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Eco-geographic Environment and Regional Development in Xinjiang of China

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Abstract: The study on relationship between eco-geographic environment (EGE) and regional development (RD) is of theoretical and practical significance to promote the comprehensive study on nature and human factors and regional coordination development. Based on the evaluation index system and models of EGE and RD, Quadrant Analysis Method (QAM) and the Coordination Degree and Coordinated Development Degree Model (CDCDDM) were applied to studying the relationship between EGE and RD in Xinjiang in this paper. The results show that Xinjiang can be divided into four type regions according to the relationship between EGE and RD, namely high coordination region (HCR), overloading development region (ODR), low coordination region (LCR) and potential development region (PDR). Most areas of Xinjiang belong to LCR which can not bear a larger population and support large-scale economic development. HCR, ODR and PDR, which are mainly distributed in piedmont oases and take basin as unit, should be focused on in the development of Xinjiang. The EGE has great influence on RD, and there is serious contradiction between them. Relevant suggestions on development strategies were put forward according to the character of different type regions, and the key regions of macro-layout of RD in Xinjiang were pointed out.

Keywords: eco-geographic environment; regional development; harmonious degree; Xinjiang

1 Introduction

In the regional social and economic development, as the material basis on which human socio-economic system depends and the important guarantee for realizing sustainable development, the eco-geographic environment (EGE) has been concerned continuously and extensively. However, due to the great diversity of geographical conditions in different regions, the high-speed development of social economy, rapid population growth and the increasing pressure on resources demands, together with the impact of widely unreasonable development and utilization of natural resources, the eco-geographic environments of many regions are constantly deteriorating and resources are exhausting. Fragile environment will, and has become an important factor to restrict the regional development (RD) in many regions. Therefore, since the 1990s, more and more scholars have identified the view of comprehensive regional system study in combination with natural and socio-economic factors (Huang, 1996; Zheng, 1999; Zheng *et al*., 2005). It is an important way and one of the important "national goals" of geography development to comprehensively understand the geographical bases of regional development of China, and reveal the functional mechanism and the coupling rules between geographical elements and regional development (Lu and Liu, 2003).

For studying the relationship between natural environment and regional development, the environmental carrying capacity and the sustainable development concepts were adopted to establish the models from the social economy and natural environments in foreign researches (Chaker *et al*., 2006; Kyushik *et al*., 2005; David, 1999; Grossman and Krueger, 1995; Munda, 2005; López-Ridaura *et al*., 2002). It was also the main method and was applied at county or province scales in

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domestic studies (Tang and Ye, 1998; Fu, 2000; Song and Cai, 2004). Based on the eco-geographic regionalization system proposed by Zheng (1999), Li and Guo (2007) adopted the partial certainty coefficient to characterize the "marginal contribution rate" of physio-geographical condition and its spatial pattern to the spatio-temporal differentiation of regional development. Overall, although the physio-geographical condition and its spatial pattern is one of the basic reasons for regional development differentiation, there is no effective analysis method to express and analyze it (Lu and Liu, 2000; 2003). And there is no efficient technology to realize the impact of physio-geographical pattern on the spatio-temporal differentiation of regional development, too (Lu and Cai, 2001). Therefore, the research on the relationship between eco-geographic environment and regional development is conducive to the in-depth interdisciplinary research of combining human geography with physical geography in theory, and it is of great significance to promote the harmonious development between nature and social economy in practice.

Xinjiang Uygur Autonomous Region (called Xinjiang for short) of China is a region with many ethnic minorities and being bounded by many foreign countries. Its socio-economic development is of vital importance to the implementation of common prosperity policies of all ethnic groups. The vast land, rich biological and mineral resources and the implementation of the western region development strategy have provided good foundation and opportunities for the development of Xinjiang. However, it is one of the regions with the extremely harsh natural conditions in China. Because of the importance of eco-geographic environmental harnessing and protection and the urgency of regional socio-economic development, it is of great theoretical significance and practical value to study the relationship between eco-geographic environment and regional development so as to promote the harmonious development of natural environment and social economy in Xinjiang.

2 Materials and Methods

2.1 Study area

Xinjiang is located in the hinterland of the Eurasian continent. Lying in Northwest China, it covers a huge area of 1.66×10^6 km^2, of which 49.5% was mountainous area, 28.0% plains and 22.5% deserts, occupying one-sixth of China's total territorial area and being larger than any other Chinese province or autonomous region. Xinjiang is characterized by its unique topography with an extremely large elevation range from −154 m in the Turfan Basin to 8 611 m at the summit of the Kunlun Mountains. The Altay Mountains and Kunlun Mountains lie in the north and the south of Xinjiang, respectively. The magnificent Tianshan Mountains, with an elevation of 3 000−5 000 m, stretches from east to west in the middle of the region, dividing Xinjiang into north and south sections. The Junggar Basin between the Tianshan Mountains and the Altay Mountains contains the Gurbantunggut Desert in the middle. The Tarim Basin is enclosed by the Tianshan Mountains and the Kunlun Mountains with the Taklimakan Desert in the middle (Fig. 1).

Situated deep in the interior of Asia and not penetrated by the air currents from the oceans, Xinjiang has conspicuous continental climate, with highly changeable temperature, sharp difference in temperature between day and night, abundant sunshine, intense evaporation and little precipitation. The mean annual temperature is 4℃−8℃ and 9℃−12℃ in the southern and northern Xinjiang, respectively. And mean annual precipitation is 25−100 mm and 100−500 mm in the two sections, respectively.

Subjected to the impact of temperature, water resources, elevation, topography and other geographical conditions, there are a series of serious natural or artificial ecological problems, such as the widely distributed gobi and desert, desertification, soil erosion, soil salinization, ecosystem degradation, shrink or even disappearance of rivers and lakes, soil fertility declining and so on, which are great pressure to the EGE of Xinjiang, and have constrained the regional development.

The GDP of Xinjiang was 349.442×10^9 yuan (RMB) in 2007. Taking price rise into account, it was 16.7 times that in 1978, with an annual growth rate of 10.4%. The per capita GDP rose to 16 860 yuan and ranked the 15th place in China in 2007. Xinjiang's industrial structure has been constantly adjusted and optimized. The primary, secondary and tertiary industries accounted for 17.9%, 46.6% and 35.5% of the GDP in 2007, respectively. Compared with 1978, the proportion of the output value of primary industry dropped by 17.9 percentage points, that of the secondary industry dropped by 0.4 percentage points, and that of the tertiary industry rose

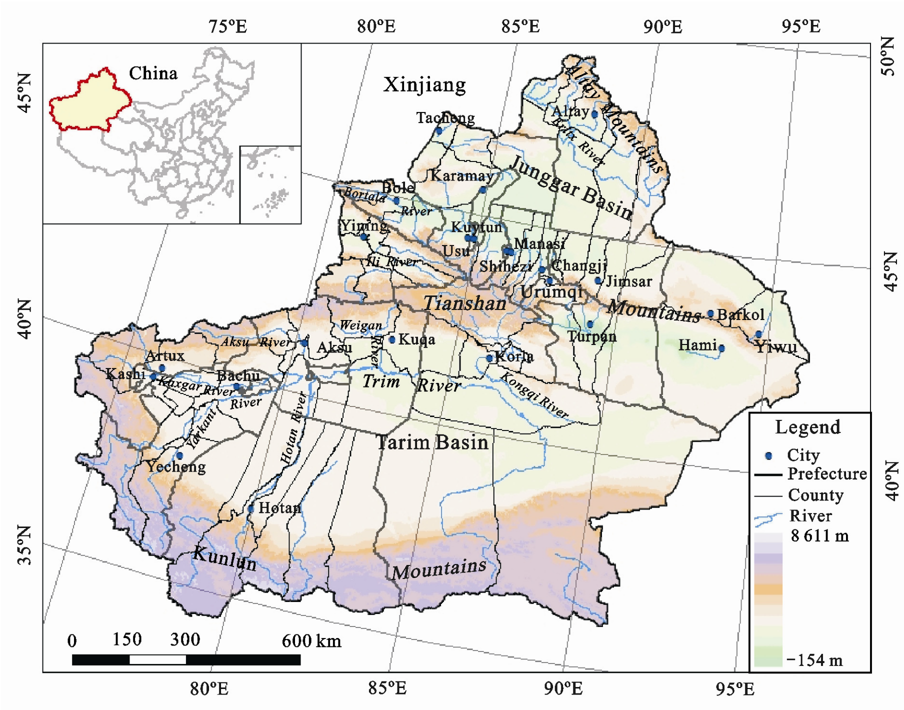


Fig. 1 Location and elevation map of Xingjiang

by 18.3 percentage points (Statistics Bureau of Xinjiang Uygur Autonomous Region, 2008).

2.2 Index system and data sources

The study on relationship between EGE and RD should firstly focus on the patterns of EGE and RD. The research on EGE pattern includes EGE background, ecosystem vulnerability and ecosystem services importance. Drawing on the theory and methods of Comprehensive Physical Regionalization (Yang *et al*., 2002; Zheng *et al*., 2008), four indexes of elevation, air temperature, water (a index integrated by dry-wet index and surface water), and relief amplitude were selected to analyze the basic pattern of eco-geographic conditions in the EGE background research. Five indexes including desertification, soil erosion, soil salinization, ecosystem degradation (calculated by Normal Differential Vegetation Index (NDVI) means of 1981–1990 and 1991–2000), gobi and desert distribution were chosen to study the ecosystem vulnerability (Liu, 1992; 1995). Four indexes of water conservation, windbreak and sand fixation, soil conservation and biodiversity conservation were selected to research the ecosystem services importance (Jia *et al*., 2005; Ministry of Environmental Protection and Chinese Academy of Sciences, 2008). For the study on RD pattern, the integrated measurement indexes were established with respect to population distribution and GDP distribution (Lu and Xu, 2002).

Soil salinization data came from Research Center for Eco-environmental Sciences, Chinese Academy of Sciences. The 1∶1 000 000 Vegetation Map of China came from Institute of Botany, Chinese Academy of Sciences. Data of elevation, temperature, desertification, soil erosion, the gobi and desert distribution, NDVI, landuse, population and GDP distribution came from Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences. These basic vector or raster data were transformed into 1 km^2 raster data with Albers Equal Area Conic. Longitude of central meridian was 105°E, and two standard parallels were 25°N and 47°N. And data of water, relief amplitude, ecosystem degradation, water conservation, windbreak and sand fixation, soil conservation and biodiversity conservation were calculated in this study.

2.3 Comprehensive assessment methods of indexes

Previous studies mainly adopted the Weight Analysis Method to integrate indicators (Su, 2001; Yang, 2006), i.e., setting different weights for different factors. However, due to the complexity and diversity of the natural background, a principal factor in a region may become a secondary factor in another region. For all regions, if the study on the regional differentiation with a fixed weight, it is difficult to accurately describe the features of natural background. In this paper, based on a comprehensive analysis, Principal Factor Method was employed to study the EGE pattern and Weight Analysis Method was adopted to study the RD pattern.

As for Principal Factor Method, the maximum value of all factors that affects the regional EGE is adopted as the final evaluation result. Through the comparative analysis, for Principal Factor Method, $\mathrm{Max}(X_1, X_2, \ldots, X_n) \geq X_i$, and for weight analysis method, $\mathrm{Min}(X_i) < \mathrm{Sum}(w_i X_i) < \mathrm{Max}(X_i)$, therefore, $\mathrm{Max}(X_1, X_2, \ldots, X_n) > \mathrm{Sum}(w_i X_i)$. In the equations above, X_i is the value of factor i, $\mathrm{Max}(X_1, X_2, \ldots, X_n)$ is the result of Principal Factor Method, $\mathrm{Sum}(w_i X_i)$ is the result of Weight Analysis Method, w_i is the weight of factor i, $\mathrm{Min}(X_i)$ is the minimum value, and $\mathrm{Max}(X_i)$ is the maximum value. The results of Principal Factor Method are larger than those of Weight Analysis Method. Therefore, the Principal Factor Method can better reflect the natural features of regions, which is more suitable to the EGE study.

The study on the RD pattern should reflect the overall pattern of regional economy and social development under the impact of EGE. Through the analysis of the interrelationship between population and GDP and the factors influencing GDP, it is believed that 1) human beings is the first factor in the RD. GDP occurs in the regions where human productive activities exist; 2) regional GDP is decided by the human beings, such as population quantity, population quality, *etc*.; 3) in addition to the impact of EGE, the development of regional GDP is affected by regional resources conditions, location factors and state policies to a large extent; and 4) the development of regional economy has a great impact on the population aggregation, however, EGE plays a decisive role in the macro pattern of population distribution. Therefore, the population distribution can better reflect the influence of regional EGE on the regional development pattern. In this paper, Analytical Hierarchy Process (AHP) method was adopted, and the weights of population distribution and GDP distribution were 0.7 and 0.3, respectively.

2.4 Methods to study relationship between EGE and RD

The Quadrant Analysis Method (QAM) and the Coordination Degree and Coordinated Development Degree model (CDCDDM) were adopted to validate and improve the reliability of the study results in this paper.

2.4.1 Quadrant Analysis Method

In Quadrant Analysis Method (Chen *et al*., 2009), based on the basic concept of four quadrants division according to the two-dimensional Cartesian coordinate system, by setting the standard of EGE and RD as the origin, the relationship between EGE and RD is divided into four types of regions: the first quadrant is high coordination region (HCR) where the EGE and RD status are higher than the standard level, which is the main region for current development; the second quadrant is overloading development region (ODR) where EGE status is lower than the standard level, but RD status is higher than the standard level, which is need to be adjusted; the third quadrant is low coordination region (LCR) where the EGE and RD status are both lower than the standard level, which is required to focus on the harnessing and protection of EGE; the fourth quadrant is potential development region (PDR) where the EGE status is higher than the standard level, while the development level is lower than the standard level, which can be developed properly.

The data standardization of QAM adopts the sampling standard deviation method:

$$Z = (x_i - \overline{x})/S \tag{1}$$

where Z is standardization value, x_i is sample value, $\overline{x}$ is the sample mean, and S is the sampling standard deviation. According to the relationship between EGE and RD, the standardization data are corresponding divided into HCR, ODR, LCR and PDR.

2.4.2 Coordination Degree and Coordinated Development Degree Model

Coordination refers to inter-system or intra-system harmony, which can lead a system or elements to have more and more harmonious relationship (Yang, 1997). Coordinated development is a deepening process of the coordinated system or intra-system elements from low level to high level, from simplicity to complexity and from disorder to order. It is a comprehensive development of multi-systems or elements under the beneficial restriction of coordination (Yang, 1997). Therefore, the coordination degree between EGE and RD is a measurement of the coordinated state between EGE and RD. The coordinated development degree between EGE and RD is a quantitative indicator for measuring the regional EGE and regional socio-economic coordinated development, representing the overall function or development level of regional EGE and regional socio-economy.

The calculation model of the coordination degree between EGE and RD is (Yang, 1997):

$$Cv = \left(\frac{4 \times E_i \times D_i}{(E_i + D_i)^2} \right)^n \tag{2}$$

where Cv is coordination degree, E_i is EGE value, D_i is RD value, n is the adjustment coefficient, $n \geq 2$. In this paper, to increase the distinction of the coordination degree, the value of n is 3. As indicated by calculation model, $0 \leq Cv \leq 1$, the greater the value of Cv, the better the coordination state. Otherwise, the coordination state is poorer.

In order to reflect the RD level, the coordinated development degree (H) model is introduced to evaluate and compare EGE and regional coordinated development state (Wu, 1999).

$$H = \sqrt{Cv \times I \times P(D_i / E_i)} \tag{3}$$

$$I = aE_i + bD_i \tag{4}$$

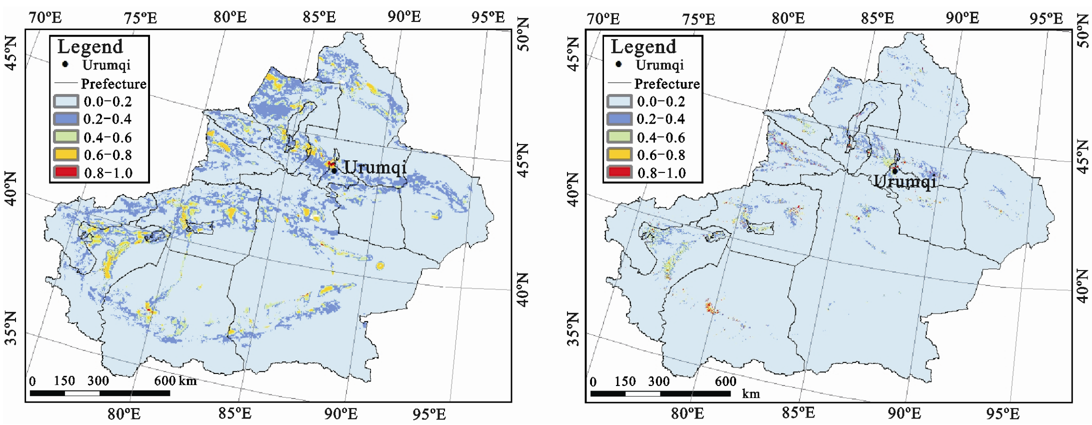
where H is coordinated development degree, I is the comprehensive evaluation index of EGE and RD level, a and b are the weights of EGE and RD to be determined. Because EGE and RD are equally important, the values of a and b are both 0.5. $P(D_i/E_i)$ is the development level discriminant function, which is introduced to amend the regional development level. When $D_i/E_i \geq 1$, $P(D_i/E_i)=1$; and when $D_i/E_i \leq 1$, $P(D_i/E_i)=D_i/E_i$. Coordination degree and coordinated development degree are respectively classified into two types according to the value of 0–0.5 and 0.5–1.0, i.e. uncoordinated development and coordinated development for coordination degree, and low development level and high development level for coordinated development degree. The type combinations under this model and the type regions under the QAM have the following correspondence: 1) coordinated development with high development level, i.e., HCR; 2) uncoordinated development with high development level, i.e., ODR; 3) coordinated development with low development level, i.e., LCR; 4) uncoordinated development with low development level, i.e., PDR.

3 Results and Analyses

3.1 EGE and RD patterns

3.1.1 EGE pattern

The higher the EGE value, the better the status of EGE. According to Fig. 2a and data analysis, the overall state of the EGE in Xinjiang is poor. Mere 28 264 km^2 of land has an EGE value of >0.6, accounting for 1.74% (based on the statistical area of 1 625 068 km^2), which are mainly distributed in piedmont oases in strip- and belt-shape and take basin as unit. The area with EGE value being 0 is 1 043 147 km^2, representing 64.19%, which are mainly distributed in mountainous areas and extremely arid gobi and desert areas. A total area of 553 657 km^2 mainly making up rivers and lakes have an EGE value of >0 and ≤0.6, accounting for 34.07%, which are scattered on plains surrounding the piedmont oases in a stripped and banded form.



(a) EGE pattern

(b) RD pattern

Fig. 2 EGE pattern and RD pattern in Xinjiang

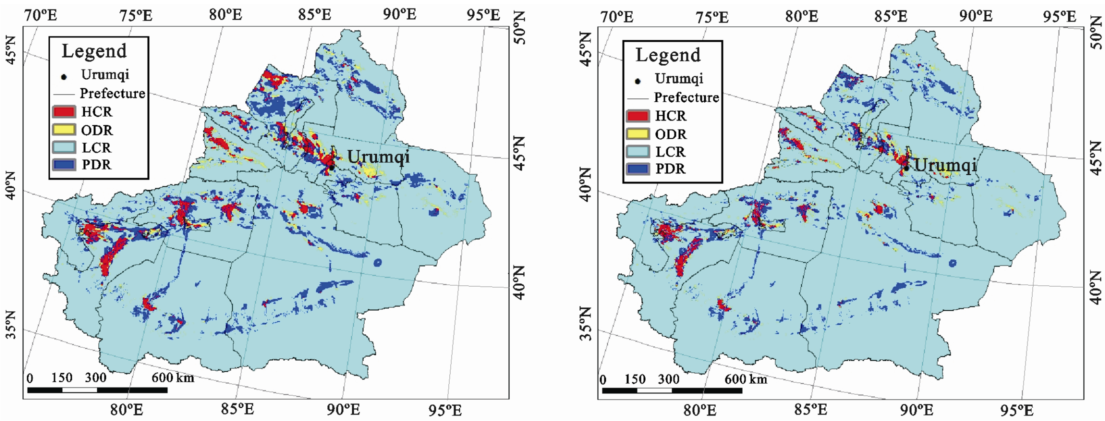
3.1.2 RD pattern

The higher the RD value, the better the RD level. According to Fig. 2b and data analysis, the overall level of RD is extremely low in Xinjiang. The area with RD value greater than 0.4 totals 29 576 km^2, accounting for only 1.82% (based on the statistical area of 1 630 394 km^2), which are mainly distributed in piedmont oases and take basin as unit. The area with a value less than or equal to 0.4 is 1 600 818 km^2 in total, accounting for 98.18%, of which 1 293 837 km^2 are the area with no distribution of population and GDP, predominantly being mountainous areas and the water-short deserts and Gobi.

3.2 QAM analysis on relationship between EGE and RD

As seen from the type regions under the QAM (Fig. 3a), HCR presents a banded distribution taking city as core and basin as unit. ODR, basically distributed in the periphery of HCR, presents a banded distribution taking basin as unit, and radiated to the urban periphery, where the overall trend is consistent with HCR. LCR is the main body on relationship between EGE and RD, which is widely distributed in mountainous areas, desert areas and Gobi areas. PDR is fundamentally distributed in the areas where major rivers pass through.

The ratio of EGE to RD reflects the degree of the supporting role of EGE on the RD. In terms of EGE value, RD value and their ratio, for HCR, they are 0.30–0.90, 0.40–1.00 and 0.30–2.50, respectively; for ODR, the values are 0–0.30, 0.30–1.00 and 0–0.96, respectively; for LCR, the values are 0–0.30, 0–0.14 and 0–∞, respectively; and for PDR, they are 0.30–1.00, 0–0.15 and 2.20–∞, respectively.



(a) Type regions under QAM

(b) Type regions under CDCDDM

Fig. 3 Relationship between EGE and RD under QAM and CDCDDM

3.3 CDCCDM analysis on relationship between EGE and RD

The distribution of type regions under the CDCCDM (Fig. 3b) is essentially consistent with that under the QAM, but the areas of HCR, ODR, and PDR are less than, while the area of LCR is greater than the corresponding areas as calculated under the QAM.

In terms of the distribution of the EGE value, RD value and their ratio, for HCR, the values are 0.30–0.90, 0.40–1.00 and 0.50–1.90, respectively; for ODR, they are 0–0.55, 0.45–1.00 and 0–0.67, respectively; for LCR, the values are 0–0.40, 0–0.30 and 0–∞, respectively. And for PDR, they are 0.30–1.00, 0–0.45 and 1.30–∞, respectively.

3.4 Type regions division

3.4.1 Same type regions under two methods

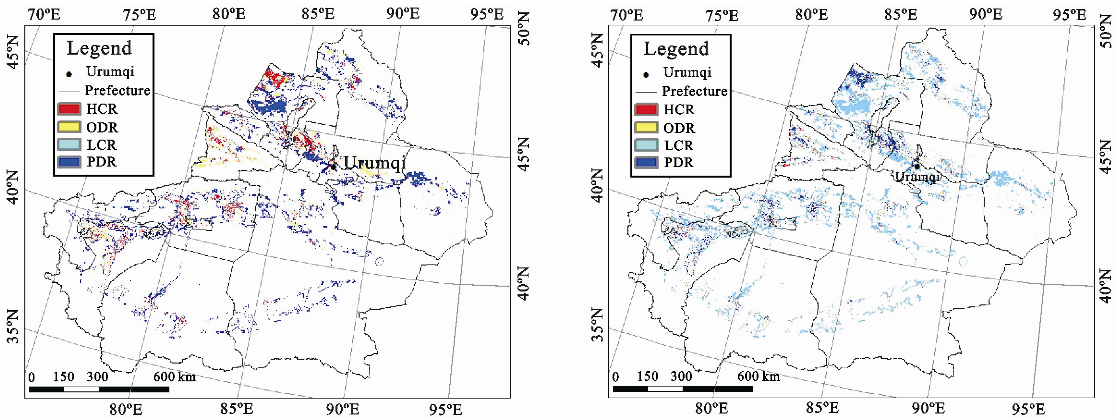
A comprehensive analysis on the results of the QAM and the CDCCDM reveals that in the macroscopic pattern of the relationship between EGE and RD, HCR is distributed in the banded area taking city as core and basin as unit; ODR has a relatively small area and is distributed in the surrounding areas of cities; LCR form the main body of the relationship between EGE and RD in Xinjiang, mainly distributed in mountainous areas, desert areas and gobi areas; PDR is basically distributed in a ring form on the desert edge and the piedmont areas of the Tarim Basin and the Junggar Basin. Statistics shows that there is a common area of 1 529 841 km^2 for the both methods, accounting for 93.81% (based on the statistical area of 1 630 818 km^2), of which, the areas of HCR, ODR, LCR and PDR are 30 400 km^2, 18 648 km^2, 1 421 713 km^2 and 59 080 km^2, respectively, accounting for 1.86%, 1.14%, 87.18% and 3.62%, respectively.

3.4.2 Different type regions under two methods

The results by two methods show that the total different area is 100 977 km^2, accounting for 6.19%. The differential regions include HCR, ODR and PDR under the QAM (Fig. 4a). In terms of the CDCDDM, they comprise of HCR, ODR, LCR and PDR (Fig. 4b).

Starting from three different type regions under the QAM, the corresponding type regions under the CDCDDM are discriminated.

(1) HCR under the QAM. HCR under the QAM corresponds to the type regions of ODR, LCR and PDR under the CDCDDM. For the ODR, EGE value, RD value and their ratio are 0.30–0.55, 0.45–1.00 and 1.50–3.40, respectively. The RD level is noticeably higher than EGE value, thus it is reasonable to recognize the region as ODR under the CDCDDM. As for the LCR, they are 0.30–0.40, 0.10–0.20 and 1.50–3.00, respectively, representing relatively poor EGE conditions with an extremely low development level. Despite the ratio between them is relatively large, this type region has a lower bearing capacity, therefore, it is appropriate to classify the region as LCD under the CDCDDM. For PDR, the values are 0.30–1.00, 0.20–0.45 and 1.30–4.00, respectively. This region has certain economic base and a greater capacity of EGE and should be appropriately classified as PDR under the CDCDDM.



(a) Under QAM (b) Under CDCDDM

Fig. 4 Different type regions between two methods

(2) ODR under the QAM. ODR under the QAM corresponds to the type regions of HCR and LCR under the CDCDDM. As to HCR, EGE value, RD value and their ratio are 0.20–0.45, 0.20–3.00 and 0.60–1.50, respectively. This region has relatively poor EGE conditions, low RD level and less development potential, so it should be classified as LCR rather than ODR under the QAM or HCR under the CDCDDM. As for LCR, the values are 0–0.30, 0.15–0.30 and 0–2.10, respectively. This region has relatively poor EGE conditions and low RD level as well as less development potential, therefore it is rational to classify it as LCR under the CDCDDM.

(3) PDR under the QAM. PDR under the QAM only corresponds to LCR under the CDCDDM. The EGE value, RD value and their ratio of LCD are 0.30–0.40, 0–0.15 and 2.20–∞, respectively, indicating that the region has relatively poor EGE, low RD level and less development potential, hence it is appropriate to classify it as LCR under the CDCDDM.

We can find that, through type recognition on the different type regions, except for an area of 5 144 km^2 in ODR under the QAM, being HCR under the CDCDDM, which is finally identified as LCR, all of the other regions are identified as the corresponding type regions under the CDCDDM (Table 1).

3.4.3 Relationship between EGE and RD in Xinjiang

Through above analysis, we can draw some conclusions on the relationship between EGE and RD as follows (Fig. 5, Table 2).

(1) HCR: The area of HCR is 30 400 km^2, accounting for 1.86% (based on the statistical area of 1 630 690 km^2). HCR shows a distinctive strip and belt-shaped dis-

Table 1 Determination of different type regions under QAM and CDCDDM

QAM			CDCDDM			Determined type
Type region	Area (km^2)	Percent (%)	Type region	Area (km^2)	Percent (%)	
HCR	18941	1.16	ODR	2565	0.16	ODR
			LCR	1854	0.11	LCR
			PDR	14522	0.89	PDR
ODR	13699	0.84	HCR	5144	0.32	LCR
			LCR	8555	0.52	LCR
PDR	68337	4.19	LCR	68337	4.19	LCR
Total	100977	6.19	Total	100977	6.19	

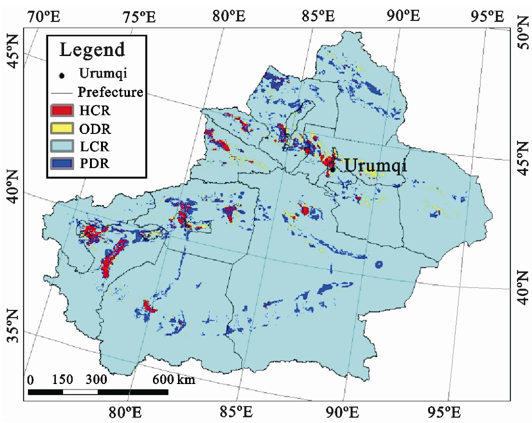


Fig. 5 Relationship between EGE and RD in Xinjiang

Table 2 Type regions of relationship between EGE and RD in Xinjiang

Type region	Area (km^2)	Percent (%)
HCR	30400	1.86
ODR	21204	1.30
LCR	1 505483	92.33
PDR	73603	4.51

tribution taking city as the core and basin as the unit with an obvious trend to concentrate toward the piedmont plain in the middle and western Tianshan Mountains. The relatively concentrated regions include Urumqi, Changji, Shihezi, Kuytun and Karamay, the Bortala River Basin along Jinghe to Bole to Usu, the Ili River Basin, the Konqi River Basin in the periphery of Korla, the Weigan River Basin in the periphery of Kuqa, the Aksu River Basin and the Tarim River Basin in the periphery of Aksu, the Kaxgar River Basin in the periphery of Kashi, the Yarkant River Basin along Yecheng to Bachu and the Hotan River Basin in Hotan, *etc*.

(2) ODR: The area of ODR is 21 204 km^2, accounting for 1.30%. ODR radiates in a strip and belt shape from cities and takes basin as unit, with an overall distribution trend consistent with HCR. It is basically distributed around HCR and concentrates on the southern edge of Junggar Basin, especially the desert edges along Jimsar to Manas, with some in the Eritx River Basin, Tacheng, Hami and Barkol.

(3) LCR: The area of LCR is 1 505 483 km^2, accounting for 92.33%. LCR is the most widely distributed type region in Xinjiang. By and large, the mountains, desert areas and gobi areas in Xinjiang belong to LCR.

(4) PDR: The area of PDR is 73 603 km^2, accounting for 4.51%. PDR is principally distributed in river basins. The most part are located in the Eritx River Basin, the river basins in northern Tianshan Mountains, the northern and southern margin areas of the Tarim River Basin, and some in Hami, Barkol and Yiwu.

4 Conclusions and Discussion

(1) In combination of the QAM and the CDCDDM, Xinjiang can be divided into four type regions by the relationship between EGE and RD, namely HCR, ODR, LCR and PDR. Most areas of Xinjiang belong to LCR, which can not bear a large population or large-scale economic development activities. HCR, ODR and PDR are remarkably distributed in piedmont oases and take basin as unit, which should be the focus in the development of Xinjiang.

(2) The EGE of Xinjiang has important influence on its RD, and there is serious contradiction between them. Most population and GDP of Xinjiang are distributed in HCR and ODR with a total area of 51 604 km^2, being the main regions of current development. ODR of Xinjiang, accounting for 41.09% of Xinjiang′s main regions

of current development, shows a sharp contradiction between EGE and RD. Therefore, it is necessary to utilize the limited resources and unfavorable environment rationally and to avoid the adverse factors while harnessing and protecting EGE for promoting the harmonious co-development of the nature and the society.

(3) Relevant suggestions on development strategies are put forward according to the characteristics of each type region: to enhance the competitiveness of HCR through upgrading and restructuring of industries; to focus the development of ODR on transferring and upgrading the industrial structure with no large-scale development activities, which will have a greater impact on the EGE; to appropriately develop soil and water resources in PDR, capitalized on its relatively higher ecological capacity and the advantageous soil and water resources; to focus the development of LCR on the ecosystem harnessing and protection with no large-scale development activities.

(4) As for the macro layout, key regions of development in Xinjiang are the Eritx River Basin, Northern Tianshan Mountains Economic Belt, Tacheng Basin, the Bortala River Basin, the Ili River Basin, the Tarim River Basin, the Konqi River Basin, the Weigan River Basin, the Aksu River Basin, the Kaxgar River Basin, the Yarkant River Basin and the Hotan Rive Basin.

In an attempt to link the nature with human beings in this paper, eco-geographic environment background, ecosystem vulnerability and ecosystem services importance are combined in the research of the pattern of EGE. However, data, indices and research methods still need to be improved in the future. The research on RD pattern is restricted by 1 km^2 raster data, only taking population and GDP into account, so it further needs to be perfected. In addition, the research methods for the relationship between EGE and RD also need further study.

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