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Analysis on the Coupling Coordination Degree between Urban-Rural Construction Land and Economic Growth Rate in the Central Plains Urban Agglomeration

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Abstract:

This paper selects 30 cities in Central Plains urban agglomeration as spatial units. The coupling coordination degree and relative development degree between urban-rural construction land and economic growth rate in different development stages of cities in Central Plains urban agglomeration are calculated and analysed based on the area of urban-rural construction land and Annual Gross Regional Product (GDP) in each town in the past 20 years (2001-2020). The research shows that, in the past 20 years, the coupling coordination degree between urban-rural construction land and economic growth rate in the Central Plains urban agglomeration has generally developed toward a high value. In the high-level coupling stage, cities tend to change from northwest to Southeast in space. Secondly, from the perspective of relative development degree, the spatial differentiation of development characteristics of cities is apparent, and the changes of cities along and to the north of the Yellow River are the most significant. Almost all of them are characterised by economic growth lagging behind the growth of urban-rural construction land. We should pay attention to optimising the regional development model in time.

Keywords*: coupling coordination degree; relative development degree; urban-rural construction land; economic growth; Central Plains urban agglomeration*

I. INTRODUCTION

The Central Plains urban agglomeration spans 30 cities in 5 provinces of Shanxi, Hebei, Shandong, Henan and Anhui. It is a crucial urbanisation agglomeration area and economic growth plate in central

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China and plays an important strategic position in the high-quality development of the Yellow River Basin [1]. As early as the 1980s, some scholars proposed to build a cross-provincial Central Plains Economic Zone with Zhengzhou as the centre [2]. After 2000, the connotation and extension of the Central Plains urban agglomeration and the Central Plains Economic Zone have continued to expand. Many scholars have conducted in-depth research and discussion on their integration and development [3-5]. In November 2012, the State Council approved the "Central Plains Economic Zone Planning", and the inter-provincial Central Plains town system was officially recognised. In December 2016, the State Council approved the "Central Plains Urban Agglomeration Development Plan". The National Development and Reform Commission formally issued the "Thirteenth Five-Year Plan for Promoting the Rise of the Central Region". The development of the Central Plains urban agglomeration entered the fast lane.

An urban agglomeration is an advanced form of urbanisation development and the primary carrier of the regional economy and human settlements. Since entering the 21st century, China has experienced the economic transformation from high-speed to high-quality, and urbanisation from rapid to new development [6]. In this process, the urban-rural construction land within the urban agglomeration is bound to be affected by regional economic growth. In recent years, the research on urban-rural construction land and its related factors has gradually become a hot spot. For example, many studies on a single city: Yuan Yuan, Luo Zhijun, and others took Nanchang as an example to evaluate the urban-rural construction land potential at the urban scale [7]. Xing Ying et al. used the coupling coordination degree model to study the coordination of land-use change and economic growth in Duyun [8]. Chen Zhenyu et al. evaluated the coupling and coordination relationship between land use benefit and urbanisation in Xi'an [9]. There has also been a lot of progress at the scale of urban agglomerations. Li Zaiyan, Shi Peiji and others used comprehensive indicators to analyse the spatial pattern characteristics of the development intensity of construction land in Lanxi urban agglomerations [10]. Ma Xin, He Shumin and others used urban construction land data to analyse the spatiotemporal pattern characteristics and driving factors of urban land expansion in the Central Plains urban agglomeration [11]. Zhang Haipeng, He Renwei and others explored the coupling and coordination relationship between the urban-rural population and construction land in Henan Province [12]. It can be seen from the relevant literature that the coupling and coordination relationship between urban-rural construction land and other factors is a recent research hotspot. Still, there is no in-depth research on the relationship between urban-rural construction land and economic growth within the urban agglomeration scale. At the same time, in terms of urban-rural construction land, due to the great difficulty in obtaining data, there are many studies on a single city, but few studies on a large scale area; few studies are comparing the indicators of rural construction land. This study analyses the coupling coordination degree of urban-rural construction land and economic growth rate in the Central Plains urban agglomeration based on long-span and high-precision data.

II. DATA AND METHODS

(1) Data Sources

The study takes the 30 prefecture-level cities of the Central Plains urban agglomeration as the spatial unit and selects the period from 2000 to 2020 as the analysis period. Given the regional economic

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development and the expansion of the construction land scale in certain stages, combined with the actual situation in China, the total period is divided into 2000-2005, 2005-2010, 2010-2015, 2015-2020 Four sub-periods.

(2) Methods

Step.1

This study first calculated the urban-rural construction land growth rate *LR* and economic growth rate *ER* of 30 cities through Formula 1 and Formula n 2.

$$LR = \frac{L_b - L_a}{L_a} \qquad (1)$$

Formula 1 L_a is the total area of urban-rural construction land in the beginning year of the stage and L_b is the total area of urban-rural construction land in the last year of the stage.

$$GR = \frac{G_{max} - G_a}{G_a} \qquad (2)$$

In Formula 2, G_a is the gross regional product (GDP) at the beginning of the stage and G_{max} is the highest value of the regional GDP in the stage. Since the comparison is based on stages, the growth rate of the regional GDP can be matched with the difference in the growth of urban-rural construction land by taking the highest value in the stage minus the initial value of the stage.

Step.2

There are many ways to standardise the data [14,15]. This paper uses the maximisation method to standardise the indicators (Formula 3-4). The advantage of this labelling process is that the highest value of the sequence is 1, but the minimum value is not fixed.

$$\overline{LR_{ij}} = \frac{LR_{ij}}{max(R_j} \qquad (i = 1,2,\cdots,n;\ j = 1,2,\ \cdots,m) \qquad (3)$$

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$$\overline{GR_{ij}} = \frac{GR_{ij}}{\max(GR_j)} \qquad (i = 1,2,\cdots,n;\ j = 1,2,\ \cdots,m) \qquad (4)$$

In Formula 3 and Formula 4, $\overline{LR_{ij}}$ and $\overline{GR_{ij}}$ are respectively the growth rate of urban-rural construction land and the economic growth rate in the stage after standardisation, LR_{ij} and GR_{ij} are the original values, $\max(LR_j)$ and $\max(GR_j)$ are the maximum values in the same index sequence of prefecture-level cities.

Step.3

The coupling coordination degree calculation is next based on the above values. The term "coupling" comes from physics and refers to a phenomenon influenced by the interaction between two or more factors or systems [16]. Many disciplinary institutes have borrowed the coupling at present. In this paper, the coupling degree *C* can reflect the interaction between the growth rate of urban-rural construction land and the economic growth rate, which can be expressed by Formula 5. The comprehensive evaluation index *T* between the growth rate of urban-rural construction land and the economic growth rate can be represented by Formula 6.

$$C = 2\sqrt{\frac{\overline{LR_{ij}} \times \overline{GR_{ij}}}{(\overline{LR_{ij}} + \overline{GR_{ij}})^2}} \qquad (5)$$

$$T = \alpha\,\overline{LR_{ij}} + \beta\,\overline{GR_{ij}} \qquad (6)$$

The codes in Equation 5 and Equation 6 have the same meaning as in Equation 3 and Equation 4. where α and β represent undetermined coefficients and α+β=1. Since both metrics are considered equally important, both α and β are equal to 0.5.

The coupling coordination degree *D* can be expressed and calculated by Formula 7.

$$D = \sqrt{C \times T} \qquad (7)$$

The value range of *D* in Formula 7 is [0,1]; the more significant the value, the better the coordination state, the smaller the deal, the worse the coordination state.

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The relative development degree E is the relative development level that can compare the growth rate of urban-rural construction land and the economic growth rate in the region, expressed by Formula 8.

$$E = \frac{\overline{LR_{ij}}}{\overline{GR_{ij}}} \quad (8)$$

Referring to relevant research literature [10,16-18], combined with the coordinated development and relative development of urban-rural construction land growth and economic growth in the Central Plains urban agglomeration, it can be divided into the low-level coupling, antagonistic stage, running-in stage and high-level coupling. This detailed classification can be found in TABLE I

TABLE I. Coupling coordination development stage and type table

STAGE	RANGE OF D	RANGE OF E	TYPE
LOW-LEVEL COUPLING	0＜D≤0.4	0＜E≤0.8	Ⅰ
		0.8＜E≤1.2	Ⅱ
		1.2＜E	Ⅲ
ANTAGONISTIC STAGE	0.4＜D≤0.6	0＜E≤0.8	Ⅳ
		0.8＜E≤1.2	Ⅴ
		1.2＜E	Ⅵ
RUNNING-IN STAGE	0.6＜D≤0.8	0＜E≤0.8	Ⅶ
		0.8＜E≤1.2	Ⅷ
		1.2＜E	Ⅸ
HIGH-LEVEL COUPLING	0.8＜D≤1	0＜E≤0.8	Ⅹ
		0.8＜E≤1.2	Ⅺ
		1.2＜E	Ⅻ

III. RESULTS AND ANALYSIS

By substituting the calculation results of the coupling coordination degree into the geographic information software, ArcGIS, combined with the index classification (Table 1), the spatial pattern of the coupling coordination degree between urban-rural construction land and economic growth rates in different periods in the Central Plains urban agglomeration can be generated. In Fig 1, it can be seen from the figure that there are apparent spatial differences in the coupling coordination degree between urban-rural construction land and economic growth rate in the 30 prefecture-level cities of the Central Plains urban agglomeration in different times periods.

As shown in Fig 1, from 2000 to 2005, the coupling coordination between urban-rural construction land and economic growth rate in the Central Plains urban agglomeration was high in the northwest and low in the southeast. From 2005 to 2010, the coupling coordination degree of all cities has improved as a whole

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except Luohe. The number of cities in the high-level coupling stage has been increased to 5. The number of cities in the run-in stage has risen to 19, the number of cities in the antagonistic stage has dropped to 6, and there are no cities in the low-level run-in stage. Although the value of the coupling coordination degree has been improved in an all-around way, it is still high in the northwest and low in the southeast from the perspective of the spatial pattern. From 2010 to 2015, the number of cities in the high-level coupling stage rose to 8. The number of cities in the running-in stage has been increased to 20, while there are only two cities in the antagonistic stage, and there are no cities in the low-level running-in stage. The most prominent feature of this period is that the coupling coordination degree has evolved into a spatial pattern of high southeast and northwest low. From 2015 to 2020, the degree of coupling coordination has declined relatively, but it is still a spatial pattern of high in the southeast and low in the northwest. There is only one city in the southeast of Fuyang in the high-level coupling stage. There are still 17 cities in the running-in phase and ten cities in the antagonistic stage. Handan and Sanmenxia have dropped to a low-level running-in stage. Although the core city of Zhengzhou has fallen to the running-in stage, the coupling coordination degree is still high (0.791), close to the standard of the high-level coupling stage (0.800).

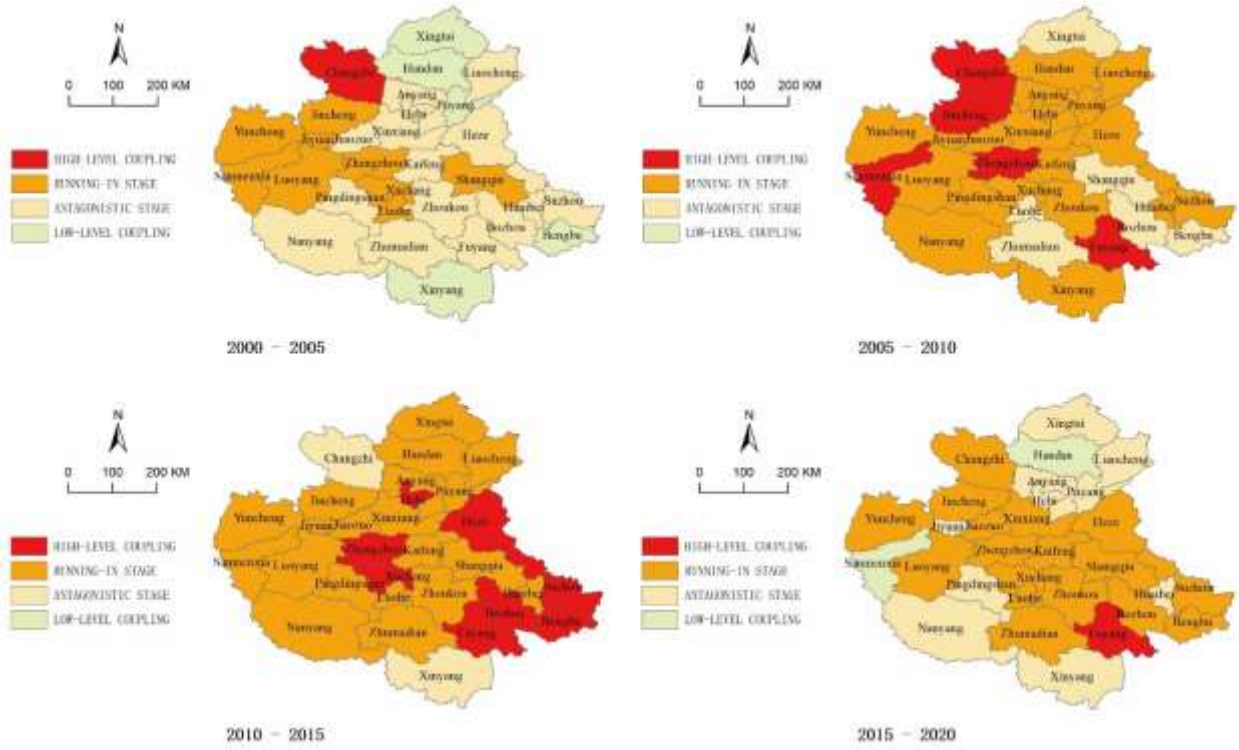

Fig 1: Spatial pattern of coupling coordination degree between urban-rural construction land and economic growth rate in different periods of the Central Plains urban agglomeration

Using the same method, the calculated value of the relative development degree is substituted into ArcGIS to generate Fig. 2.

As shown in Fig 2, from 2000 to 2005, Among the 30 prefecture-level cities in the Central Plains urban agglomeration, the relative development degree of 28 cities is lower than 0.8, which is characterised by the

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fact that the growth of urban and rural construction land lags behind the economic growth. This indicates that this period is a period of rapid economic development. From 2005 to 2010, the overall spatial pattern did not change much. From 2010 to 2015, the number of cities with the characteristics of simultaneous development of urban-rural construction land and economic growth increased significantly. From 2015 to 2020, the relative development degree showed a pronounced spatial differentiation, and the entire urban agglomeration was divided into three sections. The cities along the Yellow River and its northern areas have shown strong economic growth lagging behind the development of urban-rural construction land. The southeastern cities of the Central Plains urban agglomeration are still characterised because the growth of urban-rural construction land lags behind the economic growth.

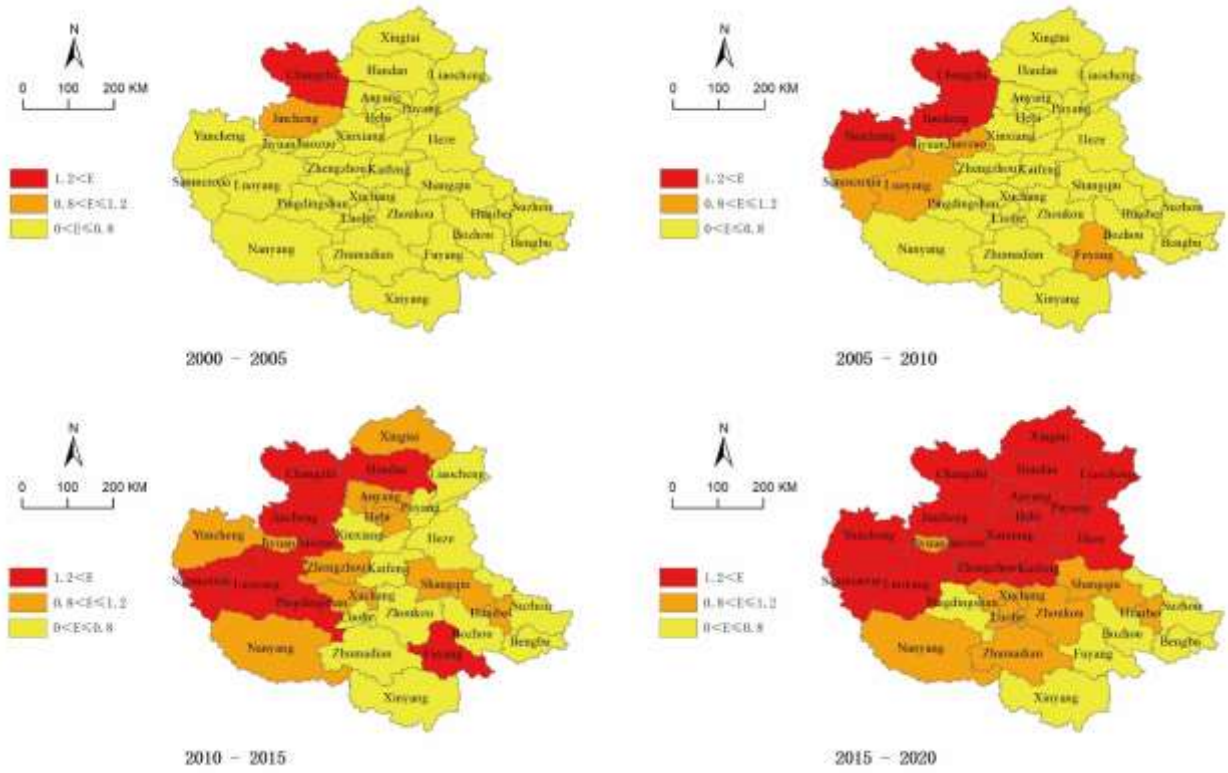

Fig 2: Spatial pattern of relative development degree of urban-rural construction land and economic growth rate in different periods of the Central Plains urban agglomeration

IV. CONCLUSION AND DISCUSSION

This paper uses 30 prefecture-level cities in the Central Plains urban agglomeration as spatial research units. By calculating the coupling coordination degree and relative development degree, the urban domains of different periods in other cities in the Central Plains urban agglomeration are classified. This study draws the following conclusions:

(1) Judging from the coupling coordination degree between urban-rural construction land and economic growth rate, the Central Plains urban agglomeration cities have generally developed toward

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high value over the past 20 years. The spatial pattern evolved from most cities in the antagonistic stage at the beginning of the study period to the form of the majority of cities in the run-in stage. Cities in the high-level coupling stage tend to change from northwest to southeast in space. At the end of the study period, Handan and Sanmenxia dropped to the low-level coupling stage, which needs to be observed.

(2) From the perspective of relative development degree, each city's spatial differentiation of development characteristics is significant. Almost all the cities along and north of the Yellow River had the part that the growth of urban and rural construction land lagged behind the economic growth from 2000 to 2005. However, in the 2015-2020 time period, they have become the characteristics of economic growth lagging behind the growth of urban and rural construction land. This change illustrates an agglomeration shift in the regional development model. In the Central Plains urban agglomeration southeast, Xinyang, Bozhou, Bengbu, and Suzhou have always characterised urban and rural construction land growth lags behind economic growth.

Coupling coordination degree is a relative concept, and numerous associated indicators should be comprehensively considered in the freedom of time and space. In the first ten years of the study period (2000-2010), cities such as Changzhi in the northwest have a high degree of coupling and coordination. Still, their economic growth lags behind the development of urban-rural construction areas. This shows that the low coupling degree of other cities in the Central Plains urban agglomeration is caused by the growth of urban-rural construction land lags behind the economic growth. In the last ten years of the study period (2010-2020), the coupling coordination degree of each city has improved. Still, the spatial pattern of development models is significantly different, reflecting the spatial agglomeration effect of development models. It can be understood that the economic model of urban-rural construction still drives the southeastern region of the Central Plains urban agglomeration. From the perspective of development trends, the spatial agglomeration effect of the coupling coordination degree between urban-rural construction land and economic growth rate among cities in the Central Plains urban agglomeration gradually strengthens the regional integration development trend.

This study suggests that the southeastern cities of the Central Plains urban agglomeration should increase urban-rural construction accordingly and coordinate the relationship between economic and spatial development. This study also suggests that the urban agglomeration along the Yellow River in the Central Plains and the northern cities should ensure the quality of urban-rural construction, optimise the industrial structure, and steadily increase the rate of economic growth.

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