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Regenerative Design - Climate Adaptation & Mitigation
Circular Economy - Citizen Agency - Urban Livability

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Spatial and temporal evolution of urban reserve available land resources in the Karst region of North China from 1990 to 2020: a case study of Jinan city

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Abstract

With the rapid development of urbanization, land resources are mainly converted into urban areas in most karst mountain regions of North China over the last decade, so studying available land resources would have implicational significance to regional planning and sustainability. Based on RS, GIS, DEM, slope information and the evaluation methods for reserve available land resource, this study explored the spatial and temporal evolution of urban reserve available land resources from 1990 to 2020 in Jinan city, which is located in the karst region of North China. The results reveal that the potential of the reserve available cultivated land in Jinan city is large, covering an area of 360.67 km², and the differences of reserve available cultivated land for each district are mainly caused by the combined effects of regional conditions, economic conditions, population, and industrial zones. The area of reserve suitable construction land in Jinan city is 292.48 km², which is decreasing and mostly in the southern part of the study area. Based on the overlap and differences of the two types of land, combined with regional socio-economic development and natural environmental conditions, the reserve land resources in the southern region of Tian Qiao, Chang Qing and North Huai Yin, Shi Zhong, and Li Xia within the study area can be converted into construction land, but the reserve land resources in the central and southern regions of Li Cheng and the central and southeastern regions of Chang Qing can be converted into new cultivated land.

Keywords

Reserve available land resources; Reserve available construction land; Reserve available cultivated land; Jinan city; China's North Karst

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1. Introduction

Land resources are an essential material basis for human survival and social and economic growth in the world (Yeeles, 2019; Katharine et al., 2019) and also a unique and finite economic resource with diverse uses for various land uses that cannot be separated from the urbanization process (Ziari et al., 2025; Papa, 2025). With the rapid urban expansion on a global scale, land resources are mainly converted into urban areas (Di Giacomo, 2015; Xu et al., 2012; Adam, 2020; Keith et al., 2021; Garau et al., 2023; Ziari et al., 2025). In recent decades, China has achieved rapid economic growth, large-scale industrialization, and urbanization since it initiated economic reforms and an open-door policy in 1978. At the same time, the contradiction between economic and social development and land resources is becoming increasingly serious, and the inefficient use of land resources and ecological space extrusion pose significant challenges to urban sustainable development (Feng et al., 2024; Zhou, 2025; Vishal & Damodaran, 2026). In the context of rapid urbanization process, the prominent performance is that the expansion of urban construction land brought about a sharp decline in the amount of arable land (Deng et al., 2015; Özkan et al., 2025). Moreover, the scale of urban construction land will continue to expand, which inevitably continue to occupy arable land with the future economic and social development, thereby resulting in the reduction of the amount of arable land, and posing a threat to food security (Zhou et al., 2021; Deng et al., 2015).

Notably, China is one of mountainous and hilly countries in the world, and its karst mountainous geological area accounts for 25% of the world's carbonate rock (Jiang & Yan, 2010). Because the fragile karst ecosystems develop on carbonate rock (e.g. limestone or dolomite) and are characterized by slow-forming soils that are generally infertile, thin, and susceptible to degradation and loss by erosion (Cheng et al., 2016), the area of arable land in karst regions is limited, and the karst topography specifically complicates land reserve evaluation. The China's karst mountainous regions cover an area about 344×10^4 km², which consists of the China's South Karst and North Karst (Lu, 1986). Owing to the rapid development of urbanization and irrational human activities, the China's karst mountainous regions have undergone the spatial pattern change of land use in recent years, especially in the urban karst mountainous region of North China (Qi & Zhang, 2011; Xu et al., 2012; Zhang et al., 2018), thereby affecting the city's sustainable development of land resources.

In this context, in order to meet the needs of future economic and social development for new construction land, while ensuring national food security, it is an inevitable choice to develop a part of reserve usable land resources in a timely and appropriate amount (Yang et al., 2019). Reserve available land resources refer to the potential or surplus land in a region, which can be used for newly-added cultivated land or newly-added construction land. The reserve available land resources mainly include two types, namely the reserved land suitable for construction and for cultivation (Xu et al., 2010; Xu et al., 2025). Moreover, it can be used to evaluate the carrying capacity of land resources within a region for future agricultural development or population gathering, industrialization, and urbanization.

Nowadays, many case studies have been reported for the reserved land suitable for cultivation (Kim et al., 1999; Reshmidevi et al., 2009; Feizizadeh & Blaschke, 2013; Jin et al., 2013) or the reserved land suitable for construction (Xu et al., 2011; Dang et al., 2014; Xu & Xu, 2016). But most of studies have only focused on a single type of reserve available land resources potential calculation. Moreover, the contradiction and conflict between the reserve suitable land for construction and the reserve suitable land for cultivation have not been fully considered and resolved, particularly for the cities located in the China's North Karst. Therefore, it is highly required to study in-depth the reserve available land resources within the cities.

Jinan city is one of cities belonging to the China's North Karst, and well known as the City of Springs. It has undergone increasingly rapid urban expansion, especially in its urban karst mountainous area in recent years (Qi & Zhang, 2011; Xu et al., 2012), thereby profoundly resulting in the spatial pattern change of urban land resources within city. Therefore, the aim of this study is to evaluate the reserve available land resources

from 1990 to 2020, further probe into Jinan city's regional orientation, thereby achieving urban sustainable development of land sources of Jinan city.

2. Materials and methods

2.2 Study area

Jinan city ($116^{\circ} 49' - 117^{\circ} 14' E$, $36^{\circ} 32' - 36^{\circ} 51' N$) is located in the China's North Karst, and is the capital city of Shandong Province. It exhibits a typical warm-temperate, semi-humid, continental monsoon climate, and well-defined seasons. The mean annual temperature is $14^{\circ} C$, and the average mean precipitation 650–700 mm (Qi et al., 2020). The area in this study covers 3257 km². Administratively, the study area includes 6 districts, namely Tian Qiao, Huai Yin, Li Xia, Li Cheng, Shi Zhong, and Chang Qing (Fig.1). In recent years, Jinan city has undergone a rapid process of urban expansion, and its urbanization rate reached 72.1%. For instance, the urban area of Jinan city increased from 23.2 km² in 1948 to 561 km² in 2020, and its main types of land use within the city were cultivated land and construction land (Shandong province bureau of statistics, 2021). By 2020, the area of cultivated land and construction land was 1,373 km² and 922 km², respectively.

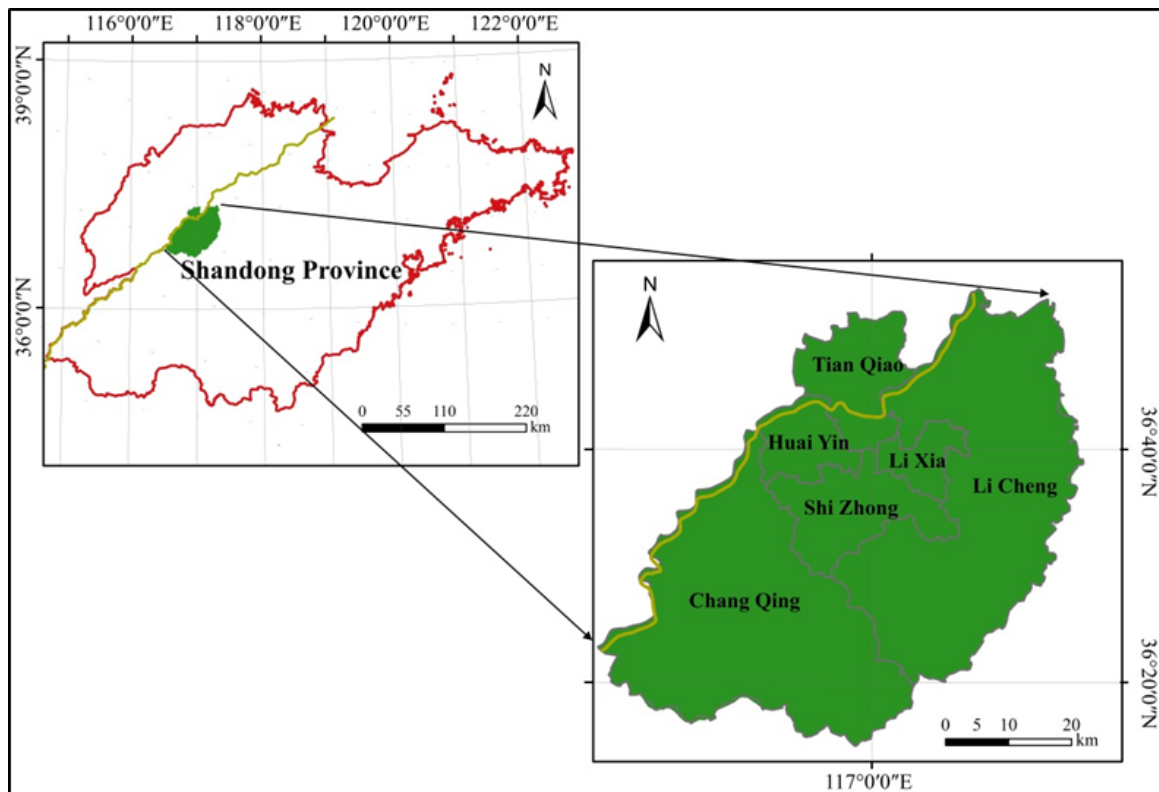


Fig.1 Location map of study area

2.2 Data sources

The land use data taken in 1990, 2000, 2010, and 2020 were obtained from remote sensing data Landsat images at 30-m spatial resolution. The land cover was classified into six types applicable to the study area, that is, cultivated land, forestland, grassland, water, construction land, and unused land listed in the Resources and Environmental Database Center of the Chinese Academy of Sciences (<https://www.resdc.cn/>). On the other hand, an object-based image analysis (OBIA) approach to the satellite interpretation, which was described in detail by previous studies (Congalton, 1991; Walker & Blaschke, 2008; Wang et al., 2013,

2016; Zhu et al., 2019), was used to detect land use landscape types and interpret the land cover map by eCognition software in the study area.

2.3 Methods

The reserve available land resources are mainly divided into the reserved land suitable for construction and the reserved land suitable for cultivation (Xu et al., 2010; Xu et al., 2025), whose spatial distribution has the characteristics of overlap and difference. The former belongs to the reserved suitable cultivated land when the slope of the terrain is less than 15°, that is, if the reserved available land resources can be used as new construction land in the future, it can also be used as new cultivated land. The latter lies in the value of slope, which is $\leq 15^\circ$ for reserve land suitable for construction and $\leq 25^\circ$ for arable land (National Committee on Agricultural Zoning, 1984; Xu et al. 2008). According to the connotation of reserve available land resources, followed the previous work (Feizizadeh & Blaschke, 2013; Xu & Xu, 2016; Xu et al., 2021), the evaluation methods to reserve available land resources, the reserved land suitable for construction and for cultivation were obtained, which can be calculated by the following equations:

Calculation of the available land resources:

$$L=L_{\sigma}+L_{\phi} \quad (1)$$

where L is the area of the available land resources, L_{σ} and L_{ϕ} refer to the available land resources whose slope is respectively less than 15° and 15°–25° and satisfies certain elevation conditions.

Calculation of the reserved land suitable for cultivation:

$$L_{au}=L-L_{fg}-L_{wa}-L_{pz}-L_{gd}-L_{ec}-L_{cu}-L_{ga} \quad (2)$$

where L_{au} is the area of the reserved land suitable for cultivation, L_{fg} is the area of forestland contained in the regional available land resources, L_{wa} is the area of water contained in the regional available land resources, L_{pz} is the area of preserve zone contained in the regional available land resources, L_{gd} is the area of gobi and desert contained in the regional available land resources, L_{ec} is the area of existing construction land contained in the regional available land resources, L_{cu} is the area of cultivated land contained in the regional available land resources, L_{ga} is the area of garden land and basic farmland contained in the regional available land resources.

Calculation of the reserved land suitable for construction:

$$L_{sc}=L_{\sigma}-L_{fg\sigma}-L_{wa\sigma}-L_{pz\sigma}-L_{gd\sigma} \quad (3)$$

$$L_{fa\sigma}=L_{cu\sigma} \times \alpha, \quad \alpha \in [0.9, 1] \quad (4)$$

$$L_{ac}=L_{sc}-L_{eco}-L_{fa\sigma}-L_{ga\sigma} \quad (5)$$

where L_{sc} is the suitable area for construction, L_{ac} is the reserve suitable area for construction, $L_{fg\sigma}$ is the area of forestland contained in the available land resources whose slope is less than 15°, $L_{wa\sigma}$ is the area of water contained in the available land resources whose slope is less than 15°, $L_{pz\sigma}$ is the area of preserve zone contained in the available land resources whose slope is less than 15°, $L_{gd\sigma}$ is the area of gobi and desert contained in the available land resources whose slope is less than 15°, L_{eco} is the area of existing construction land contained in the available land resources whose slope is less than 15°, $L_{cu\sigma}$ is the area of cultivated land contained in the available land resources whose slope is less than 15°, $L_{ga\sigma}$ is the area of garden land contained in the available land resources whose slope is less than 15°, $L_{fa\sigma}$ is the area of basic farmland contained in the available land resources whose slope is less than 15°, and the value of α can be determined according to the distribution pattern of the red line of cultivated land protection defined by the land department. Referring to relevant studies (Dang et al., 2014; Xu et al., 2021), the value of α for reserve

suitable construction land in this study was determined to be 1, in order to ensure the balance between occupation and compensation of cultivated land in the study area.

On the other hand, a topographic map of Jinan was prepared from the obtained administrative territorial entity maps of the study area, land use maps, water system maps and elevation maps in this study; then the topographic slope was divided into five grades, namely less than 3°, 3°–8°, 8°–15°, 15°–25°, and more than 25° according to the national classification standard of topographic elevation and the characteristics of the study area. After superposition matching, the reserve available construction land area and the reserve suitable cultivated land area were obtained by the above equations (1)-(5).

In view of the differences and overlaps in the spatial distribution of the reserved suitable land for construction and the reserved suitable arable land, the geographic orientation of the two types of land use was determined based on Jinan city's natural economic and social development status and relevant planning and policies.

3. Results and discussion

3.1 Potential analysis of the reserve available cultivated land

The spatial distribution pattern of the reserve available cultivated land was relatively stable in the study area (Fig.2), whose area covered 360.67 km². During the period of 1990–2020, the reserve available cultivated land decreased first and then increased, reaching 360.67 km² in 2020, with a total decrease of 18.33 km². Because Jinan city has undergone increasingly rapid urban expansion from 1992, and its urbanization rate reached 30.21%, and the urban space expansion in Jinan city experienced three stages, namely medium-strength and low-speed, high-strength and medium-speed, and low-strength and high-speed from 1992 to 2018 (Wang et al., 2020). Therefore, the reserve cultivated land decreased until 2010 and then increased by 2020.

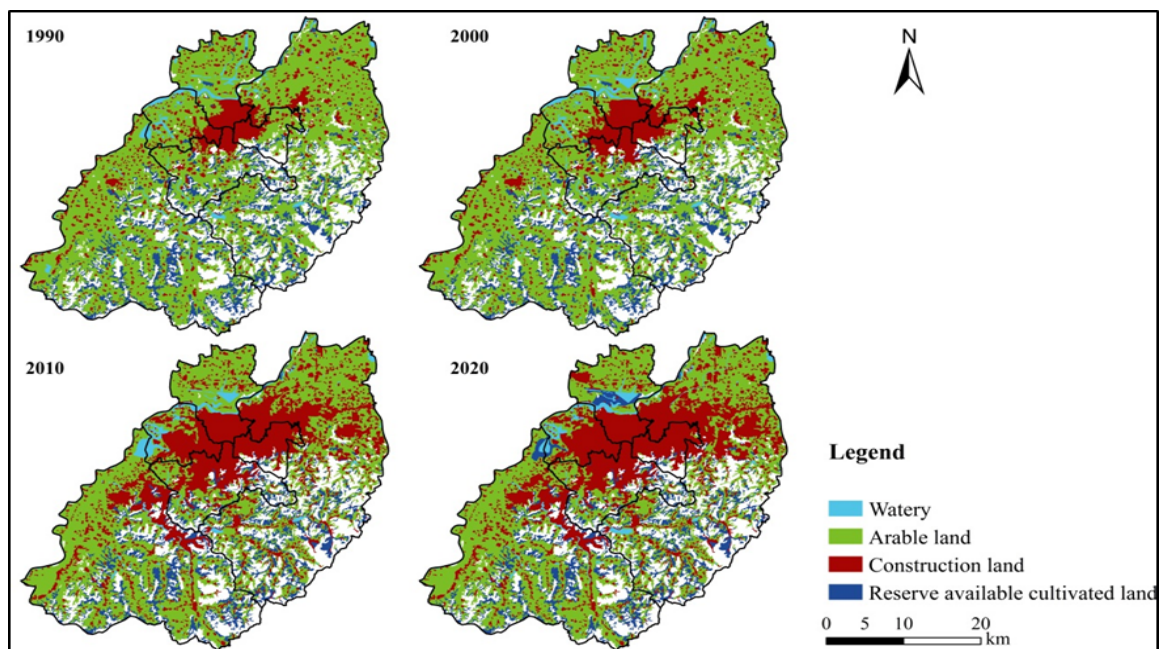


Fig.2 Spatial distribution of the reserve available cultivated land from 1990 to 2020

As shown in Tab.1, the area of reserve available cultivated land in Tian Qiao, Shi Zhong, and Huai Yin decreased first and then increased from 1990 to 2020, but continued to decrease in Li Xia and Chang Qing.

From 1990 to 2000, the area of reserve available cultivated land in Li Cheng was stable and showed a downward trend after 2000.

	Tian Qiao	Huai Yin	Li Xia	Li Cheng	Shi Zhong	Chang Qing	Jinan
1990	3.74	1.48	5.28	146.66	44.77	177.07	379.00
2000	3.50	1.48	5.28	146.66	44.67	177.09	378.68
2010	0.00	0.08	3.74	132.46	33.98	160.25	330.51
2020	17.71	4.43	3.69	132.10	34.21	168.53	360.67
1990–2020	13.97	2.95	-1.59	-14.56	-10.56	-8.54	-18.33

Tab.1 Area change of the reserve available cultivated land in each district from 1990 to 2020 (unit: km²)

On the other hand, the area change range of reserve available cultivated land in each district was Li Cheng, Tian Qiao, Shi Zhong, Chang Qing, Huai Yin, and Li Xia in sequence, among which Tian Qiao and Huai Yin showed an overall growth trend, respectively increased by 13.97 km² and 2.95 km² during the study period. The other four districts showed a decreasing trend, which were Li Cheng, Shi Zhong, Chang Qing, and Li Xia in order, with a decrease of 14.56 km², 10.56 km², 8.54 km², and 1.59 km², respectively. These area changes showed that the potential of reserve available cultivated land in Tian Qiao and Huai Yin was increasing, but in other four districts was decreasing.

On the whole, the differences of reserve available cultivated land in each district of Jinan city were mainly due to the combined effects of regional conditions, economic conditions, population, and industrial zones. Among these districts, Tian Qiao, Huai Yin, Shi Zhong, and Li Xia were the important regions for Jinan city's economic development, so the potential of reserve available cultivated land was relatively small, but the construction land was in great demand because of the relatively high population and urbanization level in the region. In addition, Li Cheng and Chang Qing possessed the following characteristics of sparse population, low levels of urbanization, and undulating terrain, so the two districts were not suitable for the development of construction land, but they could be used as cultivated land. Therefore, the potential for reserve available cultivated land in the regions was greater.

3.2 Potential analysis of the reserve available construction land

Because the arable land is the main land use type in the study area, the construction land is mainly distributed in the central-northern region of the study area, and showed a significant expansion trend. During the period of 1990–2020, the spatial distribution pattern of land suitable for construction was relatively stable and mainly distributed in the southern region of Jinan city (Fig.3). In terms of each district, the reserve land suitable for construction was mainly distributed in the southern region of Chang Qing and southwestern region of Li Cheng, and scattered in the southern region of Tian Qiao, northwestern region of Huai Yin, and southeastern region of Li Xia.

Over the past 30 years, the area of land suitable for construction in the study area showed a declining trend. From 1990 to 2010, the area of the reserve suitable construction land continued to decline, but the area increased from 2010 to 2020. By 2020, the area of reserve land suitable for construction would be reduced to 292.48 km², a decrease of 5.11% compared with 1990, accounting for 8.85% of the total area of the study area (Tab.2). In terms of land quantity, the potential of reserve construction land in the study area is large, which can meet the need of further development of reserve construction land resources. However, in terms of each district, the areas of land suitable for construction in Chang Qing and Li Cheng are relatively larger, which are 138.08 km² and 100.75 km² respectively, accounting for 34.45% and 47.21% of Jinan city's total reserved land suitable for construction, respectively. But in Tian Qiao, Shi Zhong, Li Xia, and Huai Yin are relatively lower, with an area of 17.71 km², 28.31 km², 3.20 km², and 4.43 km², respectively.

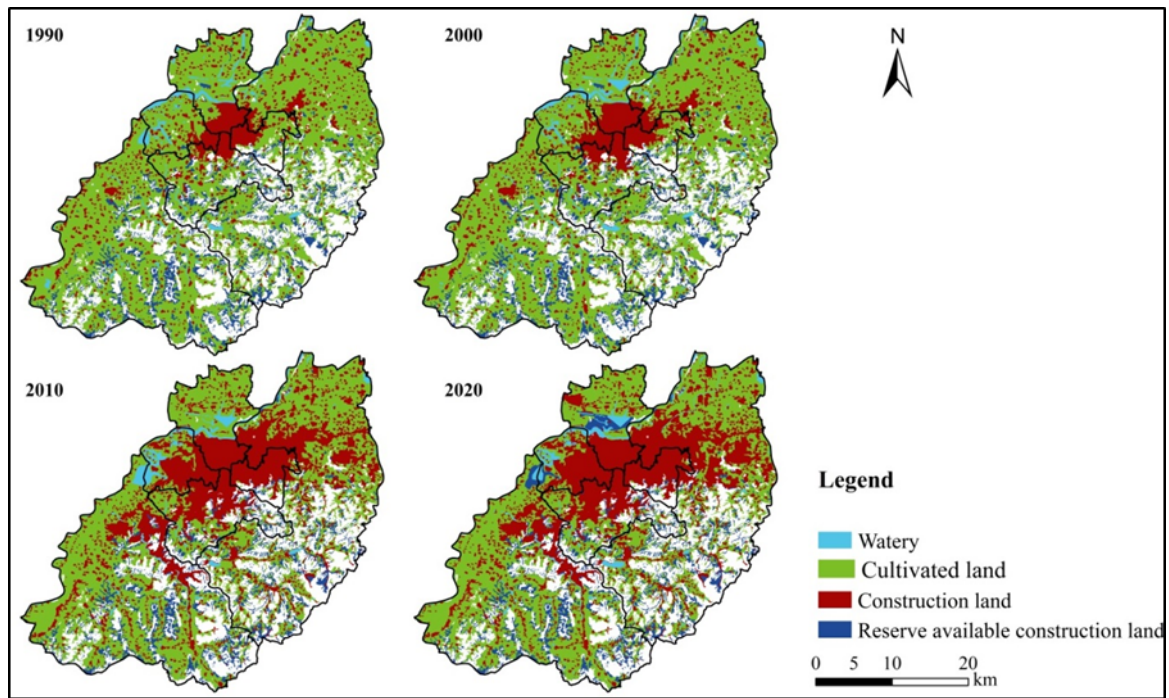


Fig.3 Spatial distribution of the reserve available construction land from 1990 to 2020

	Tian Qiao	Huai Yin	Li Xia	Li Cheng	Shi Zhong	Chang Qing	Jinan
1990	3.74	1.48	4.69	114.59	37.97	145.77	308.24
2000	3.50	1.48	4.69	114.6	37.88	145.78	307.93
2010	0.00	0.08	3.23	100.4	27.93	129.54	261.18
2020	17.71	4.43	3.20	100.75	28.31	138.08	292.48
1990–2020	13.97	2.95	-1.49	-13.84	-9.66	-7.69	-15.76

Tab.2 Area change of the reserve available construction land in each district from 1990 to 2020 (unit: km²)

According to the results obtained from the area changes of the reserve available construction land, we could conclude that the urbanization rate of Jinan city is rising. Therefore, the construction land is expanding in recent years. Because the districts of Tian Qiao, Shi Zhong, Li Xia, and Huai Yin are mainly distributed in the more flat terrain area of North Jinan city, the potential for the reserve available construction land is lower in these districts. However, the districts of Chang Qing and Li Cheng are located in the southern part of Jinan city with the undulating terrain, so the construction area is small and the development condition is bad. Therefore, the potential for the reserve available construction land is higher in the two districts (Wang et al., 2020).

On the other hand, in terms of area change, the area of reserve construction land in Tian Qiao, Shi Zhong, Huai Yin and Chang Qing first decreased and then increased, but the area in Li Cheng and Li Xia continued to decrease. The area change range of the reserve construction land in each district is Tian Qiao, Li Cheng, Shi Zhong, Chang Qing, Huai Yin, and Li Xia in order. In the past 40 years, the total area of the reserve construction land in Tian Qiao and Huai Yin has increased by 13.97 km² and 2.95 km², respectively. The total area of the reserve construction land in Shi Zhong, Li Xia, Li Cheng, and Chang Qing has decreased, which decreased by 9.66 km², 1.49 km², 13.84 km² and 7.69 km², respectively. These indicate that the construction potential of Tian Qiao and Huai Yin has been rising, leading to a trend of counter-urbanization, while the other four districts, such as Li Cheng, are developing and building, and the potential of reserve construction has decreased slightly owing to the macroeconomic regulation and control of government policy (Li, 2017). Based on the above analysis, the changes of reserve available construction land in the study area

also correspond to 3 periods of the urban space expansion, namely high-strength and medium-speed, low-strength and high-speed, and medium-strength and low-speed, (Wang et al., 2020).

3.3 Region-oriented analysis of the reserve available land resources

The total area of reserve available land resources in Jinan city is 360.66 km², which mostly distributed in the central and southern regions of study area (Fig.4). According to the dividing standard of terrain slope less than 8°, 8°–15°, and 15°–25°, the reserve suitable cultivated land resources in the study area are divided into three grades, namely suitable, more suitable, and conditional suitable. Meanwhile, the reserve suitable construction land resources are divided into three grades, that is, suitable, more suitable, and conditional suitable according to the dividing standard of terrain slope less than 3°, 3°–8°, and 8°–15° (Xu et al., 2008). According to the overlap between the standard of reserve land suitable for construction and reserve land suitable for cultivation in the concept of reserve available land resources, the reserve land resources with a slope between 15°–25° in the study area are classified as reserve arable land, but with the slope between 0°–15° can be used as the reserve suitable cultivated land and the reserve suitable construction land.

Based on the above mentioned, this study analyzes the regional development orientation combined with the regional natural and social economic conditions of Jinan city. On the one hand, the area of the conditional suitable reserve land resources in the study area is 229.53 km², and is distributed sporadically and mainly located in the central and southeastern regions of Chang Qing and the southern region of Li Cheng, but scattered in the districts of Li Xia and Shi Zhong (Fig.4). According to the classification criteria, these reserve land resources can be converted into new cultivated land resources in future planning and development, and serve as a reserve resource for maintaining Jinan city’s arable land redlines and food security.

Orientation of the reserve available land resources in each district

Tian Qiao	Most of the reserve land resources are suitable grade, which is suitable for reserve cultivated land or reserve construction land.
Huai Yin	The reserve available land resources are mostly suitable grade, and can be used as the reserve suitable cultivated land or construction land.
Li Xia	The reserve land resources are scattered, and will be suitable for the development of new construction land.
Li Cheng	The reserve available land resources are scattered, which mostly belong to the suitable grade and the conditional suitable grade, and are suitable for the reserve suitable cultivated land.
Shi Zhong	The distribution of reserve land resources is scattered, so the reserve land resources will be suitable for the development of new construction land.
Chang Qing	The suitable, more suitable, and conditional suitable grades of reserve available land resources are relatively uniform, so near the urban construction area can be planned as construction land, but the south-eastern part of the district can be used as the reserve arable land.

Tab.3 Orientation of the reserve available land resources in each district

Type of the reserve suitable land	Reserve available land	Suitable grade		More suitable grade		Conditional suitable grade	
		Cultivated land	Constructi on land	Cultivated land	Constructi on land	Cultivated land	Constructi on land
Tian Qiao	17.71	17.71	17.71	0.00	0.00	0.00	0.00
Huai Yin	4.43	4.41	4.35	0.02	0.06	0.00	0.02
Li Xia	3.68	1.16	0.09	2.04	1.10	0.49	2.04
Li Cheng	132.10	34.09	4.50	66.67	29.58	31.35	66.67
Shi Zhong	34.21	10.83	1.14	17.48	9.69	5.90	17.48
Chang Qing	168.53	63.08	14.52	75.01	48.56	30.44	75.01
Jinan city	360.66	131.28	42.31	161.22	88.99	68.18	161.40

Tab.4 Classification area of the reserve suitable land in each district from 1990 to 2020 (unit: km²)

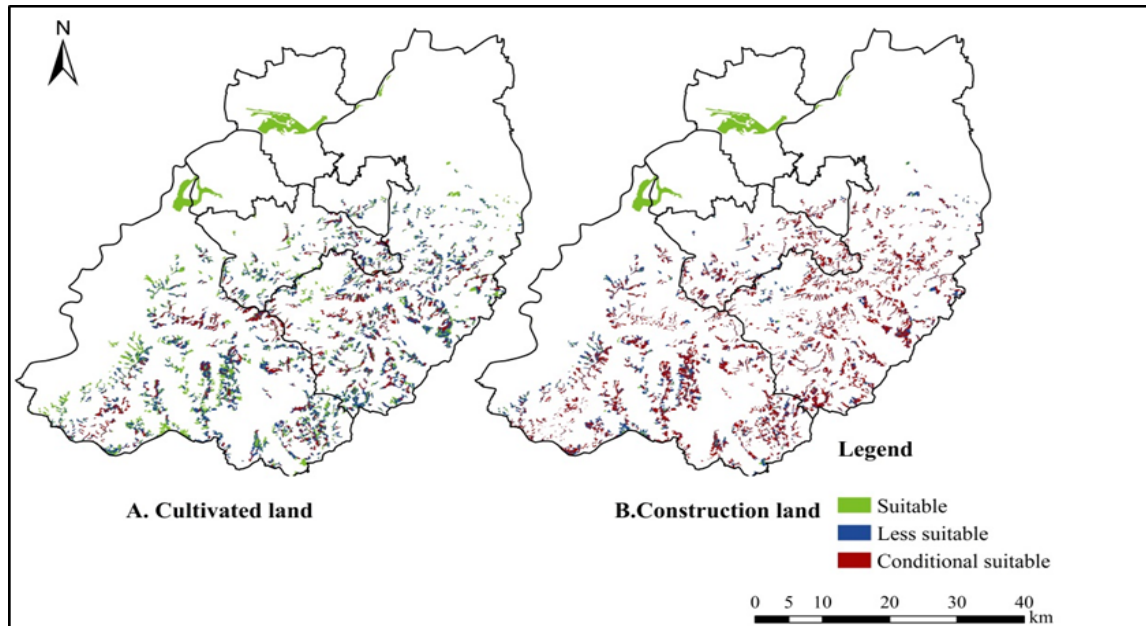


Fig.4 Spatial distribution of the reserve available construction land from 1990 to 2020

Considering the geographical environment, population gathering, land use status, and urban development planning, the orientation of reserve land use resources in each district is different in the study area (Tab.3). The distribution of reserve land resources with a total area of 17.71 km² in Tian Qiao is relatively concentrated, and most of the reserve land resources are suitable grade, which is suitable for reserve cultivated land or reserve construction land (Tab.4).

Furthermore, considering the high level of economic development, the large number of transport hubs (e.g. station), the dense population, the concentration of economic activities, the obvious resource advantages, and the combination of urban development planning within Tian Qiao, this district belongs to the industrial agglomeration area on the north bank of Jinan city, and many new and high-tech industrial parks have been built. Therefore, the reserve land resources can be used as the reserve suitable construction land in order to meet the needs of urban development and industrial agglomeration, promote the urban industrial function, and promote the industrial integration development (Yang & Zheng, 2006).

In Huai Yin district, the reserve available land resources are mostly suitable land resources, with an area of 4.43 km², which can be used as the reserve suitable cultivated land or construction land. Meanwhile, this district has a number of stations (e.g. the Jinan West station) which can bring a large number of people, and is one of Jinan city's important transport hubs, so the land resources in this region can be planned for construction land.

On the other hand, the area of reserve land resources in Chang Qing is 168.53 km², and the 3 suitable types (suitable, more suitable, and conditional suitable grades) are relatively uniform. Moreover, this district has built the College Town to promote economic development, and has a number of Science and Technology Innovation Industrial Parks, which are planned as an industrial cluster zone in the western region of Jinan city (Yan et al., 2005). Therefore, the reserve land resources near the urban construction area can be planned as construction land; but the south-eastern part of Chang Qing can be used as the reserve arable land owing to the rugged terrain.

In addition, the suitable reserve land resources are distributed in succession in the contiguous part of the Southwest Huai Yin and the North Chang Qing. Combining the characteristics and geographical location of the two regions, so the reserve land resources are suitable for reserve construction land in order to better integrate with the surrounding areas and meet the needs of further industrial expansion. However, the distribution of reserve land resources in the districts of Li Xia and Shi Zhong are scattered, with an area of 34.21 km² and 3.68 km², respectively. Because the two districts are the main urban area of Jinan city with

densely populated and economically developed, where is home to many government departments and has a high degree of urbanization, the reserve land resources will be suitable for the development of new construction land to meet its development momentum.

In addition, the distribution of reserve available land resources in Li Cheng is scattered, with a total area of 132.10 km². These land resources mostly belong to the suitable grade and the conditional suitable grade. Combined with its topographical conditions, most of the reserve land resources in the central and southern parts of Li Cheng are located in the southern mountainous areas whose terrain is undulating; meanwhile, the carrying capacity of the reserve land resources is relatively insufficient and the concentration trend of reserve land resources is not obvious (Zhang & Zheng, 2001; Zheng et al., 2016; Liu et al., 2021), which is not conducive to centralized development and construction. Meanwhile, the Jinan city plans to designate the southern mountainous areas as the ecological recreation zone, giving priority to the protection and restoration of the ecological environment. Therefore, this part of the reserve land resources is suitable for the reserve suitable cultivated land in order to make up for the problem of cultivated land occupation in the process of urbanization, and to maintain the balance of cultivated land occupation and compensation.

4. Conclusions

Owing to the mass construction of the market housing and excessive real estate investment in the karst area of North China, land resources in Jinan city are mainly converted into urban areas, which result in the increasingly improving dwelling conditions. But both human interaction with karst environments and modern development could cause widespread the disturbance of karst environment in the study area. Based on the above analysis, the spatial and temporal evolution of urban reserve available land resources were explored in Jinan city from 1990 to 2020 in the present study. The results indicated that (1) the reserve construction land was mainly distributed in the southeastern region of the study area and has the lower potential. By 2020, the total area of the reserve construction land was 292.48 km². The potential of the reserve construction land was different to each district. Owing to the constraints of terrain and development conditions, the development of construction land in the districts of Li Cheng and Chang Qing was relatively low but the potential of reserve construction land was higher. However, the potential in other districts was lower.

During the past 40 years, the construction land in Jinan city had been expanding with the acceleration of urbanization, and the area of reserve construction land had been decreasing, shrinking by a total of 15.76 km². Under the macroeconomic regulation and control of government policy, the quantity of reserve construction land varied within districts. The area of reserve construction land in Li Cheng, Shi Zhong, Chang Qing, and Li Xia was on a downward trend, which decreased by 13.84 km², 9.66 km², 7.69 km² and 1.49 km², respectively. But the area of reserve construction land in Tian Qiao and Huai Yin showed an upward trend, increasing by 13.97 km² and 2.95 km², respectively.

(2) The spatial distribution characteristic of reserve cultivated land was similar with the reserve construction land in the study area, and the potential was higher. With the expansion of construction land, the area of reserve cultivated land showed a downward trend, which decreased from 379.00 km² in 1990 to 360.67 km² in 2020. During the study period, in accordance with the requirements of the social development plan, the area of reserve cultivated land in Li Cheng, Shi Zhong, Chang Qing, and Li Xia decreased by 14.56 km², 10.56 km², 8.54 km², and 1.59 km², respectively, but the area of reserve cultivated land in Tian Qiao and Huai Yin increased by 13.97 km² and 2.95 km², respectively. The potential of reserve cultivated land in Chang Qing, Li Cheng, and Shi Zhong was relatively higher owing to the impacts of the distribution of industrial parks and the topography. By 2020, the area of reserve cultivated land in the 3 districts was 168.53 km², 132.20 km², and 34.21 km², respectively.

(3) According to the spatial distribution characteristics of land use and regional natural economic situation, the regional use orientation of each district was different. On the one hand, the reserve land resources in Tian Qiao could be used for the reserve construction land and cultivated land. Because the regional economic development level of Tian Qiao was higher, the urbanization process was faster, and the flow of people was large. Therefore the regional direction of reserve land resources was more inclined to construction land.

On the other hand, the reserve land resources in Huai Yin, Shi Zhong, Li Xia, and the northern part of Chang Qing could be divided into construction land. Because the reserve land resources in Li Cheng and the southeastern region of Chang Qing were limited by natural factors (e.g. topography), so could be divided into the cultivated land in order to make up for the balance of arable land.

In addition, this study also revealed that the reserve land use resources were significantly affected by natural, economic and social factors. It was difficult to quantify the impact of government policy macroeconomic regulation and control and economic development policies on regional orientation in a complex reserve land planning system. Moreover, the existing evaluation methods regarded the slope and elevation of terrain as the important constraint conditions for the evaluation of reserve usable land resources according to the evaluation methods of reserve usable land resources. For example, in some regions, such as Jinan city, it was applicable, but in other regions, it was necessary to construct new constraints based on regional characteristics. Therefore, in the process of reserve land use evaluation in the karst region of North China, how to build a reasonable index system to evaluate reserve land use resources and analyze the direction of regional use was an important worth considering problem in the future.

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Image Sources

All figures are original produced by the Authors for this paper.

Fig.1: Location map of study area;

Fig.2: Spatial distribution of the reserve available cultivated land from 1990 to 2020;

Fig.3: Spatial distribution of the reserve available construction land from 1990 to 2020;

Fig.4: Spatial distribution of the reserve available construction land from 1990 to 2020.

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