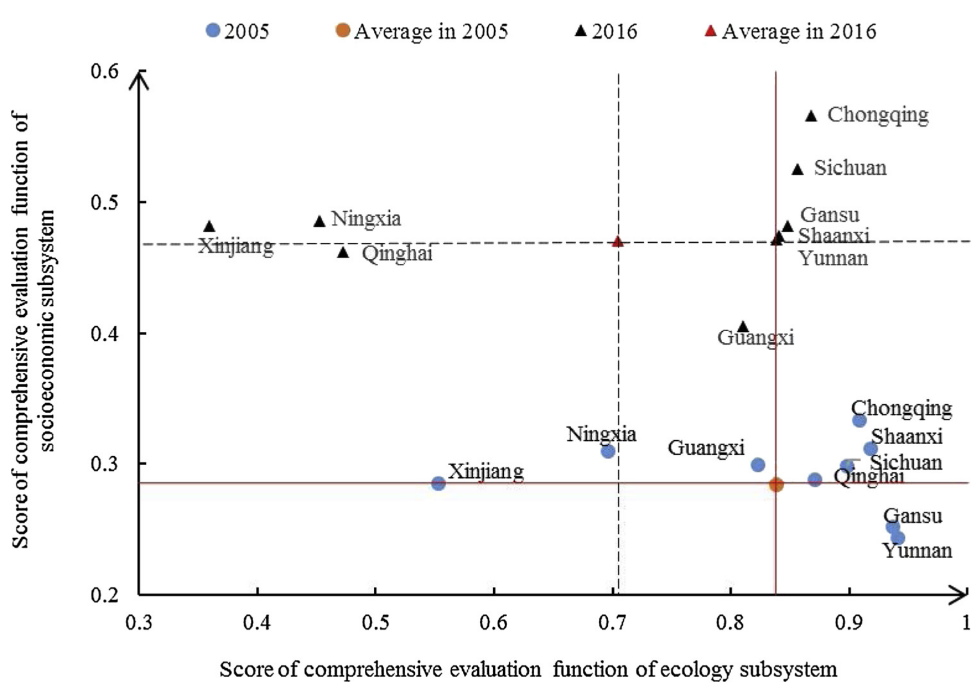

Fig. 5. The evaluation result of comprehensive evaluation function score of ecological and socioeconomic subsystems in the provinces along the SREB in China in 2005 and 2016.

Table 7
The coordination degree between ecological and socioeconomic subsystems in the provinces along the SREB in China from 2005 to 2016.

Year		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Northwest	Shaanxi	0.731	0.726	0.750	0.755	0.767	0.780	0.794	0.800	0.801	0.796	0.796	0.793
	Gansu	0.697	0.687	0.707	0.730	0.738	0.752	0.768	0.783	0.788	0.790	0.793	0.800
	Qinghai	0.707	0.714	0.716	0.716	0.726	0.741	0.681	0.688	0.691	0.699	0.677	0.684
	Ningxia	0.681	0.676	0.680	0.692	0.687	0.680	0.668	0.675	0.668	0.668	0.671	0.685
	Xinjiang	0.630	0.628	0.640	0.674	0.677	0.692	0.693	0.691	0.662	0.653	0.659	0.645
Southwest	Chongqing	0.742	0.758	0.783	0.796	0.778	0.799	0.811	0.822	0.818	0.827	0.833	0.837
	Sichuan	0.720	0.730	0.742	0.728	0.757	0.771	0.788	0.798	0.799	0.804	0.813	0.819
	Yunnan	0.692	0.717	0.729	0.732	0.747	0.756	0.770	0.779	0.811	0.784	0.792	0.795
	Guangxi	0.704	0.712	0.707	0.705	0.727	0.733	0.732	0.748	0.750	0.754	0.736	0.757
The region		0.699	0.702	0.704	0.718	0.723	0.730	0.734	0.751	0.759	0.741	0.733	0.759

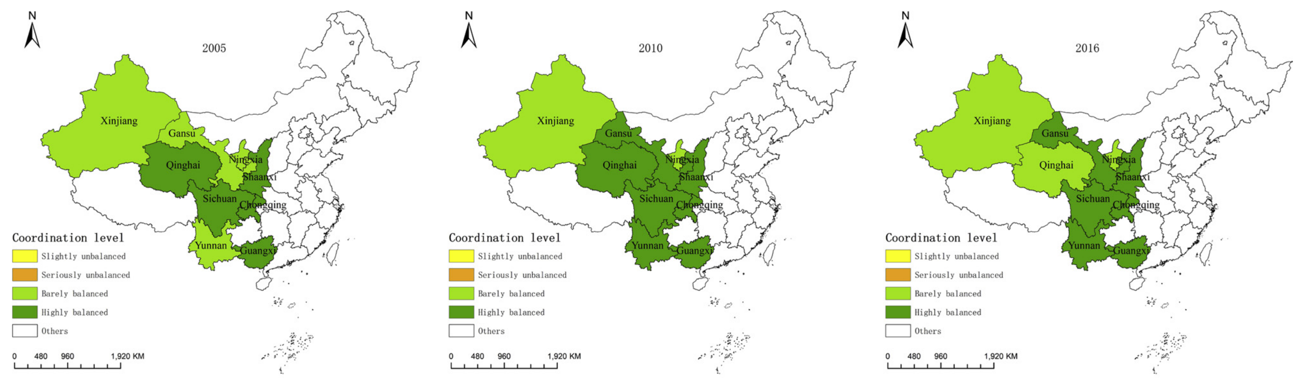

Fig. 6. The coordination degree between ecological and socioeconomic subsystems in the provinces along the SREB in China in 2005, 2010 and 2016.

development level in the provinces along the SREB in China from 2005 to 2016, the calculation results of the coupling coordination degree between ecological and socioeconomic development fluctuated (Table 7 and Fig. 6) but remained above 0.5. The coupling coordination level was barely balanced or better. The coupling coordination degree in Shaanxi, Chongqing, Sichuan and Guangxi increased by 8.46%, 12.82%, 13.83% and 7.49%, respectively. The coupling coordination degree always fluctuated within the interval (0.7,1], and the coordination level remained in a highly balanced state. The per capita ecological footprint of Shaanxi, Chongqing, Sichuan and Guangxi showed an overall increase, but the change was relatively slow. The ecological comprehensive evaluation function scores of these provinces in 2016 were reduced by 8.62%, 4.50%, 4.68% and 1.58%, respectively, compared with the conditions in 2005. With the increasing demand for an ecological environment, products based on biological resources, energy consumption and pollutant discharge, particularly the consumption of fossil energy (Sun et al., 2018), were the main drivers of the increase in the per capita ecological footprint. In the process of energy consumption, the provinces should promote the centralized use and clean utilization of coal, focus on reducing the proportion of non-electric coal. The comprehensive evaluation function scores of the socioeconomic subsystem in Shaanxi, Chongqing, Sichuan and Guangxi increased by 51.43%, 69.65%, 76.12% and 35.63%, respectively, to a highly balanced state. The continuous improvement of cultural education, social security and the quality of economic development continuously improved the level of socioeconomic development.

The coupling coordination degree between ecological and socioeconomic subsystems in Ningxia and Xinjiang increased from 0.681 to 0.685 and 0.630 to 0.645, respectively, fluctuating slightly but remaining within the range of (0.5,0.7] during the study period. The coordination level was barely balanced. The per capita ecological footprint in Ningxia and Xinjiang showed an overall increase, and the change was rapid. The comprehensive evaluation function scores for the ecological subsystem of these provinces were reduced by 35.04% and 34.93%, respectively. As the per capita ecological footprint of the biological resources and pollution discharge accounts increased, Ningxia and Xinjiang faced increased ecological pressure. The comprehensive evaluation function score of the socioeconomic subsystem in Ningxia and Xinjiang increased by 56.83% and 69.15%, respectively, putting them in a barely balanced state.

The coupling coordination degree between ecological and socioeconomic subsystems in Gansu and Yunnan increased by 14.76% and 14.87%, respectively. The results showed that the per capita ecological footprint of the two provinces increased slowly, and their comprehensive evaluation function scores decreased by 9.51% and 10.63%, respectively. The energy consumption account of Gansu and the biological resources account of Yunnan lead to the occupation of biologically productive land, thus leading to ecological and environmental problems. The comprehensive evaluation function score of the socioeconomic subsystem in Gansu and Yunnan increased by 91.56% and 94.82%, respectively. The improvement of the socioeconomic development in Gansu and Yunnan, especially the improvement of the social security level, which was characterized by the coverage rate of basic social insurance and the proportion of rural and urban residents who receive subsistence allowances, was faster than those of other provinces in the region. A good socioeconomic development system provided the foundation for optimizing the ecological environment and promoting the coordination level of Gansu and Yunnan. Gansu from a barely balanced level in 2005 to 2006 to a highly balanced level from 2007 to 2016. Yunnan from a barely balanced level in 2005 to a highly balanced level from 2006 to 2016.

Qinghai is the only province along the SREB in China where the coordination level has declined. The coordination degree between the ecological and socioeconomic subsystems in Qinghai decreased from 0.707 to 0.684, representing a cumulative decrease of 3.36%. The results showed that the per capita ecological footprint of Qinghai increased rapidly, while the comprehensive evaluation function score of the ecological subsystem decreased by 45.76%. The extensive industrial development in Qinghai has led to the increasing occupation of biologically productive land, leading to pollution discharge and increasing environmental pressure. The cumulative rate of increase in the socioeconomic comprehensive evaluation function score was 60.77%, with an average annual rate of increase of 4.04%. Qinghai has a good ecological foundation. However, due to environmental problems caused by an unreasonable industrial structure and extensive socioeconomic development, the coordination level in Qinghai has been reduced from highly balanced in 2005 to 2010 to barely balanced in 2011 to 2016.

China is a sponsor of the construction of the SREB and the "Belt and Road Initiative". In the "Belt and Road Initiative", the Chinese government advocates the coordinated ecological and socioeconomic development, and integrates ecological environmental protection into all aspects and processes of the "Belt and Road Initiative". In 2017, it proposed to promote the "Green Belt and Road Construction" (The State Council Information Office of the People's Republic of China, 2017). This showed that China has noticed the importance of promoting the coordinated development of ecological and socioeconomic subsystems. The provinces along the SREB in China will take the lead in coordinating ecological and socioeconomic development. Moreover, the calculation results of coupling coordination degree show that the coordinated ecological and socioeconomic development increased in general. This further confirmed the necessity of implementing the Green Belt and Road Construction policy.

5. Conclusion

Considering ecological footprint, the *CDI* and *Statistical Monitoring Scheme for Building a Well-off Society in an All-round Way* constructed the evaluation indicator system for coordinated ecological and socioeconomic development. By using the coupling coordination degree model, the ecological and socioeconomic conditions of the provinces along the SREB in China from 2005 to 2016 were evaluated. The spatial and temporal characteristics of the coordinated development between regional ecological and socioeconomic subsystems was analysed to reveal the problems existing in the ecological construction and socioeconomic development in the region.

The results showed that the ecological environment of the provinces along the SREB in China gradually deteriorated, especially in Xinjiang, Ningxia and Qinghai. The large consumption of fossil energy such as coal was the main reason for the decline in ecological quality. The socioeconomic development of the provinces along the SREB in China has been increasing rapidly. The degree of coordinated development between ecological and socioeconomic subsystems has gradually improved. However, the deterioration of the ecological environment will gradually play a restrictive role in the socioeconomic development, which will further curb the improvement of the coordinated development of the ecological and socioeconomic subsystems. The provinces should rely on the implementation of the "Belt and Road Initiative" and the "Green Belt and Road Construction", establish and improve the regional cooperation mechanism, adhere to the implementation of projects, and appropriately develop renewable energy industries and new energy sources. This is of great significance to the coordinated development of the ecological and socioeconomic subsystems in the provinces along the SREB in China.

It does not have raw data statistics of some indicators, such as the per capita expenditure of the basic public service, before 2005. Therefore, the period from 2005 to 2016 was chosen for the research. The study period used is relatively short. If a longer period can be adopted, it will more fully and comprehensively reflect the spatial and temporal evolution characteristics of the ecological environment and socioeconomic development.

Declarations of interest

None.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.scs.2019.101466.

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