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Measurement of urban-rural integration level and its spatial differentiation in China in the new century

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ABSTRACT

Urban-rural integration (URI), as a tendency of urban-rural development worldwide, is an inevitable way to create a coordinated and sustainable human society. China has been haunted by a variety of issues related to uncoordinated urban-rural interaction in recent decades and is in the midst of a critical stage faced with great challenges and opportunities as well in realizing urban-rural integration. Therefore, only by fully understanding the URI characteristics in different regions over vast China can we better formulate and implement targeted strategies and regionally adapted policies to boost URIs in the new era. This paper develops a conceptual framework based on the basis, driver and goal (i.e., BDG framework) of the URI system, which could potentially reflect the interaction mechanism between urban and rural areas. Then, the URI index (URII) was constructed based on 39 indices to measure the regional differentiation and explore the spatiotemporal evolution of the URI level from 2000 to 2018. The results showed that: (1) during the study period, the overall URI in China remained at a low level, and the evolution of the URII demonstrated a U-shaped curve, with 2006 as the inflection point, after which the URI level continuously increased. (2) The URII was characterized by significant spatial agglomeration as “high in the east and low in the western and central regions”. Hot spots of the URI level included Beijing, Tianjin, Shanghai, Zhejiang and Fujian in China’s eastern part, while the cold spots were concentrated in the transition zones between the eastern and western parts of China, mainly composed of Sichuan, Hubei, Shaanxi and Gansu. (3) Three types of URIs were identified using the latent profile analysis (LPA) method, corresponding to the early, middle and later stages of URI development in China, and their spatial distribution presented a gradient descending pattern from the southeast coast to the northwest. In the future, it will be necessary to focus on the characteristics of the basis-driver-goal indices and the nine related second-level indices of each URI type to strengthen the strengths and compensate for the weaknesses to further realize national URI development. This study will provide a scientific reference for the effective implementation of rural revitalization and regional coordinated development strategies.

1. Introduction

Alongside the global advancement of urbanization and industrialization, the contrast between the decline of rural areas and the prosperity of urban areas has become increasingly prominent in many parts of the world. There was a reciprocal relationship between urban and rural areas so that the spread of urbanization would lead to rural degradation or even disappearance (Ann et al., 2014). Therefore, balancing urban-rural development and achieving sustainable urban-rural integration have already been a common challenge for all countries to tackle (Bennett et al., 2018; Ma et al., 2021), which is closely related to the global achievement of the Sustainable Development Goals (SDGs). Although countries around the world have diverse histories, cultures, economic development and other aspects, they also suffer from uneven development between urban and rural areas (Abrham, 2011; Dong et al., 2011; Leibert et al., 2015; Liu & Li, 2017; Zitti et al., 2017). For a long time, the constraints of China’s urban-rural dual system and urban-biased policies have brought about the problems of unbalanced urban-rural development and inadequate rural development, which have become major obstacles to the future’s urban-rural integration and rural revitalization in China (Liu, 2018; Liu et al., 2016). At present, the issues of rural decline are becoming increasingly prominent, and

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different types of rural problems (Zheng & Liu, 2018) have led to the incoordination of human-environment relationships and dysfunctional rural regional systems. However, these problems lack enough time for resolution, as the development of China's urbanization was highly compressed in the space and time dimensions and was complex in the content dimension (Liu & Li, 2011). Urban and rural areas are two different yet coexisting systems (Ann et al., 2014), and they need to be treated as but two sides of the same coin (Potter & Unwin, 1995). Only coordinated development of the two systems can support and promote each of the systems (Ji et al., 2019; Liu & Li, 2017). In this context, research on urban-rural relationships and urban-rural integration is of great significance to solve the three rural issues concerning agriculture, countryside and farmers and reduce the gap between urban and rural areas.

Urban-rural integration is essentially a stage in the evolution of urban-rural relationships. Urban-rural relationships are complex and refer to the interactive symbiotic relationship between urban and rural areas that interacts with and influences each system. It is the most basic economic and social relationship in the development of human society (Herberholz & Phuntsho, 2018; Potter & Unwin, 1995). In the context of regional sustainable development, the urban-rural relationship provides a significant perspective to understanding the key territorial development issues and formulating effective policies to address them (Davoudi & Stead, 2002). Its connotation covers many aspects of urban-rural economic, social, ecological, spatial and humanistic aspects (Liu, 2018; Long & Tu, 2018; Tacoli, 2002). Urban-rural relationships have gone through roughly three stages of development (Wang & Chen, 2006), and the corresponding theories are the urban-rural linkage theory represented by urban-rural integration of utopian socialism and Marxism, urban-rural dual structure represented by the Lewis-Ranis-Fei Model, and urban-rural coordinated development represented by the Desakota Model and the regional network model (Lysgård, 2019; Ma et al., 2020). Promoting urban–rural dependencies is seen as a way of supporting sustainable, regional growth (Caffyn & Dahlström, 2005).

Urban-rural relationships in China typically experience a gradual transformation from separation and opposition towards coordination and integration (Liu et al., 2020). Scholars have realized the inevitability and permanence of urban-rural transformation (Palang et al., 2004; Yang et al., 2020). Since the 21st century, the Chinese government has begun to pay attention to and solve the long-standing contradictions of urban-rural division, land partition and man-land separation, which were caused by urban-oriented development strategies, citizen-oriented income distribution systems, and heavy industry-oriented industrial structures (Liu, 2018). Among these efforts, related policies were successively put forward, such as coordinated urban-rural development (*cheng xiang tong chou*) (2002), urban-rural unity (*cheng xiang yi ti hua*) (2013) and urban-rural integration (*cheng xiang rong he*) (2017). Among these policies, coordinated urban-rural development focuses more on the coordinating role of the government and the individual status of urban and rural areas and only considers rural areas while enhancing urban economic and social development. Urban-rural unity tries to weaken the independence of urban and rural areas as individuals and pursues the narrowing of the urban-rural gap. This policy prefers to develop rural areas in the way of developing cities, ignoring the main status of rural areas and diluting the unique value of rural existence to a certain extent. Urban-rural integration (URI) focuses more on sharing development opportunities and equal status between urban and rural areas and recognizes the unique and endogenous value of rural areas. As a coordinated policy of urban-rural integration, the 'rural revitalization strategy' put forward in 2017 aims at solving the key problems of rural development and improving the ability and competitiveness of sustainable development by realizing industrial prosperity, ecological livability, rural civilization, effective governance and prosperous life in rural areas. From the global and historical view of urban-rural development, Liu (2020)[1] believes that rural areas give birth to cities, and the relationship between rural areas and urban areas can be compared to the relationship between mother and child. Therefore, researchers and policymakers should address the imbalance of urban and rural areas from the perspective of urban-rural integration, and the strategy should be transformed from "city leading the countryside" to "city integrating with the countryside" in the new era.

Policy-making on URIs requires a good understanding of the current situation of the URI level in different regions, and then adaptive policies should be formulated for regions according to their development stages. Therefore, the spatiotemporal variation in the URI level needs to be measured using appropriate methods. With socioeconomic development and strengthened spatial connections between urban and rural areas, the connotation of URIs presents new features, which are reflected in the following three main aspects: (1) From the spatial perspective, URIs integrate urban and rural entities into a continuous, networked, multinode and permeable regional complex; (2) From the perspective of development economics theory, the elimination of dual institutional barriers drives the flow of urban and rural elements from unidirectional to bidirectional (Wylie, 2013). The elimination of dual institutional barriers transforms the heterogeneous dual structure into a homogeneous unitary structure, which becomes the key to urban-rural integration. (3) From the viewpoint of the system theory, the plurality and complexity of the urban-rural system determines that the URI is not only the integration of the economy but also the multiple integration of the population, space, society and environment, which is the URI's concrete embodiment (Zhou et al., 2019). Thus, a single index such as income, which was often used in some previous studies, cannot fully represent the URI level in the new context. In view of this factor, some researchers tried to build a multidimensional evaluation index system of URI through urban-rural population integration, spatial integration, social integration, economic integration, ecological integration and functional integration to compensate for the limitations of the single index measurement (Liu et al., 2015; Zhou et al., 2019). In addition, Liu and Lu (2019) analyzed the mismatch of urban and rural factors and URI development in China from 2000 to 2015 by constructing the URI level index from the perspective of people-land-industry integration. Ma et al. (2020) constructed an index system of the quality of urban and rural life involving economic, social and environmental aspects to evaluate urban-rural differences and integration. However, most of the existing studies build evaluation index systems according to the classification or composition of the URI system from a static angle and do not fully consider all three new features of the connotation of URIs mentioned above. In this context, the URI level evaluation index system still needs to be explored from dynamic and systematic perspectives.

China is a country of vast territory and has huge socioeconomic and geographic variation. As such, urban-rural interactions and integration levels present significant differentiation among regions (Li, 2012). Therefore, this research tries to construct a conceptual framework of URI from its basis, driver and goal perspectives (i.e., the BDG framework) which is process-oriented. Then, this research constructs an evaluation system of the URI level based on this framework to explore the spatiotemporal changes in China's urban-rural integration in the new century. This research will provide theoretical support for the effective implementation of rural revitalization and regional coordinated development strategies.

[1] This view was proposed in the "Annual Conference on agricultural geography and rural development of the Geographical Society of China" held in Lanzhou, China in September 2020.

2. Index selection and research methods

2.1. Theoretical framework

Urban-rural linkages are an integral part of fostering development in both urban and rural communities (Somanje et al., 2020). The term 'urban-rural linkages' refers to the spatial flows of individuals, merchandize, money, resources, and sectorial flows, such as agriculture and nonagricultural employment between urban and rural areas (Baffoe et al., 2021; Schlesinger et al., 2015; Tacoli, 1998, 2003; Vandercasteelen et al., 2018; Von Braun, 2007). Based on the existing research on urban-rural relationships, urban-rural integration (URI) is characterized by a two-way flow and the optimal allocation of socioeconomic factors such as capital, labor, and material between urban and rural areas, constituting a giant urban-rural system with interaction, exchange and correlation among its elements. The URI is a process of integrating the city and countryside into an organic whole and promoting the balanced allocation of urban and rural resources and the free flow of elements. It is also a key to changing past urban-biased strategies and starting to move toward the path of mutual development and coordinated development of urban and rural areas.

In the context of urban-rural transformation, the regional system of urban-rural relationships has gradually evolved into a spatial structural system of flowing and clustering of production factors, which interact and interconnect (He et al., 2017). Whether urban and rural production factors flow freely has a major impact on URI development. From the perspective of factor flow, rural labor force transfer, capital profitability and technology diffusion have led to a widening gap between urban and rural resource allocation, which further aggravates the urban-rural disparity. Therefore, the realization of URIs is based on the free flow of urban-rural production factors, including the population, land, capital, technology and industry (He et al., 2019; Yan et al., 2018; Ye & Christiansen, 2009; Zhao & Wan, 2021). Land, labor and capital are the three classical means of production. China's urbanization rate of the permanent population has exceeded 60%, but it is still far below the average level of 80% in developed countries. Therefore, the trend of rural population transfer to cities will continue. On the one hand, the rural population and land resources show a net inflow to cities; on the other hand, the implementation of rural revitalization enables the urban elements to be allocated to agriculture and rural areas to realize the net inflow of capital, technology and other elements to rural areas (He, 2018).

To realize the free flow of urban and rural factors, we need to rely on the construction of transportation networks and information networks between urban and rural areas, and the degree of flow depends on the environmental carrying capacity. Therefore, the transportation information network and environmental carrying capacity are the driving forces for urban-rural integrated development. The construction of an urban-rural transportation information network has provided a channel for the free flow of factors and industrial interaction between urban and rural areas, which forms the necessary flow carrier to ensure the orderly circulation of population, capital, technology and commodities between urban and rural areas by improving transportation and telecommunications infrastructure (Zhang et al., 2019). Meanwhile, the environmental problems during the process of urban-rural integration should not be ignored. People should pay attention to environmental carrying capacity while pursuing economic development.

URI is a process of narrowing the gap between urban and rural areas and the process of urban-rural social, economic, ecological and other spatial dynamic balance. The goal of China's URI and rural revitalization is to achieve roughly equal quality of life in rural and urban areas under different lifestyles. That is, achieving no difference in the quality of life between urban and rural areas and the equivalence of urban and rural public services is the ideal goal of urban-rural integration. Although urban-rural equivalence cannot be fully realized in reality, URIs can narrow the gap between urban and rural quality of life and public services. Therefore, the achievement of URI is the integration of urban-rural income consumption and public services. The integration of urban-rural income could be reflected in narrowing the return rate difference between agricultural production departments and industrial production departments, and the integration of consumption aims to bridge the gap in the level and structure of consumption between urban and rural residents. The integration of public services reduces the gap in urban-rural education, medical care, social security, etc.

In summary, the free flow of urban and rural population, land, capital, technology and other factors and the interaction of industries are URI's basis and premise, the transportation information network and environmental carrying capacity are the internal and external driving forces of URI, while the URI's goal is to achieve the equalization of urban and rural quality of life for residents and the equivalence of public services. According to this scheme, we constructed a process-oriented BDG (basis-driver-goal) framework of urban-rural integration (Fig. 1), and then we built the following URI index system based on this framework.

2.2. Index system construction

The urban-rural integration index (URII) is a comprehensive evaluation index used to measure the status of regional urban-rural integrated development. The value of the URII quantitatively describes the degree of interaction and integration between urban and rural areas in the process of economic development. The evolution of the urban-rural relationship is a transformation of a dual heterogeneous structure into a unitary homogeneous structure, which is the key to the integration of urban and rural areas. From this aspect URI can be seen not only as a goal but also as a state, more importantly, a process. Therefore, it is necessary to consider the multidimensional evaluation indices, which include the following three types: the comparative indices that reflect the differences and comparisons between urban and rural communities, the status indices that help identify the status of urban-rural integration system and its factor mobility at a specific time, and the dynamic indices that drive urban-rural mobility.

Based on the above BDG framework and the existing literature, this paper selects 39 indices from the three dimensions (i.e., the basis, driver and goal) of URI to construct the index system to measure the URII (Table 1). Factor flow and industrial interaction between urban and rural areas are the basis of realizing the integration of urban and rural development. This study selects 15 indices (X1-X15) to represent the flow of urban and rural factors, including population, land, capital, technology, and the interaction between industries. The information transportation network and environmental carrying capacity are the driving forces of URIs and the carriers of urban-rural factor flow. Previous studies have shown that transportation infrastructure is an important channel and spatial carrier of urban-rural factor flow (Yang,

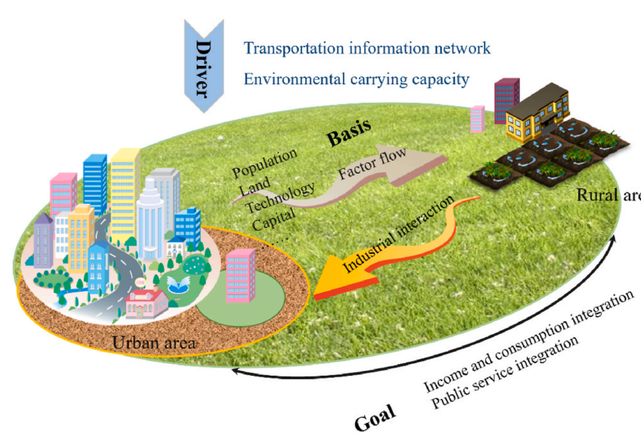

Fig. 1. The BDG framework of urban-rural integration.

Table 1
Evaluation index system of URI.

Target layer	First-level Indices	Second-level Indices	Third-level Indices	Calculation or Description of the Indices	Index Code	Index Properties
Urban-rural integration index (URII)	Basis index (BI)	Population mobility	Urbanization rate	Level of population urbanization, urban population/total population, %	X1	+
			Total passenger turnover	100 million people/km	X2	+
			Total passenger transportation	Ten thousand people	X3	+
			Ratio of nonagricultural to agricultural employment	Ratio of employees in secondary and tertiary industries/proportion of employees in primary industries	X4	+
		Land mobility	Utilization efficiency of arable land	Output value of primary industry/area of cultivated land	X5	+
			Utilization efficiency of construction land	Output value of secondary and tertiary industries/area of construction land	X6	+
			Ratio of urban to rural land use	Area of urban built-up area/area of cultivated land	X7	+
		Capital mobility	Ratio of financial support to agriculture	%	X8	+
			Ratio of fixed asset investment in urban and rural areas	Rural fixed asset investment/urban fixed asset investment	X9	+
		Technology mobility	Ratio of science and technology expenditure	Science and technology expenditure/fiscal expenditure, %	X10	+
			Number of invention patents granted		X11	+
			Percentage of agricultural technicians	Agricultural technicians in public-owned economic enterprises and institutions/total professional technicians in public-owned economic enterprises and institutions, %	X12	+
		Industrial interaction	Proportion of nonagricultural production value	GDP of secondary and tertiary industries/total GDP, %	X13	+
			Ratio of industrial and agricultural water consumption	Industrial water consumption/agricultural water consumption	X14	+
			Binary comparison coefficient	(Output value of primary industry/employees in primary industry)/(Output value of secondary and tertiary industries/employees in secondary and tertiary industries)	X15	+
	Driver index (DI)	Transportation information network	Density of transportation network	Total mileage of roads and railroads in operation/total area of the region, km/km^2	X16	+
			Private car ownership per capita in urban and rural areas	Private car ownership of urban and rural residents/total population, unit/person	X17	+
			Per capita postal and telecommunications services	Total post and telecommunications services/total population, ten thousand yuan/person	X18	+
			Length of long-distance fiber optic cable lines	km	X19	+
			Cargo turnover	100 million ton-km	X20	+
		Environmental carrying capacity	Harmless treatment rate of urban domestic waste	%	X21	+
			Urban sewage treatment rate	%	X22	+
			Completed investment of industrial pollution treatment	100 million yuan	X23	+
			Greening coverage rate of built-up areas	%	X24	+
			Rural sanitary toilet penetration rate	%	X25	+
			Forest coverage rate	Forestland area/total land area, %	X26	+
			Investment ratio of environmental pollution treatment	Investment in environmental pollution control/total output value, %	X27	+
	Goal index (GI)	Income and consumption level	GDP per capita	Total GDP value/total population, Yuan/person	X28	+
			Ratio of per capita income of urban and rural residents	Per capita annual disposable income of urban households/per capita annual net income of rural households	X29	–
			Wage income ratio of urban and rural residents	Per capita wage income of urban residents/per capita wage income of rural residents	X30	–
			Property income ratio of urban and rural residents	Per capita property income of urban residents/per capita property income of rural residents	X31	–
			Engel's coefficient between urban and rural areas	Urban Engel coefficient/rural Engel coefficient	X32	+
			Comparison of consumption levels between urban and rural residents	Consumption level of urban residents/consumption level of rural residents	X33	–
			Comparison of urban and rural residents' cultural, educational and entertainment coefficients	Urban residents' household expenditure on culture, education and entertainment/rural residents' household expenditure on culture, education and entertainment	X34	–
			Ratio of urban and rural residents' expenditure on transportation and communication	Urban residents' transportation and communication expenditure/rural residents' household transportation and communication expenditure	X35	–
		Public service level		Urban per capita health care expenditure/rural per capita health care expenditure	X36	–

(continued on next page)

Table 1 (*continued*)

Target layer	First-level Indices	Second-level Indices	Third-level Indices	Calculation or Description of the Indices	Index Code	Index Properties
			Comparison coefficient of health care per capita between urban and rural areas			
			Ratio of health technicians per 1000 people in urban and rural areas	Number of health technicians per 1000 urban residents/Number of health technicians per 1000 rural residents	X37	–
			Difference in education level between urban and rural areas	(Proportion of population with high school education or above in urban areas)/(Proportion of population with high school education or above in rural areas)	X38	–
			Ratio of social security expenditure	Social security expenditures/fiscal expenditures, %	X39	+

2017). This research chooses X16-X20 to represent the transportation information network and X21-X27 to measure the environmental carrying capacity. In addition, the ultimate goal of URIs is to improve and coordinate the living consumption level of urban and rural residents and achieve urban-rural equivalence. Among these goals, the equalization of urban and rural public services refers to the provision of basic public services and products in basic education, social security and health care for urban and rural residents. Based on this scheme, this study selects 12 indices (X28-X39) to measure the level of urban and rural income and consumption and public services to represent the URI results. In this study, the basis indices, driver indices and goal indices of the URII are mostly status indices, dynamic indices and comparative indices, respectively.

Unlike other studies that focus on building the system according to the classification and composition of the URI system from a static angle, the evaluation index system constructed in this study based on the BDG framework of URIs could dynamically reflect the core mechanism of urban-rural integration to a certain extent. In addition, this new index system could play the role of system diagnostics to discover the weaknesses and advantages of the urban-rural integration system. Then, the results could provide feasible and practicable policy guidance for policymakers, as the index system systematically reflects the URI's integrant elements and the structure functions.

2.3. Data sources and data processing

2.3.1. Data sources

The index system of this study covers a wide range of indicators. To ensure data accuracy and timeliness, the data were derived mainly from the National Bureau of Statistics, and they were in good agreement with each other. The data sources included the China Statistical Yearbook 2000–2018, China Rural Statistical Yearbook, China Urban Statistical Yearbook, China Compendium of Statistics of 1949–2008, China Health Statistics Yearbook, Education Statistics Yearbook of China and statistical yearbooks of provinces (municipalities and districts). Missing data were filled by the linear interpolation method, while the data of the Tibet Autonomous Region, Hong Kong, Macao, and Taiwan were omitted due to serious data deficiency.

2.3.2. Data processing

On the strength of the constructed framework of the index system, the data shall be preprocessed first. In this study, the maximum difference normalization method (Equation (1)) is used for standardization.

$$\begin{cases} Y_{ij} = (1-a) + a\dfrac{X_{ij} - X_{\min j}}{X_{\max} - X_{\min}j} \cdot (Positive\ indices) \\ Y_{ij} = (1-a) + a\dfrac{X_{\max j} - Xij}{X_{\max j} - X_{\min j}} \cdot (Negative\ indices) \end{cases} \quad (1)$$

where Y_{ij} refers to the normalized value, X_{ij} refers to the original value of the j_{th} index in year i, X_{maxj} and X_{minj} represent the maximum and minimum values of the j_{th} index, respectively, and α is generally 1.

2.3.3. Methods

As one of the commonly used and objective assignment methods, generalized principal component analysis (GPCA) can achieve the measurement of panel data and overcome the inconsistency between the measurement results of time series data and cross-sectional data compared with traditional principal component analysis methods. In this study, GPCA was used to measure the URII. First, 39 indices from 30 provinces of China (except Tibet Autonomous Region, Hong Kong, Macao, and Taiwan) during 2000–2018, which were standardized above, were substituted into SPSS 22.0 to construct a time-series three-dimensional data table. The appropriateness of variable selection was measured based on the principles of KMO>0.7 and Bartlett's spherical test ($p < 0.01$). The results showed that KMO = 0.81 and $P < 0.001$, and the selected indices were suitable for GPCA. Then, the GPCA was applied to extract the principal components of the URII from 39 indices. The covariance matrix was chosen to be used, and a total of 6 principal components were extracted based on the principle that the eigenvalues were greater than 1, and the cumulative contribution of variance was not less than 75%. The same method was used to explore the principal components of the scores of the three dimensions of urban-rural integration of basis, driver and goal.

The factor loading of each index on the six principal components of the URII is shown in Table 2. The statistical significance of the loading a_{ij} is the correlation coefficient between the i_{th} variable X_i and the j_{th} principal component F_j, that is, the weight of X_i's dependence on F_j. In this study, we consider the factor loadings of the indices that rank in the top 10 to be high. On the first principal component, the four indices of X21, X22, X25 and X24 belong to the environmental carrying capacity, and the three indices of X17, X16 and X18 in the transportation information network have high loadings, which reflect the URI driver at its two sublevels. Therefore, the first principal component is named the URI driver layer. In the second principal component, the loadings of X4 and X1 in population mobility, X7 in land mobility, X9 in capital mobility, X10 in technology mobility, and X14 and X13 in industrial interaction are high. Hence, the second principal component is named the URI basis layer. On the third and fourth principal components, X34, X35, X29 and X33 at the income and consumption level, as well as X36 and X39 at the public service level, have high loadings. Correspondingly, both the third and fourth principal components are named the URI goal layers. In the fifth principal component, the factor loadings of X2, X16, X3, X23, X27, X32 and X31 top the list. These indices cover the URI basis, driver and goal, so the fifth principal component is named the composite layer. In the sixth principal component, the factor loadings of X2, X19, X20, X3, X17, X18, X11 and X10 are high; therefore, the sixth principal component is named the URI basis-driver layer.

The score value of the k_{th} principal component is calculated according to Equation (2), and the urban-rural integration index (URII) of each region in China at different periods is weighted according to Equation (3).

Table 2
Factor loading of each index.

First-level Indices	Index code	1	2	3	4	5	6
Basis index	X1	0.179	**0.075**	0.04	−0.047	−0.007	−0.053
	X2	0.073	−0.006	−0.096	0.048	**0.083**	**0.073**
	X3	0.031	0.009	−0.071	0.03	**0.051**	**0.039**
	X4	0.086	**0.095**	0.021	−0.049	−0.047	0
	X5	0.124	0.016	−0.057	0.06	−0.028	−0.005
	X6	0.186	0.002	−0.023	−0.029	−0.016	0.014
	X7	0.091	**0.104**	0.014	−0.046	−0.053	−0.003
	X8	0.049	−0.189	0.012	−0.009	−0.014	0.007
	X9	−0.134	**0.081**	0.022	0.088	0.04	**0.053**
	X10	0.14	**0.082**	−0.018	−0.005	−0.032	**0.056**
	X11	0.112	0.04	−0.027	−0.003	−0.045	**0.067**
	X12	−0.096	−0.158	0.039	−0.068	−0.037	0.013
	X13	0.126	**0.05**	0.018	−0.071	0.039	−0.001
	X14	0.039	**0.102**	0.015	−0.042	−0.002	−0.021
	X15	0.025	0.003	−0.015	0.091	−0.016	−0.018
Driver index	X16	**0.176**	0.087	−0.079	−0.029	**0.055**	−0.011
	X17	**0.226**	−0.062	0.027	−0.03	−0.057	**0.038**
	X18	**0.166**	−0.009	0.008	−0.013	−0.093	**0.033**
	X19	0.06	−0.125	−0.071	0.005	0.036	**0.065**
	X20	0.111	0.058	−0.023	−0.018	0.014	**0.054**
	X21	**0.25**	−0.083	−0.025	0	0.014	−0.012
	X22	**0.242**	−0.094	−0.037	−0.058	0.036	−0.027
	X23	0.06	0.011	−0.032	−0.009	**0.045**	0.062
	X24	**0.163**	−0.022	−0.052	0.009	0.026	−0.043
	X25	**0.201**	0.017	−0.023	0.009	−0.003	−0.032
	X26	0.073	−0.029	−0.118	0.178	−0.085	−0.081
	X27	−0.002	−0.025	0.063	−0.038	**0.037**	−0.015
Goal index	X28	0.194	0.026	0.013	−0.043	−0.043	0.016
	X29	0.108	0.072	**0.097**	**0.089**	0.043	−0.011
	X30	0.072	0.036	0.006	0.028	0.035	−0.004
	X31	−0.03	0.017	0.009	−0.043	**0.056**	−0.032
	X32	0.059	−0.042	−0.014	−0.044	**0.077**	−0.078
	X33	0.156	−0.002	**0.075**	**0.063**	0.023	−0.023
	X34	0.115	−0.026	**0.133**	**0.102**	0.001	0.029
	X35	0.138	−0.03	**0.107**	**0.056**	0.032	0.012
	X36	0.175	−0.042	**0.098**	**0.047**	0.032	0.023
	X37	0.046	0.01	−0.001	0.002	0.025	−0.038
	X38	0.137	0.007	−0.014	0.004	0.025	−0.021
	X39	0.088	−0.085	**0.029**	−0.009	−0.008	−0.001
Contribution		42.5%	11.40%	7.25%	7.16%	4.41%	3.54%
Cumulative contribution		42.5%	53.90%	61.15%	68.30%	72.71%	76.25%

Note: The index in both bold and underlined format indicates that it has a higher score (at least top 10) in the corresponding principal component.

$$F_k = \sum_{i=1}^{39} \lambda_{ki} N_{ij} \tag{2}$$

$$URII = \frac{\sum_{i=1}^{k} a_k F_k}{\sum_{i=1}^{k} a_k} \tag{3}$$

where N_{ij} is the standardized index value, λ_{ki} is the factor loading of the i_{th} indicator on the k_{th} principal component, F is the score value of the k_{th} principal component, a_k is the variance contribution rate of the k_{th} principal component, and *URII* is the urban-rural integration index. The URII takes a range of (0, 1). A value closer to 1 indicates a higher level of urban-rural integration development, and a value lower than 1 indicates a greater development gap between urban and rural areas.

In this study, the regional differentiation degree (RDD) was used to quantify the degree of regional difference in URII, BI, DI and GI at each time node. Here, we just list the formula of URII as an example. The RDD takes the value of $[0,+\infty)$, and the higher the degree is, the greater the regional disparity of the URII between regions. If the RDD is 0, it means that the URII is equalized between regions, and the formula is as follows.

$$RDD = \sum_{i=1}^{30} \frac{|URII_i - URII_{average}|}{URII_{average}} \tag{4}$$

where $URII_i$ is the URII value of province i, $URII_{average}$ is the arithmetic average of the national URII in that year, and *RDD* is the regional differentiation degree of the national URII.

3. Results

3.1. Measurement of URII

Fig. 2 shows that the URII in China increased from 0.23 to 0.38 between 2000 and 2018 with an increase of 65.21%, but the overall level of the URI in China was low. Overall, GI was the largest, followed by DI,

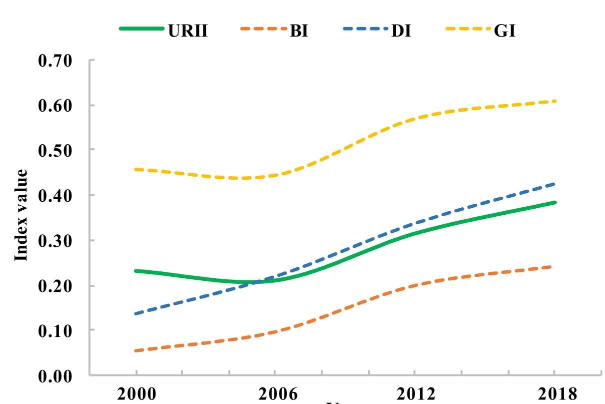

Fig. 2. The evolution curves of the URII and its three decisive indices during 2000–2018.

while BI was the lowest, indicating that the difference in the URI basis is the most critical factor leading to the divergence of the URII. In addition, BI, DI and GI increased from 0.05 to 0.24, from 0.14 to 0.42, and from 0.46 to 0.61, respectively, during the study period. Obviously, BI increased the fastest, while GI increased more slowly. The GI first decreased and then increased; correspondingly, the URII shows a U-shaped change, taking 2006 as the inflection point, revealing that the URII declined before 2006 and then continued to grow until 2018 when it reached its peak, with the largest growth rate during 2000–2012.

The URII and its components BI, DI and GI presented significant regional disparities (Fig. 3), and their differences between regions gradually decreased, characterized by the regional differentiation degree (RDD) (Fig. 4). The results showed that: (1) for the URII, its RDD demonstrated a trend of increasing and then decreasing, indicating that its regional difference peaked in 2006. Specifically, the URII in the eastern region was significantly higher than the URII in the central and western regions, with higher levels in Beijing, Tianjin, Guangdong, Zhejiang, and Fujian in the eastern region and lower levels in Chongqing, Anhui, Xinjiang, Shanxi, and Yunnan in the central and western regions (Fig. 3(a)). According to the maximum and minimum values of the URII at each time node, it was clear that Beijing and Tianjin were the leading regions of the URI, while Chongqing and Shanxi were the lagging regions of the URI. (2) BI had the highest RDD among the three component indices. The BI in the eastern region was significantly higher than the BI in the central and western regions, with higher BI in Guangdong, Beijing, Jiangsu, Shanghai and Zhejiang in the eastern region and lower BI in Shanxi, Jilin, Ningxia, Xinjiang and Gansu in the central and western and northeastern regions (Fig. 3(b)). (3) For DI, the degree of regional differences was moderate. The DI was relatively higher in the eastern regions than in the western and northeastern regions, with higher levels in Shandong, Inner Mongolia, Guangdong, Jiangsu, and Hebei in the eastern and some midwestern regions and lower levels in Hainan, Heilongjiang, Chongqing, Jilin, and Tianjin in the western and northeastern regions (Fig. 3(c)). (4) As for GI, its RDD

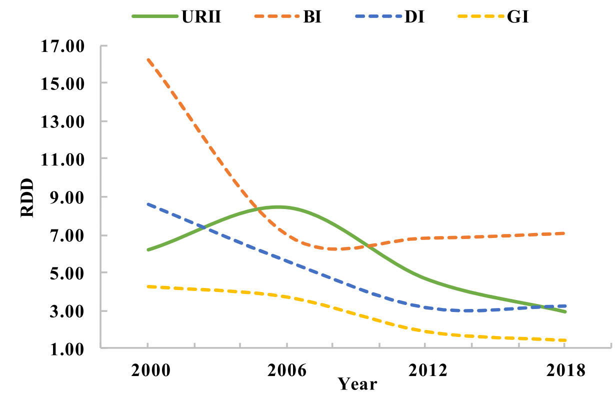

Fig. 4. Regional differentiation degree of the indices during 2000–2018.

was the lowest. The GI in the eastern region was relatively higher than the GI in the central and western regions, with higher levels in Fujian, Beijing, Jiangsu, Shanghai, and Zhejiang in the eastern region and lower levels in Chongqing, Anhui, Shaanxi, Hubei, and Qinghai in the central and western regions (Fig. 3(d)).

3.2. Spatial patterns of URII

China can be divided into four regions according to its economic management system: the east, northeast, west and central regions (Long et al., 2010). The URII of the four regions presents spatial heterogeneity with characteristics of "high in the east and low in the western and central regions". They all present a U-shaped curve over time, decreasing first and then increasing (Fig. 5). Specifically, the URII has the order of the east > northeast > national > west > central region, with the URII in the east and northeast higher than the URII of the

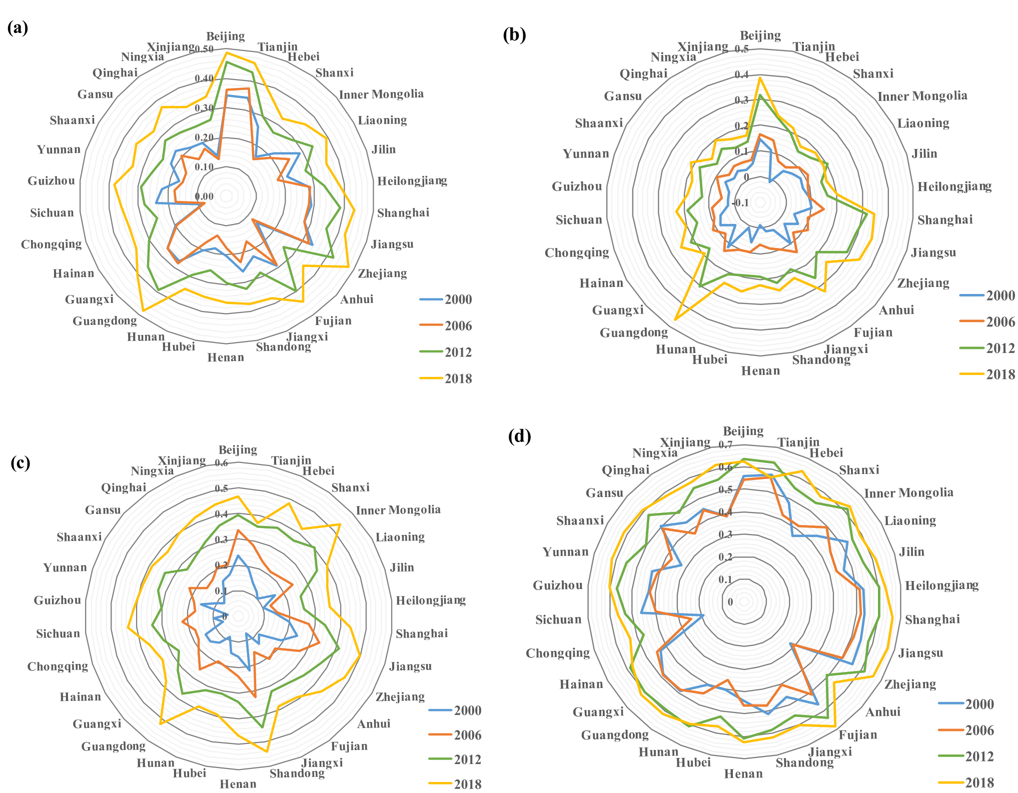

Fig. 3. The provincial URII (a), BI (b), DI (c) and GI (d) from 2000 to 2018.

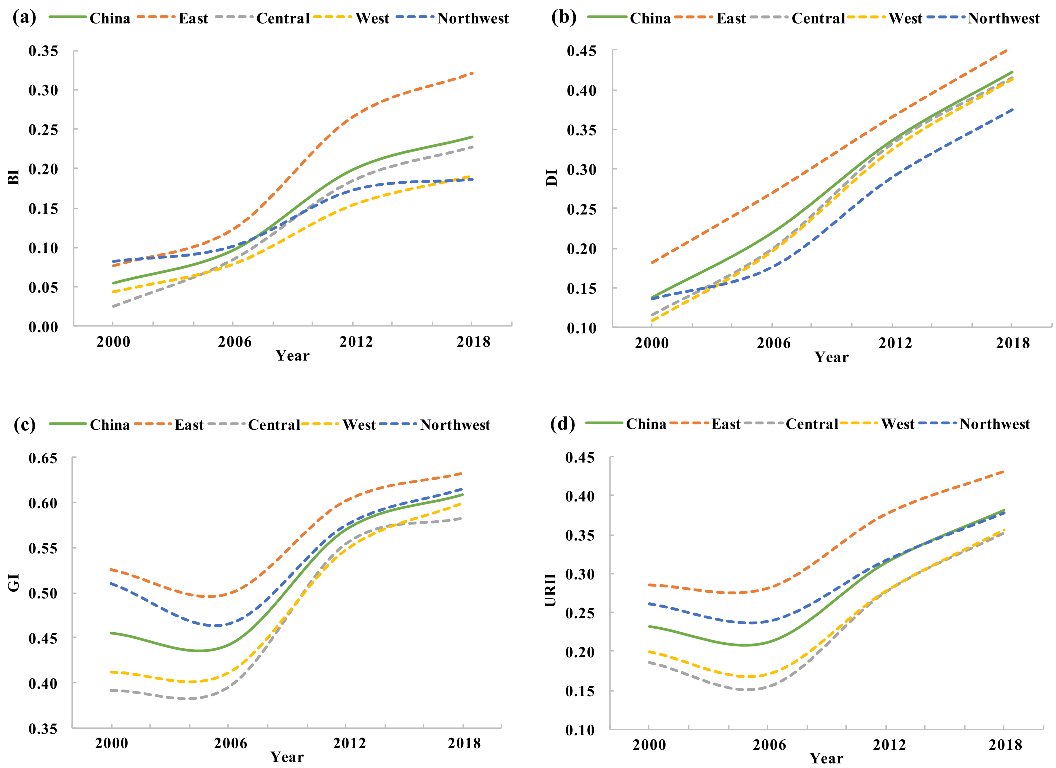

Fig. 5. The evolution curves of the four regions in BI (a), DI (b), GI (c), and URII (d) during 2000–2018.

national average and the URII in the west and central regions lower than the URII of the national average. In terms of BI, the four regions show a rising trend, with the eastern region initially lagging behind the northeastern region in 2000 but then staying ahead, the central and western regions improving faster than the northeast, and the northeast being at the lowest among the four major regions in 2018. The DI of the four regions showed a continuous increase, with the northeast always lower than in the east, west and central regions since 2006, and the gap widening. The changes in GI were similar to those of URII, which also showed the order of the east > northeast > national > west > central region.

This study classified the URII into four levels according to its

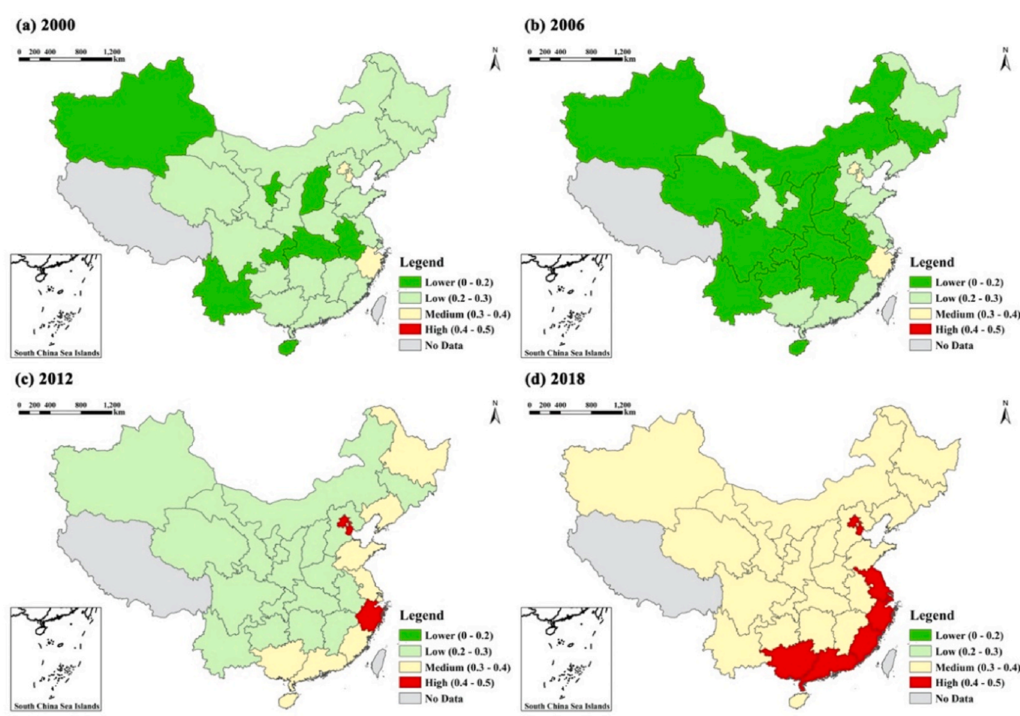

Fig. 6. The spatial patterns of URII during 2000–2018.

distribution characteristics during 2000–2018: lower (0–0.2), low (0.2–0.3), medium (0.3–0.4) and high (0.4–0.5). As shown in Fig. 6, the spatial distribution pattern of the URII changed significantly during the study period. In 2000 and 2006, there were no areas with high URII nationwide, and the areas at medium levels consisted only of Beijing, Tianjin and Zhejiang. In addition, in 2000, the lower level was concentrated in the northwestern, southwestern and central regions. In 2006, most regions of the country were at the lower level, except for Gansu, Heilongjiang and parts of the southeast coast. In 2012, the URIIs in Beijing, Tianjin and Zhejiang were upgraded to high levels, the southeast coast and some parts of northeast China had up to medium levels, while all other regions were at lower levels. In 2018, Beijing, Tianjin and southeastern coastal provinces achieved high integration levels, and all other regions reached medium levels. These findings are similar to the existing research results. Specifically, Liu et al. (2013) revealed that the spatial units of a high level of urban-rural equalized development (URED) were concentrated in eastern China near the coast, and the spatial units of a low URED level were located mainly in central and western China.

The Moran index was employed to detect the spatial clustering characteristics of the URII. The results showed that the Moran indices of the URII in 2000, 2006, 2012 and 2018 were 0.297, 0.399, 0.464 and 0.444 (p value < 0.01), respectively, indicating significant spatial agglomeration. Then, hot spot analysis was used to detect their spatio-temporal clusters (Fig. 7). In 2000, the hot spots of the URII were concentrated in Beijing, Tianjin, Shanghai and Fujian, while the cold spots were mainly in central and western provinces such as Sichuan, Chongqing, Shaanxi and Hubei. In 2006, the hot spots of the URII narrowed to three regions compared with 2000, while the cold spots expanded to Henan and Gansu. In 2012, the hot spots of the URII further expanded to Zhejiang and Fujian compared with 2006, while the cold spots remained stable. In 2018, the hot spots of the URII remained highly consistent with 2012, but the cold spots further expanded northward to Inner Mongolia and Ningxia. Therefore, according to the spatial distribution of hot/cold spots in the four time nodes, the cold spot areas were concentrated mainly in the transition zones of central and western China, such as Sichuan, Hubei, Shaanxi and Gansu, which are the links and corridors connecting central and western China and play an extremely important role in the coordinated development of the regions. These regions are in the critical period of urban-rural transformation, and economic development is constantly speeding up. However, economic growth is still at the cost of rural-to-urban migration and the conversion from rural collective land to urban state-owned land by land acquisition, which are defined as special forms of demographic dividends and land dividends, respectively. The development of rural areas is significantly lagging behind the development of urban areas, and the flow of urban-rural factors has not formed a healthy flow, thus manifesting as intense urban-rural conflicts and a low level of URI. These areas will be the key areas for future urban-rural integration development. Given that these regions' economic development levels, industrial bases and financial and technical conditions are weaker than those in the east, efforts should be made to optimize the industrial structure, promote urbanization in an orderly manner, and simultaneously coordinate the contradiction between economic development and the ecological environment.

3.3. Clustering analysis of URII

The latent profile analysis (LPA) method was used to explore the classifications of URIs in China by clustering the URIIs in 2018. First, based on the constructed index system of URI, the nine second-level indices were calculated using GPCA, and then they were used as independent variables for potential category analysis. Regression was performed using a Gaussian function to identify the latent classes, i.e., the number of URI types. We can compare the models fit above using Akaike's information criterion (AIC) and Schwarz's Bayesian information criterion (BIC), and the model with the smallest values of AIC and BIC would be considered the best. From Table 3, AIC decreases as the category increases, the BIC first decreases and then increases, and the BIC takes the minimum value when the category is 3. Therefore, the

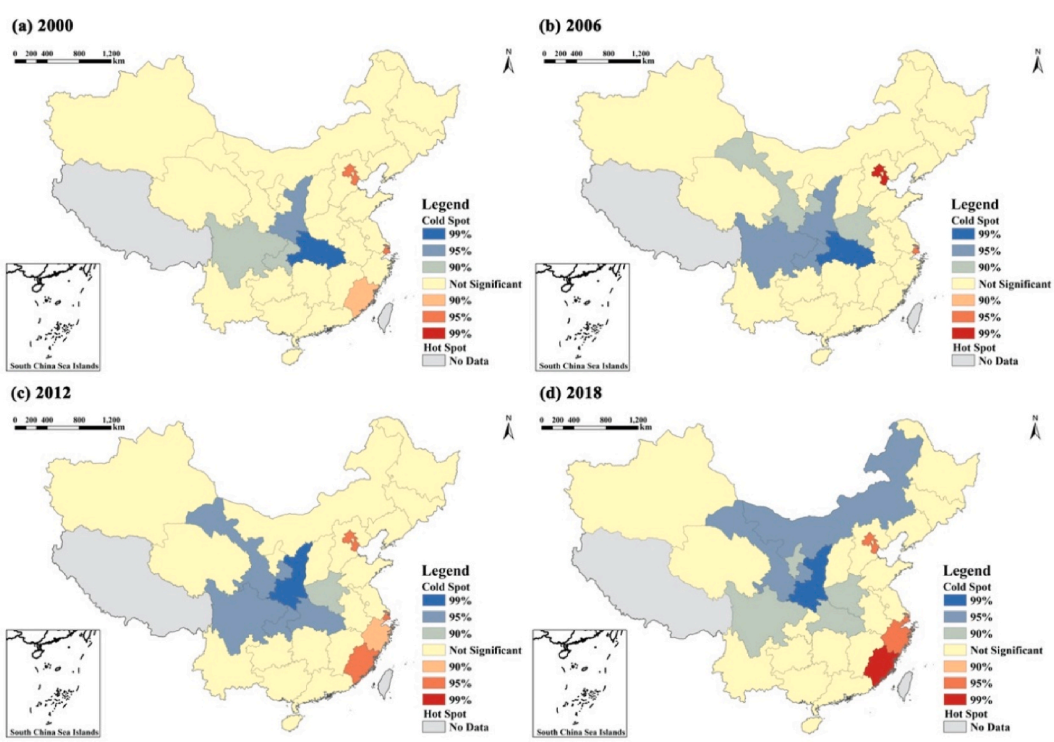

Fig. 7. The spatial distribution of hot/cold spots of the URII in China during 2000–2018.

Table 3
Parameters of different classes in LPA.

Classes	Observations	df	AIC	BIC
1	30	18	−575.87	−550.65
2	30	28	−668.99	−629.76
3	30	38	−700.49	**−647.24**
4	30	48	−703.24	−635.99
5	30	58	−710.82	−629.55
6	30	68	−726.28	−631.01

model with three latent classes was considered best fitted based on these information criteria. The URII in 2018 was used as a test variable, and the clustering results were tested by using analysis of variance (ANOVA). The mean values of Types I, II, and III were 0.3518, 0.3690, and 0.4571, respectively, with an F-value of 26.805 ($P = 0.000$), indicating that the URII was significantly different among the three categories. Therefore, the clustering results are statistically reasonable.

The characteristics of each type were analyzed according to the average scores of these second-level indices of the evaluation index system (Fig. 8). The values of the nine indices for Type I are all higher than the values of the nine indices of Type II and Type III, leading to the basis, driver and goal of URI, so this type is named a high-level coordination type. For Type II, its five indices in the URI basis are larger than those five indices in Type III but smaller than those five indices in Type I; its driver indices are behind Type I with small differences from Type III; and its two goal indices are all behind Type I and Type III. Therefore, Type II showed a moderate basis-driver-goal value and was named the medium-level imbalance type. Type III shows a relatively lagging basis and driver and is named the low-level lagging type. The spatial distribution of types I, II and III shows an obvious stepped feature (Fig. 9). Type I is distributed mainly along the southeast coast. Type III is mainly west of China's 400 mm equivalent precipitation line and the Hu line, which belong to the western arid and semiarid areas. Type II is distributed in the transition zone of Types I and II, which belongs to the vast central hinterland. Accordingly, these three types correspond to the late, middle and early stages of urban-rural integration development, reflecting the dynamics of different stages.

Type I includes mainly Beijing and five other regions along the southeast coast (Jiangsu, Shanghai, Zhejiang, Fujian and Guangdong) (Fig. 9). Its average URII reaches 0.46, with urban-rural integration entering a high-level coordination stage. In this stage, the average urbanization rate reached 74.94%, the high level of urban development effectively stimulated the synchronous development of the rural communities, and the urban-rural gap continued to narrow, specifically showing that the basis, driver and goal of URIs have reached a better level, so the URII reaches a higher level. Table 4 shows that the six regions of Type I generally lead in each index.

Type II includes 13 regions, with an average URII of 0.37, which is at the medium-level imbalance stage of URI. At this stage, the average

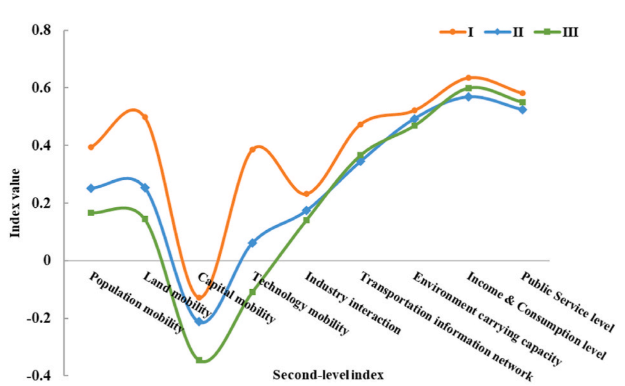

Fig. 8. Curves of the nine second-level indices for the three types in 2018.

urbanization rate was 58.67%, and the development of urbanization was in a critical period of transition. Although the basis and driver of URIs, such as population mobility, industrial interaction and transportation networks, have been significantly improved, the development of rural areas is obviously lagging behind the development of urban areas. In particular, the urban-rural gap in terms of income and consumption level and public service level is large. The problem of unbalanced urban-rural development has become increasingly prominent and has become a key obstacle to promoting URIs. Among this type, Shandong, Henan and Hebei experienced balanced development among the basis, driver and goal of URIs. Tianjin, Hubei, Hunan, Liaoning, Anhui, Jiangxi and Chongqing belong to the type with a relatively good basis but lagging drivers and goals. Sichuan, Hainan, Shanxi, Shaanxi, Guangxi and Guizhou are of the types with lagging basis-driver goals.

The average URII of Type III is 0.35, which is at a low level of the URI equilibrium stage. In this stage, the average urbanization rate was 55.01%, and the urbanization and economic development levels of these regions were relatively low compared with the urbanization and economic development levels of Types I and II, so the basis and driver of URIs were weak. In addition, the developments of both urban and rural areas lag behind, and the urban-rural gap has not yet widened, so the URI in this stage is characterized by a low level but relatively balanced urban and rural areas. In this type, all the basis indices of the eight regions are significantly low (Table 5). In addition, driver indices, including the transportation information network and environmental carrying capacity, as well as URI goal indices containing income-consumption level and public service level, are higher in Inner Mongolia than in other regions. Heilongjiang and Jilin have relatively lagging drivers of URI but relatively smaller gaps in the URI goal. Gansu, Qinghai, Ningxia, Xinjiang and Yunnan all lagged relatively behind overall.

4. Discussion

4.1. URII changes associated with urban-rural relationships

This paper constructed a BDG framework of URI based on its basis, driver and goal and measured its development level indexed by URII. The results show that the URII showed a U-shaped curve from 2000 to 2018, with 2006 as the inflection point, which is closely related to the evolution of the urban-rural relationship in China. Prior to 2002, under the national goal of focusing on economic construction and rapidly promoting urbanization, one-way circulation of urban-rural elements led to a serious lag in rural development and a low level of URI (Zhou, Qin, Liu, Zhu, & Zou, 2019). After 2003, the urban-rural relationship underwent a major transformation, and the state adopted a series of policies to promote rural development. China has introduced major strategies such as coordinated urban-rural development (*cheng xiang tong chou*), new socialist countryside construction, and new urbanization, which have made important arrangements to achieve coordinated and integrated urban-rural development. Coordinated urban-rural development was intended to fundamentally restructure economic and social relationships between cities and countrysides to produce a more equitable and harmonious society (Chen et al., 2019). By 2012, the development of urban-rural relationships in China gradually improved further, and the implementation of urban-rural unity (*cheng xiang yi ti hua*) strategies began, marking the gradual shift of urban-rural relationships from antagonism to coordination and integration. In 2017, China proposed the implementation of a rural revitalization strategy to promote urban-rural integration (*cheng xiang rong he*) for the first time, marking the beginning of the urban-rural relationship from coordination to integrated development, reflecting a significant conceptual shift. As a result, the URII increased from 2006 to 2018. Researchers constructed the urban-rural integration index in terms of population-spatial-economic-social-environment and concluded that the inflection point of urban-rural integration was in 2002 (Zhou, Qin,

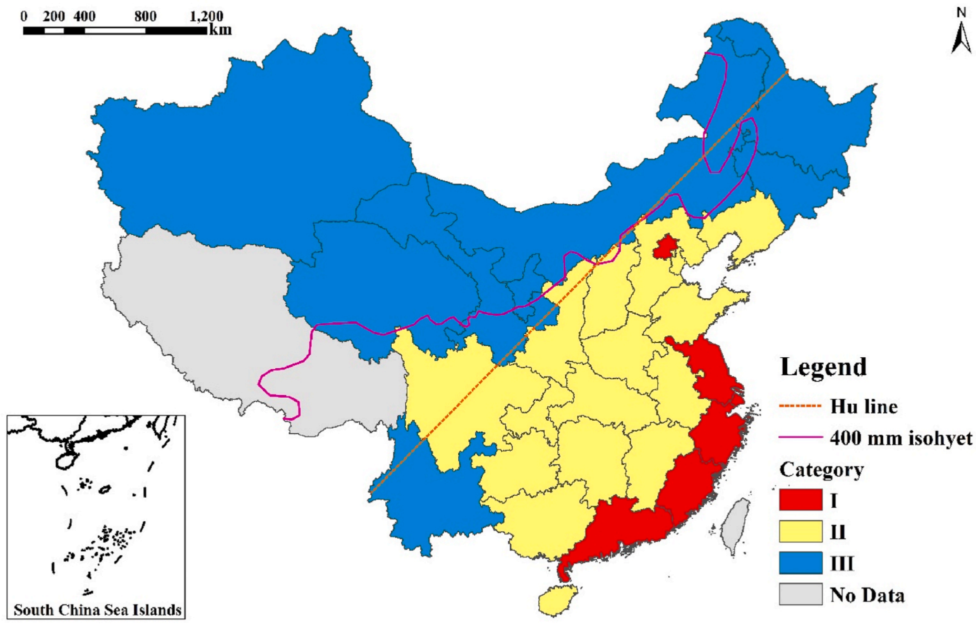

Fig. 9. Spatial distribution of URI types in 2018.

Table 4
The scores and orders of the URI second-level indices in 2018.

Region	Category	Population mobility	Land mobility	Capital mobility	Technology mobility	Industry interaction	Transportation information network	Environment carrying capacity	Income & Consumption level	Public Services level	Integration index	Rank
Beijing	I	3	2	4	2	2	6	2	4	23	1	High
Shanghai	I	2	1	3	5	1	9	8	6	2	6	
Jiangsu	I	4	6	8	3	6	4	3	12	1	7	
Zhejiang	I	5	5	6	4	11	2	13	2	18	3	
Fujian	I	14	3	9	10	16	16	15	1	3	5	
Guangdong	I	1	4	2	1	28	1	10	10	11	2	
Tianjin	II	6	7	1	8	3	27	17	22	27	4	
Hebei	II	12	14	16	18	23	7	6	8	14	15	
Shanxi	II	24	23	19	20	4	18	14	27	29	30	
Liaoning	II	11	24	5	17	18	19	19	7	28	9	
Anhui	II	13	19	12	6	17	15	9	30	24	21	
Jiangxi	II	15	15	11	11	21	28	11	21	22	12	
Shandong	II	10	11	10	9	10	5	1	15	10	13	
Henan	II	7	13	14	12	13	12	5	17	9	16	
Hubei	II	9	10	13	7	12	24	16	29	21	23	
Hunan	II	8	9	18	13	8	20	21	25	17	26	
Guangxi	II	20	18	17	16	26	22	22	9	19	8	
Hainan	II	26	8	20	22	30	30	20	26	15	20	
Chongqing	II	16	16	7	15	5	29	24	28	30	24	
Sichuan	II	17	17	22	14	24	8	18	24	26	19	
Guizhou	II	19	22	21	19	20	13	23	13	13	11	
Shaanxi	II	18	12	15	21	7	14	27	16	8	22	
Inner Mongolia	III	23	25	30	25	19	3	4	5	5	17	
Jilin	III	22	27	24	26	14	23	28	11	12	18	
Heilongjiang	III	21	30	28	29	29	21	30	3	20	10	
Yunnan	III	28	21	23	24	25	11	26	20	4	27	
Gansu	III	25	29	29	28	15	26	25	14	16	28	
Qinghai	III	30	20	27	30	22	10	29	19	25	14	
Ningxia	III	29	28	26	23	9	17	12	23	7	29	
Xinjiang	III	27	26	25	27	27	25	7	18	6	25	Low

Liu, Zhu, & Zou, 2019). In addition, Chen et al. (2020) discovered that urban-rural integrated development has improved since 2005. However, this study found the point was 2006, because there are differences in the evaluation index systems established on the one hand, and on the other hand, only two cross-sectional data are used between 2000 and 2006 in this study on condition of data deficiency which might influence the accuracy of the result. However, it should also be noted that this may be caused by the lag effect of policy implementation. Therefore, if we need to identify the specific inflection point of the urban-rural integration level, it is necessary to carry out the measurement of the URII year by year to better grasp the temporal change pattern of urban-rural integration.

4.2. Policy implications in different URI types

Entering a new era, the main contradiction of society in China has changed to the contradiction between people's growing need for a better life and unbalanced and insufficient development. Unbalanced and insufficient development is embodied not only in the region but also in urban and rural areas. Urban-rural integration is the developmental path of the new urban-rural relationship, and the measurement of the level of urban-rural integration nationwide can provide a reference for policy making. The analysis of this study shows that the problem of unbalanced regional development is still very prominent. The coordinated development of urban-rural integration in each region is conducive to improving the level of urban-rural integration development in the whole region. At the same time, increasing the ability of URI high-level regions to stimulate others can drive the development of URI low-level regions. Although the regional development imbalance has been narrowed according to the change in the URII and its three indices (i.e., BI, DI, GI) over time, the development imbalance still needs to be given great attention in terms of the development level of each region and the later development trend.

The research results show that the hot spots of the URII are concentrated in economically developed regions such as Beijing, Tianjin, Shanghai and Fujian, and the cold spots are mainly distributed in the transition zones of central and western China such as Sichuan, Hubei, Shaanxi and Gansu, which are the links between the central and western regions. The clustering results indicate that the URI level in China presents a gradient change of decreasing from the southeast coast to the northwest and is divided into three major types according to both the three first-level indices and the nine second-level indices, which should be zoned and classified to promote national urban-rural integration development in the future. Type I areas are in the development mode with a high level of URI. In these regions, the factor flow and industrial interaction between urban and rural areas, transportation information network and environmental carrying capacity, income consumption level and public service level are in the integration stage. These areas should give full advantage to their existing strengths to strengthen the radiation-driven effect on neighboring regions and use their good location advantages and economic strength to form the economic growth mode of innovation-driven development to achieve a higher level of integration (Zhou, Qin, Liu, Zhu, & Zou, 2019). Type II regions should pay attention to the inconsistency between the living standards and consumption levels of urban and rural residents, promote the equalization of urban and rural public services and products, and improve the differential resource supply (such as medical, health and education, etc.) between urban and rural areas. For Type III, the free flow of regional population, land, capital and technology, and industrial interaction should be actively promoted when the construction of a transportation information network between urban and rural areas should be strengthened to enhance the urban-rural interconnection capacity.

4.3. Development path of urban-rural integration

The basis of URI includes five indicators in this study, i.e., population flow, land flow, capital flow, technology flow and industrial interaction. According to the above analysis, the levels of population flow and land flow between urban and rural areas are the highest, the level of industrial interaction is the second highest, and the levels of technology flow and capital flow are the lowest. Urban-rural integration in the context of rural revitalization should unify urban and rural market factors, promote equal exchange and bidirectional flow of factors, and promote the integrated development of industries and cities to strengthen industrial support (Fig. 10). Specifically, (1) it is suggested to accelerate the transfer of surplus rural labor in the process of urbanization, improve the quality of citizenship of the agricultural transfer population, and introduce high-quality labor factors into the countryside to optimize the labor allocation in urban and rural sectors. The revitalization of rural industries requires the cultivation and introduction of new professional farmers, which requires investment in rural human capital and at the same time attracts a group of technicians and college graduates to wait for rural entrepreneurship and drives the flow of high-quality factors to rural areas. The "*Key Tasks of New Urbanization and Urban-Rural Integration Development in 2021*" has explored the mechanisms by which people work in rural areas, such as scientific researchers, science and technology commissioners, returned migrant workers, rural employees and entrepreneurs. The household registration system was found to have acted as an obstacle to integration due to its exclusion of rural immigrants from welfare benefits (Li & Hu, 2015). Therefore, in the process of promoting the urban-rural bidirectional flow of the population, the key is to promote the reform of the urban and rural household registration system and abolish unfair policies for farmers who go to cities for work. (2) It is necessary to rationalize the flow of urban capital to rural agriculture and optimize the allocation of capital between urban and rural areas. On the one hand, we should encourage financial resources to tilt to rural areas, provide rural inclusive finance, and fully activate the rural financial service chain; on the other hand, we should introduce social capital to rural areas, build a reasonable and close interest linkage mechanism with farmers, create a good business environment, and stimulate enterprises to invest in agriculture enthusiastically. (3) There is a need to promote rural land transfer in an orderly manner, accelerate property reforms and improve the "three rights division" of rural land ownership (i.e., collective ownership of land, contracted management rights, land management rights) (Liu et al., 2020). Meanwhile, we need to revitalize rural idle homesteads and houses and then the property income of farmers. Land is the link of urban-rural territory system. Improving the contribution of land elements is also considered to be a vital path for urban-rural integrated development in China (Yan et al., 2018). Studies regard the securing of property rights as instrumental to economic development (Galiani & Schargrodsky, 2010). (4) Technical support for rural areas needs to be strengthened. Science and technology innovation is the power source of modern agricultural development, and it is urgent to accelerate the construction of agricultural science and technology innovation systems and improve agricultural innovation, competitiveness and total factor productivity. Thus, it is necessary to crack the bottleneck constraints of talent, create investment and financing channels, meet land demands, and develop new industries and

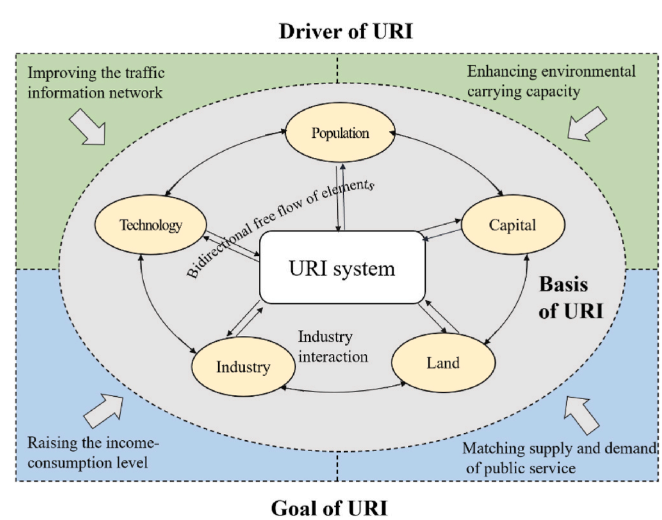

Fig. 10. Path of urban-rural integration.

new business modes to accelerate the coupled development of people-land-industry-capital (Liu et al., 2020). Only by effectively solving the problems of population, land, capital and technology in the process of urban-rural development can we provide an important guarantee for the integrated development of urban and rural areas.

In this research, the driver of URI includes 2 indicators: transportation information network and environmental carrying capacity. Overall, the transportation information network lags behind, and there is room for further improvement. The interconnection of urban and rural transportation plays a fundamental role in boosting urban-rural integration. Therefore, both the central and local governments should put more resources into the construction and upgrading of major transportation arteries, especially in expanding and improving the transportation network and information network between cities and villages, so that the carrier of factor flow between urban and rural areas can be effectively utilized. For the environmental carrying capacity, it is necessary to further improve the treatment rate of urban domestic garbage, industrial pollution and sewage by strengthening regulations, promoting the adoption of sanitary toilets in rural areas, and building a profound environmental governance system to realize coordinated urban-rural ecological protection. Shen et al. (2012) also pointed out that fairness of investment supervision and administration is especially important in the context of urban-rural coordinated development in China, and the fairness of investment environment involves 3 indicators, i.e., fairness of urban and rural natural resources, fairness of urban and rural public resources, and fairness of urban and rural energy supply.

The goal of the URI includes indices related to income consumption and public services. The research results show that the integration of urban-rural public service in China is lower than the integration of income consumption level, for which the development of urban-rural income consumption level and public service level should be actively improved. At the level of income consumption, the main objective is to increase the income of urban and rural residents through multiple channels and improve the capacity and level of domestic consumption. The outline of the 14th Five-Year Plan clearly proposes to focus on raising the income of low-income groups and expanding the middle-income group, that is, to closely address the main contradiction of unbalanced and inadequate development, to focus on narrowing the gap between urban and rural regional development and income distribution and to solidly move forward common prosperity. According to data from the National Bureau of Statistics, wage income is the primary source of farmers' income, and the share of wage income in farmers' per capita net income was 41.02% in 2018, so it is necessary to continue to promote urbanization, attract a part of surplus rural labor force to transfer to cities and increase farmers' income; however, reform and innovation should be used to stimulate endogenous sources of income for farmers, promote the development of local industries, raise the income level of residents through multiple channels, and promote the development of consumption toward green, healthy and safe. Public services need to meet the most urgent needs of farmers and promote the equalization of basic public services such as compulsory education, medical and health care, culture and sports, and social security in rural areas. Given that the public service needs of farmers in each village are different, it is necessary to provide differentiated rather than one-size-fits-all public services on a case-by-case basis to match the supply and demand of public services.

5. Conclusions

This paper proposes a process-oriented framework of urban-rural integration in the context of rural revitalization. From a multidimensional perspective, this research selects 39 indices based on the basis, driver and goal of URIs and then measures the level of China's urban-rural integration at the provincial level using the URII as a proxy. This study will provide a good understanding of the formation, regional disparity and evolution of urban-rural integration at the provincial level in the new century and serve as a scientific reference regarding decision-making in rural sustainability. Our results show that: (1) the overall ranking of the three subdimension indices of URII was as follows: GI > DI > BI. However, the growth rate showed a reverse trend. (2) The URII in China was relatively low, and it presented a U-shaped curve with 2006 as the inflection point, closely related to the evolution of China's urban-rural relationship and the implementation of rural policies. (3) The URII had obvious spatial agglomeration. The URII of the four major economic regions in eastern, middle, western, and northeastern China showed the characteristic of "high in the east and low in the western and central regions". The analysis of cold/hot spots showed that the hot spots of the URII include Beijing and Tianjin, which are the economic centers in northern China, and Shanghai, Zhejiang and Fujian in China's southeastern coast, while the cold spots were mainly concentrated in the transition zones of the central and western regions, such as Sichuan, Hubei, Shaanxi and Gansu. (4) The URII of China was divided into three types, namely, high-level coordination type, medium-level imbalance type, and low-level lagging type. The three types show gradual gradients from the southeast coast to the northwest. Urban-rural integration in the context of rural revitalization should strengthen the URI basis by unifying urban and rural market elements, promoting equal exchange of elements and bidirectional free flow, and promoting industry-city integration development. At the same time, it is necessary to improve the construction of transportation information networks and environmental carrying capacity for the flow of factors between urban and rural areas and actively improve the development of urban-rural income and consumption levels and public service levels to ensure the high-quality development of urban-rural integration.

Author statement

Yuanyuan Yang: Conceptualization, Methodology, Data curation, Formal analysis, Writing – original draft, Writing – review & editing, Funding acquisition. Wenkai Bao: Data curation, Software, Formal analysis, Visualization, Writing – original draft. Yongsheng Wang: Data curation, Investigation, Software. Yansui Liu: Conceptualization, Supervision, Funding acquisition.

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