

Spatio-temporal evolution data mining between urban population and urban land in China

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Abstract. The purpose of this study is to data mining for urbanization, evaluate the matching of urban population - land in China from the perspective of temporal sequence and spatial pattern, and put forward some suggestions on optimization of population and land area. By constructing the regional spatial matching evaluation model and regional comprehensive mismatch degree evaluation model, use the 2005-2014 China provincial urban population - land panel data, and evaluate the matching types and grades of urban population - land in China from the provincial scales, then using GIS technology to analysis the provincial urban population - land spatial characteristics. Results show that urban population - land comprehensive in Eastern China shows a fluctuating state, and central and western China are relatively stable since 2005; urban population - land comprehensive spatial matching degree of eastern China is the highest, central China follows, western China is the lowest, according to matching level spatial distribution characteristics, relative matching type of provincial accounted for a relatively small proportion, generally concentrated in eastern and central China, proportion of low mismatch type provincial is the largest, and basic maintenance is around 17 provinces, high mismatch type provincial proportion is the smallest, usually no more than two and located in the western region. Therefore, facing spatial matching problem of urban population - land in China, we should gradually build urban population - land spatial matching evaluation mechanism, reasonably evaluate types and grades of regional urban population - land spatial matching, formulate differentiated policy for population - land management, optimize spatial allocation of urban population - land, and focus on connotation of urban population - land spatial equilibrium, to build a harmonious relationship between people and land.

1. Introduction

Since the 1990s, China has gained rapid development in urbanization. Especially, since 1996, China's urbanization rate has gained rapid growth at an average annual rate of 1.37%. Under the great motive power of urbanization, economy has developed rapidly and people's living standard has improved significantly. Meanwhile, behind the positive significance of urbanization, the concurrent resource and



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environmental problems shall not be neglected [1]. On the one hand, urban space is crowded, traffic jams and the environment has become increasingly degenerated [2]. On the other, urban land is left unused and wasted, and resources are used inefficiently [3]. All these problems are significantly correlated to the match ability between urban population and land space.

Through literature analysis, the research on urbanization is mainly focused on impacts of urbanization on land use / cover change [4, 5], smart growth, effects of urbanization on climate change [6], Land use change [7], etc. Some research focus on coordination between population urbanization and land urbanization. For instance, Chen F (2010), Fan J and Zhao D (2012), Li X (2012), Li M et al. (2012), Cao W et al. (2012), Zhang G and Cui X (2013), Wu W et al. (2013), Yin H and Cu T (2013) have successively established and adopted coordinated development degree method, coordination index method, TOPSIS comprehensive evaluation method, correlation and regression analysis method, coordination coefficient method, coupling analysis method, Logistic regression model, and coefficient of dispersion method to research the coordination between population urbanization and land urbanization [8-15].

Most scholars believe that, there is the discordant problem between population urbanization and land urbanization, and there are excessive problems in land urbanization. The above research is of great significance for judging the growth rate of population and land in the process of urbanization and realizing the harmonious development between the two. However, there remains space for further research: the benign interactive development relationship between urban population and urban land can not only be confined to the development speed of the two and the harmonious development, more attention shall be paid to the spatial match ability between the two at the inferior region. Otherwise, even if coordinated growth is realized between the two, there remains the problem of space disequilibrium, giving rise to problems, such as concurrence of the crowded urban space and inefficiency land use, and idleness and waste of land.

Based on the above considerations, this research aims to evaluate and judge the spatial match ability between urban population and urban land from the provincial dimension, through building spatial match ability evaluation model, with the provincial panel data of 2005-2014, so as to find the problems lying in the spatial match ability of urban population-land, and come up with the policy suggestions for the configuration of land utilization.

2. Model building and data sources

2.1. Evaluation model of regional spatial match ability

The evaluation model of spatial match ability is built by referring to the existing spatial match ability research [16] and the existing spatial agglomeration computing method, depicting the coordination relationship between population and land in the system of urbanization based on the density degree of urban population and land in space. Therefore, the evaluation model of spatial match ability between urban population and land constructed shall be:

$$Match_i = (Pop_i / \sum_{i=1}^n Pop_i) * (Land_i / \sum_{i=1}^n Land_i)^{-1} - 1 \quad (1)$$

Where, $Match_i$ is the spatial mismatch degree of the i th region, Pop_i and $Land_i$ are the evaluating value of the urban population and urban land of the i th region, and urban land adopts the data of the built-up area. The absolute value of $Match_i$ has revealed the spatial matching degree between urban population and urban land. By analyzing the spatial matching model, we know $abs(Match_i) \in [0, +\infty)$. When the value of $abs(Match_i)$ is gradually increasing, the spatial match ability between urban population and land tends to be weakened. Namely, urban population and urban land of such region present the state of incompatibility in the spatial dimension; when $abs(Match_i)$ decreases gradually, it means that spatial match ability between urban population

and urban land of this region tends to be enhanced, and urban population and urban land of this region present relatively good correlated state in the spatial dimension.

According to the symbol $Match_i$, type of spatial match ability between urban population and land can be classified into “urban population concentration type” and “urban land concentration type”. When $Match_i > 0$, it means that, compared with urban land, urban population of this region is more concentrated, namely, it belongs to “urban population concentration type”; when $Match_i < 0$, it means that, compared with urban population, urban land of this region is more concentrated, namely, it belongs to “urban land concentration type”; when $Match_i = 0$, the population is totally matched with the land. Therefore, the zero value line is the standard line for judging the space matching degree. If the absolute value of the spatial mismatch degree of a region is gradually approaching to the zero value line, the space matching degree of such region will be enhanced continuously; otherwise, the space matching degree of such region will be weakened continuously. Since there are numerous factors affecting the spatial matching relationship between urban population and land in real life, it is quite difficult to realize the complete matching between urban population and urban land. Therefore, complete matching between urban population and land is only the ideal state. In the practice of space matching between urban population and land, we can only take certain measures to enable the spatial match ability between urban population and land to be enhanced, and head for a good “population-land” matching state.

To judge the spatial matching degree between urban population and land, type of spatial match ability between urban population and land is classified into “relatively matching type”, “low mismatching type”, “moderate mismatching type” and “high mismatching type” with the equally spaced method, according to the value range of the evaluation model for space match ability and the evaluation result interval. For the specific classification methods, please see Table 1.

Table 1. Spatial matching type and grade division of urban population-land.

Spatial matching type	Spatial matching degree	Value interval
urban land concentration type	high mismatching	$Match < -0.5$
urban land concentration type	moderate mismatching	$-0.5 \leq Match < -0.3$
urban land concentration type	low mismatching	$-0.3 \leq Match < -0.1$
Population-land relative matching type	relatively matching	$-0.1 \leq Match < 0.1$
urban population concentration type	low mismatching	$0.1 \leq Match < 0.3$
urban population concentration type	moderate mismatching	$0.3 \leq Match < 0.5$
urban population concentration type	high mismatching	$Match \geq 0.5$

2.2. Evaluation model for regional comprehensive mismatch degree

Based on the above spatial matching model for urban population-land, evaluation model of regional comprehensive mismatch degree is defined below:

$$Zmatch = \left[\left(\sum_{i=1}^n Match_i^2 \right) / n \right]^{1/2} \quad (2)$$

$Zmatch$ Is the comprehensive mismatch degree between urban population and land of the superior region? $Match_i$ Is the comprehensive mismatch degree between urban population and land of the

inferior region? Regional comprehensive mismatch degree is the comprehensive measurement of the mismatch degree between urban population and land of the inferior region included by the superior region, $Z_{match} \in [0, +\infty)$. The greater the value of Z_{match} , the higher the comprehensive mismatch degree of such superior region will be, and more unbalanced the spatial distribution between urban population and land of such region will be.

2.3. Data sources

The research intends to take China's 31 provinces as the research objects. Since data are not available temporarily, Hong Kong, Macao and Taiwan are temporarily not included, and the data are originated from China Statistical Yearbook (2006-2015). As statistical data of the built-up area of Beijing in 2010 and built-up area of Shanghai in 2008 and 2009 are missing, considering the consistency of continuity of quantitative analysis with statistical caliber, the missing data are supplemented respectively with averaging method and trend extending method.

3. Results and discussion

3.1. Temporal evolution analysis of spatial match ability between urban population and land

The research on spatial matching degree between China's urban population and land is developed respectively from the time and spatial dimension, and mainly focuses on the analysis of temporal evolution and spatial pattern of spatial matching. The research takes the provincial panel data of 2006-2014 as the evaluation basis, and adopts regional spatial matching evaluation model to estimate the spatial mismatch degree between China's urban population and land at the provincial level. For the result of estimation, please see Table 2.

To observe the temporal evolution trend of spatial matching between urban population and land, evaluation results of the model are marked on the broken line graph, as is shown in Figure 1; according to the figure, we know that: Hebei, Shanghai, Fujian, Tianjin and Hainan in Eastern China belong to urban population concentration type; Beijing, Liaoning, Jiangsu, Zhejiang, Shandong and Guangdong belong to urban land concentration type; Shanxi, Anhui, Jiangxi, Henan, Hubei and Hunan in Central China belong to urban population concentration type; Jilin and Heilongjiang belong to urban land concentration type; Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi and Qinghai in Western China belong to urban population concentration type; Inner Mongolia, Tibet, Gansu, Ningxia and Xinjiang belong to urban land concentration type.

By observing the temporal evolution trend of spatial matching between urban population and land of specific provinces, we know that, since 2005, spatial mismatch degree of Beijing is gradually approaching to 0, indicating that space matching degree between urban population and land of Beijing is improving year by year, and spatial matching between population and land is gradually enhanced; spatial mismatch degree of Liaoning hovers around -0.2, with relatively stable spatial matching, whose type of spatial matching belongs to low mismatching and land concentration type; spatial mismatch degree between urban population and land of Jiangsu Province has lowered from -0.0814 in 2005 to -0.1474, with relatively small amplitude of change in 10 years, and the spatial matching type has evolved from the relatively matching type to low mismatching type. For the evolution trend of spatial non-matching between urban population and land of other provinces, please see Figure 1.

To observe the temporal evolution of comprehensive spatial mismatch degree between China's urban population and land from 2005 to 2014 in a further way, provincial spatial mismatch data were entered into the evaluation model for comprehensive mismatch degree between urban population and land, and comprehensive mismatch degree between China's urban population and land as well as the regionalized comprehensive mismatch degree from 2005 to 2014 are obtained. Since 2005, comprehensive mismatch degree between urban population and land of the Western Region presents the fluctuating state, while it is relatively stable for the Central and Eastern Region. By comparing the comprehensive spatial mismatch degree between urban population and land of the Eastern, Central and Western Region, you can find out that, comprehensive spatial mismatch degree between urban

population and land of the Eastern Region is lowest, which is kept around 0.19; and the Central Region is kept around 0.22; and highest for the Western Region, which is kept around 0.34. Therefore, spatial match degree between urban population and land is featured by highest for the Eastern Region, followed by the Central Region and lowest for the Western Region.

Table 2. Urban population -land space mismatch in China (2006-2014).

Region	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Beijing	-0.3752	-0.3799	-0.3619	-0.3355	-0.3163	-0.1952	-0.1110	-0.1002	-0.0904	-0.1147
Tianjin	-0.1373	-0.1206	-0.1123	-0.1422	-0.1052	-0.0730	-0.0343	0.0152	0.0520	0.0337
Hebei	0.1445	0.0915	0.1305	0.1599	0.1861	0.2171	0.2331	0.2477	0.2856	0.3117
Shanxi	0.1616	0.1538	0.1502	0.1883	0.1846	0.2231	0.1735	0.1614	0.1937	0.1804
Inner Mongolia	-0.2024	-0.1807	-0.1891	-0.1467	-0.1801	-0.1862	-0.1793	-0.1926	-0.2084	-0.1691
Liaoning	-0.1874	-0.2097	-0.2091	-0.1979	-0.2059	-0.2465	-0.2242	-0.2130	-0.2041	-0.1975
Jilin	-0.1168	-0.1696	-0.1773	-0.2242	-0.2427	-0.2707	-0.2733	-0.2738	-0.2775	-0.2689
Heilongjiang	-0.2088	-0.1868	-0.1947	-0.1583	-0.1615	-0.1977	-0.1882	-0.1957	-0.1848	-0.1774
Shanghai	0.1282	0.0917	0.1094	0.0969	0.0954	0.2680	0.3204	0.3540	0.4108	0.4364
Jiangsu	-0.0814	-0.1151	-0.1088	-0.1310	-0.1279	-0.1024	-0.1196	-0.1315	-0.1300	-0.1474
Zhejiang	-0.0468	-0.0590	-0.0679	-0.0793	-0.0877	-0.0291	-0.0360	-0.0410	-0.0450	-0.0523
Anhui	0.0054	0.1641	0.1749	0.1477	0.1588	0.0580	0.0527	0.0444	0.0573	0.0757
Fujian	0.4506	0.2771	0.2690	0.2407	0.2551	0.2263	0.2033	0.1811	0.1822	0.1708
Jiangxi	0.4018	0.2916	0.2941	0.3452	0.3816	0.2967	0.2653	0.2632	0.2498	0.2537
Shandong	-0.0925	-0.1353	-0.1529	-0.1677	-0.1610	-0.1771	-0.1766	-0.1774	-0.1865	-0.1920
Henan	0.0669	0.0597	0.0793	0.1073	0.1564	0.1071	0.1420	0.1441	0.1728	0.1858
Hubei	0.0156	0.1205	0.1592	-0.0013	0.0068	0.0307	0.0363	0.0409	0.0257	0.0290
Hunan	0.3217	0.3809	0.3785	0.3620	0.3819	0.3263	0.3290	0.3448	0.3879	0.4232
Guangdong	-0.1008	-0.0774	-0.1291	-0.1140	-0.1477	-0.0785	-0.0900	-0.0963	-0.1024	-0.1081
Guangxi	0.1834	0.2915	0.2658	0.3238	0.3374	0.2075	0.2041	0.1966	0.1936	0.2106
Hainan	0.1217	0.1439	0.1666	0.2120	0.2210	0.2036	0.1711	0.0958	0.0387	0.0587
Chongqing	0.2671	0.2115	0.2157	0.2127	0.1648	0.0824	-0.0238	0.0150	0.0120	-0.0440
Sichuan	0.0963	0.2840	0.2984	0.3242	0.2981	0.2215	0.1847	0.1760	0.1517	0.1227
Guizhou	0.5719	0.4872	0.5997	0.6405	0.5252	0.5613	0.5009	0.3770	0.2406	0.2807
Yunnan	0.6206	0.4708	0.4698	0.4549	0.4420	0.3088	0.3332	0.3550	0.3201	0.3293
Tibet	-0.4223	-0.4072	-0.3947	-0.5019	-0.4750	-0.5062	-0.5168	-0.6281	-0.5995	-0.5713
Shaanxi	0.4389	0.3559	0.3889	0.4536	0.4805	0.3879	0.3765	0.3831	0.3744	0.3545
Gansu	-0.1047	-0.0978	-0.1086	-0.1199	-0.1199	-0.1001	-0.0860	-0.0677	-0.0715	-0.0850
Qinghai	0.1743	0.1466	0.1908	0.2420	0.2823	0.3627	0.3529	0.4166	0.1595	0.1548
Ningxia	-0.4089	-0.4376	-0.4513	-0.4586	-0.4452	-0.4569	-0.4612	-0.4779	-0.4734	-0.4689
Xinjiang	-0.2685	-0.3268	-0.2797	-0.3188	-0.3354	-0.3095	-0.3437	-0.3490	-0.3843	-0.3748

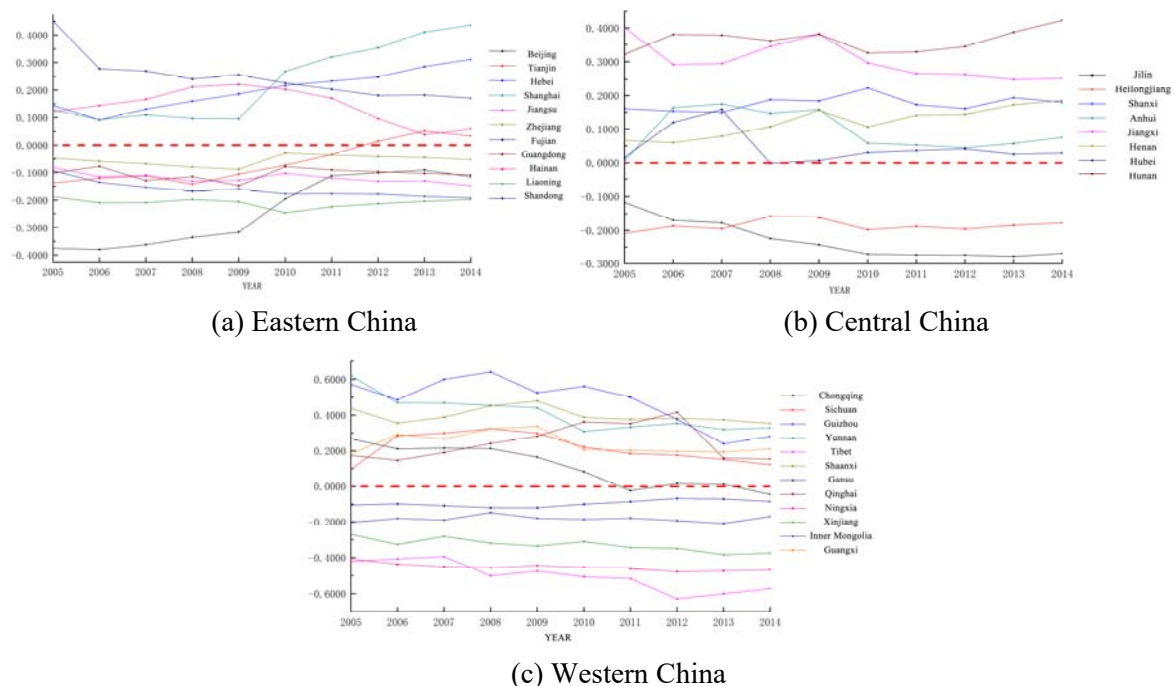


Figure 1. Temporal evolution of urban population-land spatial mismatch

3.2. Spatial pattern analysis of spatial matching between urban population and land

To analyze the spatial pattern of provincial urban population-land, matching grades between urban population and land are illustrated graphically with GIS technology, as is shown in Figure 2.

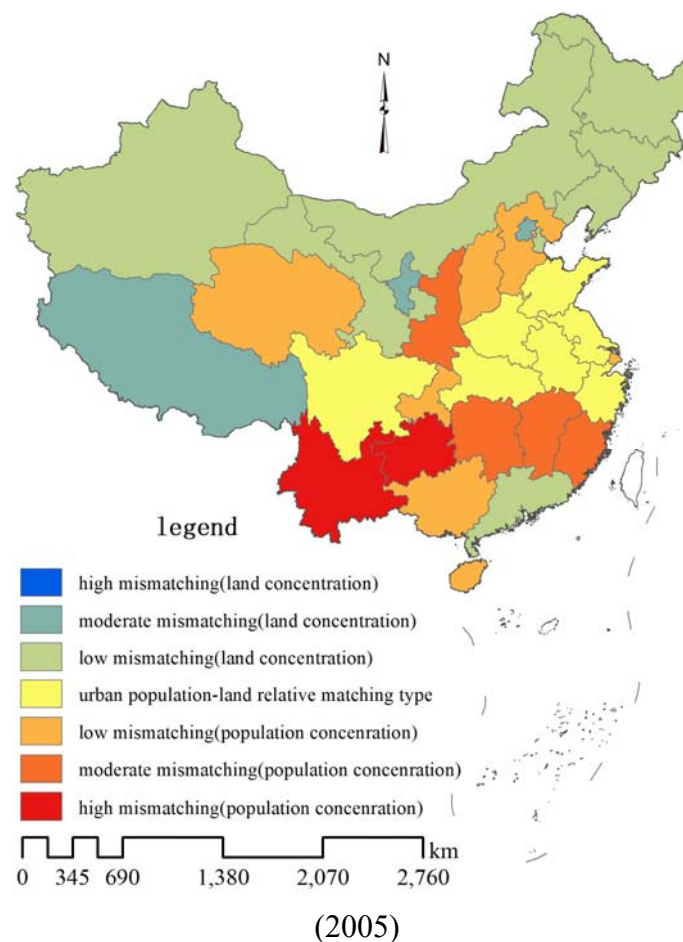
In 2005, there were 7 provinces, including Jiangsu, Zhejiang, Anhui and Henan whose spatial mismatch degree was between -0.1 and 0.1, belonging to the relatively matching type; where, Anhui Province had the highest matching, which was 0.0054. There were 15 provinces belonged to low mismatching type; where, spatial matching of 7 provinces, including Hebei, Shanxi and Shanghai belonged to the population concentration type. The remaining provinces include Tianjin, Inner Mongolia and Liaoning belonged to the land concentration type. There were 7 provinces, whose spatial matching belonged to the moderate mismatching type, where Fujian, Jiangxi, Hunan and Shaanxi belonged to the population concentration type, Beijing, Tibet and Ningxia belonged to land concentration type; and 2 provinces-Guizhou and Yunnan belonged to high mismatching type, both of which belonged to population concentration type, whose spatial mismatch degree had reached 0.5719 and 0.6206 respectively.

In 2010, there were 6 provinces, including Tianjin, Zhejiang and Anhui whose spatial matching belonged to relatively matching type. There were 17 provinces belonging to low mismatching type. Where, 8 provinces, including Hebei, Shanxi and Shanghai belonged to population concentration type; 9 provinces, including Beijing, Inner Mongolia and Liaoning belonged to land concentration type. And 6 provinces belonged to moderate mismatching type. Where, Hunan, Yunnan, Shaanxi and Qinghai belonged to population concentration type, and Ningxia and Xinjiang belonged to land concentration type. There were two provinces namely Guizhou and Tibet, whose spatial match degree between urban population and land belonged to high mismatching type, which were respectively 0.5613 and -0.5062.

In 2014, there were 7 provinces, including Tianjin, Zhejiang and Anhui having relative matching. There were 16 provinces belonging to low mismatching type. Where, 8 provinces, including Shanxi, Fujian and Jiangxi belonged to population concentration type; 8 provinces, including Beijing, Inner Mongolia and Liaoning belonged to land concentration type. There were 7 provinces belonging to moderate mismatching type. Where, 5 provinces, including Shanghai, Hebei and Hunan belonged to population concentration type; Ningxia and Xinjiang belonged to land concentration type, and only

Tibet belonged to high mismatching type, whose spatial match degree between urban population and land was -0.5713.

Combining the analysis of the space pattern of urban population-land of the various provinces in the recent ten years, we can find that, there is relatively small proportion of provinces with relative matching type, which are generally concentrated at the Central and Eastern Region of China, mostly represented by Hubei and Zhejiang; most provinces nationwide belong to low mismatching type, kept around 17 provinces. Northeast provinces, such as Inner Mongolia, Liaoning, Jilin and Heilongjiang are of low mismatching and urban land concentration type for the long term; while provinces, such as Hebei, Shanxi, Henan and Qinghai are of low mismatching and urban population concentration type for the long term. Proportion of provinces featured by moderate mismatching type takes the second place, where, the relatively representative provinces belonging to urban population concentration type are Hunan, Yunnan and Shaanxi, etc.; relatively representative provinces belonging to urban land concentration type are Ningxia and Beijing, etc.. There is the lowest proportion of provinces belonging to high mismatching type, which are generally no more than two. It is worth noting that, among the provinces belonging to high mismatching type, Tibet belongs to urban land concentration type for a long time, and Guizhou belongs to urban population concentration type for a long time.



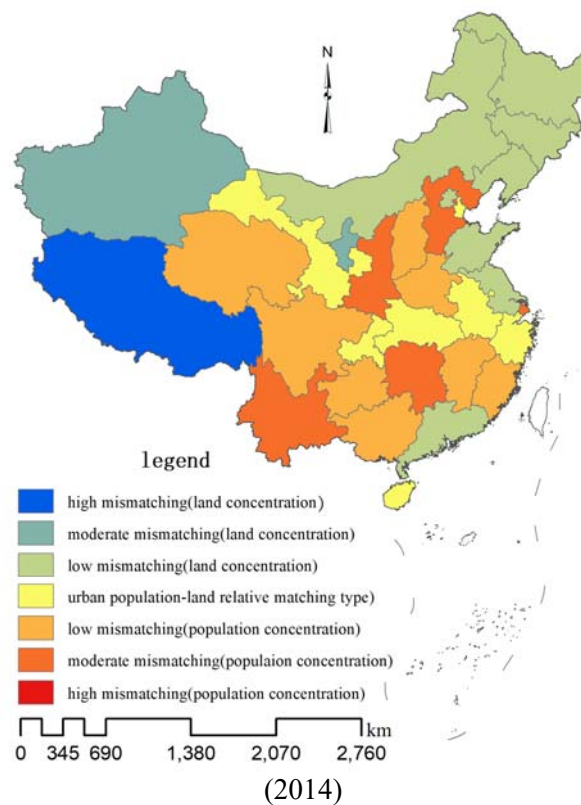
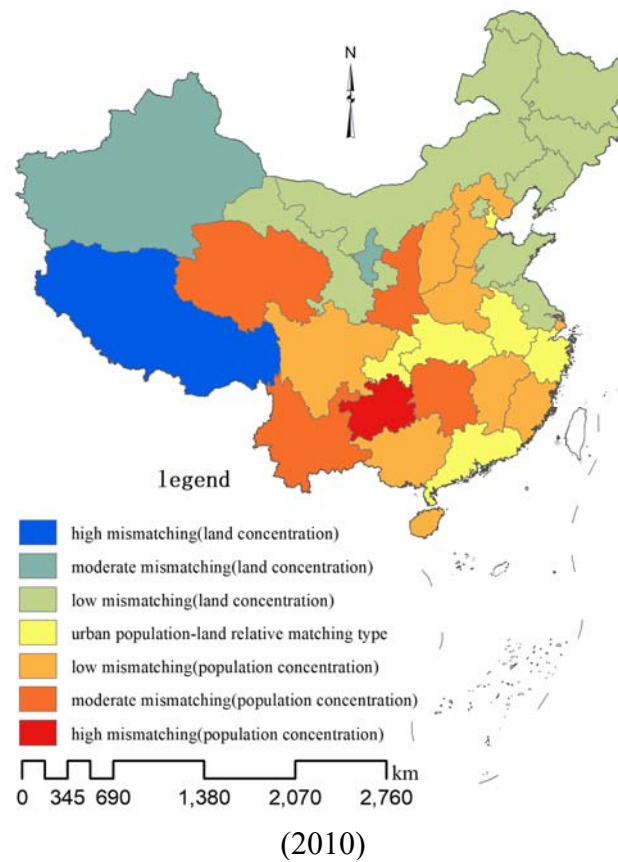


Figure 2. Analysis on spatial pattern of urban population-land space matching at provincial scale

4. Conclusions and inspiration

The research aims at estimating and evaluating the spatial mismatch degree between urban population and land of China at provincial dimension, through building the evaluation model for spatial matching between urban population and land, thus finding problems of mismatch between urban population and land. The research indicates that: (1) since 2005, the comprehensive mismatch degree between urban population and land in Western China presents the state of fluctuation, while it is relatively stable for the central and Eastern region; (2) the comprehensive spatial matching degree between urban population and land presents the feature of highest for the Eastern region, followed by the central region and lowest for the Western region; (3) viewing from the space distribution characteristics of matching grades, there is relatively small proportion of provinces belonging to relative matching, which are generally concentrated in the Eastern and Central China; there is highest proportion of provinces belonging to low mismatching type, basically kept around 17 provinces; and there is lowest proportion of provinces belonging to high mismatching type, generally no more than two provinces, both of which are located at the western region.

Based on the above analysis, the following policy suggestions are proposed:

(1) Establish the evaluation mechanism for spatial matching between urban population and land. Currently, in the revised core content of the overall planning of land utilization, there is already the implementation evaluation on the last round of overall planning. However, the content of evaluation on the regional spatial mismatch degree between urban population and land is lacking; as a result, regional equilibrium between urban population and land is not considered in the index decomposition of overall planning, and the overall planning of land utilization has lost its function of adjusting the balanced spatial development between regional urban population and land. Therefore, during the revision of the overall planning of land utilization, more attention shall be paid to the spatial equilibrium between urban population and land, and is not only to the implementation condition of the last round of planning control index, and evaluation mechanism for spatial matching between urban population and land shall be gradually established, so as to promote the equilibrium space development of urbanization of population and land urbanization.

(2) Optimize spatial configuration of urban population and land reasonably, according to the type and grade of spatial matching type. For provinces featured by land concentration, growth of the scale of urban land shall be restricted relying on the control action of the overall planning of land utilization, contrast relationship between the scale of urban population and urban land shall be adjusted, and transformation from mismatching type to relative matching type shall be accelerated; for provinces featured by population concentration, population inflow shall be guided rationally and orderly, corresponding index support of urban construction land shall be provided, so as to provide space support for urbanization and guarantee the healthy and orderly development of urbanization. Besides, attention shall be paid to the provincial spatial mismatching grade, effective population importing system and urban land control system shall be adopted, so as to enable urban population-land to transform from the mismatching type to relative matching type.

(3) Pay attention to the connotation of space equilibrium between urban population and land and establish harmonious human and environment relationship. The connotation of coordinated development of population urbanization and land urbanization shall not only include the coordination of the development speed and development scale but include space equilibrium. Only in this way, can idleness, waste and inefficient utilization of land resources be avoided, the supporting role of urbanization development space of land resources should be fully noticed, good interaction of man-land relationship be realized, and healthy and sustainable development of urbanization be guaranteed.

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