Study on Spatial and Temporal Pattern of Intensive Utilization of Farmland in Jinan

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Abstract. This paper takes Jinan as the research area, constructs the evaluation index system of intensive utilization of cultivated land based on domestic and foreign research and the present situation of cultivated land utilization in Jinan, combines the analytic hierarchy process (AHP) and entropy method to determine the weight of each index and calculates the degree of intensive use of cultivated land. On this basis, the time dynamic change of intensive use of cultivated land in Jinan from 2005 to 2016 and the spatial difference of intensive use of cultivated land in various regions in 2016 were analyzed and the cultivated land intensive utilization degree in 2016 was classified by using ArcGIS10. The results show that: from the time scale, the intensive utilization of cultivated land in Jinan from 2005 to 2016 shows an overall upward trend, with the smallest in 2005 and the highest in 2014. From the spatial scale, Jiyang county and Shanghe county are the largest in intensive utilization of cultivated land in Jinan in 2016, while the urban area and Tianqiao district are the smallest. In general, intensive utilization in plain area is greater than that in low mountainous and hilly area, and the township area is larger than the urban construction area, which accords with the “concentric circle structure” in agricultural location theory.

1. Introduction
The total cultivated land resources in China are large, but the population ranks first in the world, and the unsuitable cultivated land area accounts for more than 2/3, so the per capita cultivated land area is extremely low[1-3]. In the future, China's modernization process will continue for a long time, and the contradiction between land supply and demand will continue to increase[4].

Jinan, as the center of Shandong province, has a rapid economic development and population growth. With its unique topography and landform, the pressure of cultivated land has increased. Study of intensive utilization of cultivated land is useful to understand and analyze the current situation of cultivated land utilization, cultivated land utilization efficiency and output efficiency in Jinan, and provides data for urban development and land planning. It is conducive to adjusting the structural layout of cultivated land and arranging cultivated land resources scientifically and reasonably to achieve sustainable development of agriculture[5] and ensure the grain security of Jinan.

2. Research content and technical route

2.1. Research content
This paper takes the cultivated land under the jurisdiction of Jinan as the research object, and conducts a sub-regional study on 6 districts, 3 counties and 1 county-level city in the research area according to the current situation of land use (Lixia district, Shizhong district, Tianqiao district and Huaiyin district are urban construction area where the cultivated land resource is relatively less, so the four districts are integrated into urban areas for the convenience of research).

(1) Firstly, a multi-index comprehensive evaluation method was adopted for the construction of the evaluation index system which includes 4 criteria and 12 indicators, and the index data were standardized. Then, the weight of indicators was calculated by combining the hierarchical analysis and entropy method, and the final weight of indicators was obtained by the weighted method. Finally, according to the evaluation index system and the current status of cultivated land use, the research was conducted.

(2) Intensive use degree of cultivated land in Jinan was calculated by multi-factor comprehensive weighting method. On this basis, time dynamic change of cultivated land intensive use degree in Jinan from 2005 to 2016 and the spatial difference in 2016 were analyzed. Then, ArcGIS 10.2 was used to grade the intensive use degree of each subregion.

(3) According to the study of cultivated land use status and potential, the strategy suggestions for increasing the intensive utilization degree of cultivated land scientifically and reasonably were made, and the theoretical basis was provided for urban land use planning of Jinan.

2.2. Technical route

Based on the theoretical results at home and abroad and relevant data of agricultural information in Jinan, the technical roadmap (figure 1) of this paper was obtained.

| Literature research | Data collection |
|---------------------|----------------|
| Relevant concepts and theoretical basis of intensive utilization of cultivated land |
| Establishment of evaluation index system of intensive utilization of cultivated land |
| Index selection | Standardization of data | Determination of index weight |
| Establishment of evaluation model of intensive utilization of cultivated land |
| Intensive utilization of cultivated land |
| Time change characteristics of intensive use degree of cultivated land | Spatial variation characteristics of intensive utilization degree of cultivated land |
| Spatial and temporal pattern of intensive utilization of farmland in Jinan |

Figure 1. Technology roadmap

3. Overview of study area

Jinan (36°01′ N~37°32′ N, 116°11′ E~117°44′E) is located in the mid west of Shandong province. It is long and narrow from north to south. At the end of 2016, the total area of the city was 7992km², accounting for 5.06% of the province's area. As a densely populated area in Shandong province, Jinan is also a densely populated area with a complex population structure. With the increase of population, great population pressure and continuous decrease of the quantity and quality of cultivated land, the
per capita cultivated area in this region only accounts for 56% of the per capita average level of cultivated land in China. The contradiction between human and land is very prominent.

4. Methods

4.1. Construction of evaluation index system

On the basis of principles of objectivity, scientificity, systems and convenient operation, this paper collected and referred to the data of cultivated land utilization in the research area, and initially constructed the target level of intensive utilization of cultivated land, with input intensity, utilization degree, output efficiency and sustainable condition of cultivated land as the criterion[6-8]. A number of indicators were selected from each criterion layer scientifically, including data of 12 indicator layers, and the evaluation index system of intensive utilization of cultivated land was finally established. It made a key step for the evaluation of intensive utilization of cultivated land in the research area, as shown in table 1.

Table 1. Farmland intensive utilization evaluation index system in Jinan

| Target layer | Criterion layer | Index level | Definition of Indicator | Dimension |
|--------------|----------------|-------------|-------------------------|-----------|
| Input intensity | | Input of labor force | Rural labor force/Total cultivated area | Per capita/hm² |
| | | Fertilizer application quantity | Fertilizer application amount in planting industry/Total cultivated area | t/hm² |
| | | Input of mechanical power | Total power of planting machinery/Total cultivated area | Kw/hm² |
| | | Cropping index | Total Sown Area/Total cultivated area | % |
| Utilization degree | | Effective irrigation rate | Effective irrigation area of cultivated land/Total cultivated area | % |
| | | Land reclamation index | Newly cultivated land area/Total land area | % |
| | | GDP per hectare | Total crop output value/Total cultivated area | Ten thousand yuan/hm² |
| Output benefit | | Grain yield per hectare | Grain total output/grain acreage | kg/hm² |
| | | Labor output value | Total crop output value/rural labor force | Ten thousand yuan/Per capita |
| | | Labor force index | Rural labor force/population | % |
| | | Per capita cultivated area | Total cultivated area/population | hm²/Per capita |
| Sustainable condition | | Food security factor | Per capita grain output/Per capita grain consumption | dimensionless |

4.2. Standardization of evaluation index data

Each indicator factor relates to each other, however, due to the great differences between the indicator data, the meanings, numerical values and dimensions of the indicators are different. In order to quantify indicators with different meanings and unit, the required data should be standardized so as to facilitate comparison among indicators[9]. At present, the main standardization methods include range difference standardization, extreme value standardization, standard deviation standardization and summation standardization[10]. In this study, the range difference standardization method was used to standardize the evaluation indexes of all districts in Jinan from 2005 to 2016. The standardized formula is as follows:

\[ X_{ij} = \frac{x_{ij} - x_{\text{min}}}{x_{\text{max}} - x_{\text{min}}} \]  (1)
In the formula, $X_{ij}$ represents the processed value of an indicator, $x_{ij}$ represents the original value of an indicator, $x_{imin}$ means the minimum value of a certain type of index value, $x_{imax}$ means the maximum value of a class of index values. After standardization, the value range of each index is $[0,1]$. Table 2 and table 3 show the standardized results of indexes.

4.3. Determination of evaluation index weight

Due to the geographic difference between different regions, the importance of various indexes affecting the intensive utilization of cultivated land in different regions varies, so it is necessary to give weight to each evaluation index according to the characteristics of the study area. Common methods include subjective evaluation (e.g. AHP, Delphi method, etc.) and objective evaluation (e.g. principal component analysis, entropy method, etc.). The subjective evaluation method refers to the subjective assignment of the researchers based on their own experience and local land use status, while the objective assignment method is to assign weights according to the objective attributes of indicator factors\cite{11}.

This paper considers that the subjective valuation method does not fully reflect the objective reality of the evaluation index, and the objective valuation method lacks the importance of the index factor to the evaluation. The analytic hierarchy process (AHP) has strong subjectivity, not very objective and fixed evaluation criteria, and the horizontal comparison between the entropy method indicators is scarce\cite{12}. In order to overcome these disadvantages, the weight of the evaluation index in the research area is weighted average by combining subjective and objective methods in this paper, the comprehensive weight is finally obtained. The calculation formula is as follows:

$$W = (W' + W^*) \times 0.5$$  \hspace{1cm} (2)

Where, $W'$ is the weight of a certain index determined by the analytic hierarchy process, $W^*$ is the weight of the same index determined by the entropy method, and $W$ is the weight of the evaluation index finally determined after the weighted average. See table 4 for details.

4.4. Evaluation of intensive utilization of cultivated land

4.4.1. Establishment of evaluation model

This paper adopted the multi-index comprehensive evaluation method, and according to the current situation of cultivated land use in the study area and the weight results of the above index system, the model of intensive utilization level of cultivated land in Jinan was established. The formula is as follows:

$$F_i = \sum_{j=1}^{m} P_{ij} W_j (i = 1, 2, ..., m)$$  \hspace{1cm} (3)

Where, $F_i$ is the intensive utilization degree of cultivated land, $P_{ij}$ is the standardized value of index $j$ of the evaluation region $i$, and $W_j$ is the weight score of this index. $0 < F_i < 1$, the intensive utilization level of cultivated land gradually increases from small to large.

According to the above formula, the intensive degree of input intensity, utilization degree, output efficiency and sustainable condition of cultivated land per unit area was calculated, and the comprehensive intensive utilization degree of cultivated land was obtained. Meanwhile, ArcGIS10.2 was used for data processing, and the intensive utilization degree of cultivated land in the research area was graded according to certain principles.

4.4.2. Determination of evaluation criteria

In this paper, the ArcGIS10.2 software was used to divide the intensive use degree of cultivated land in the research area into four levels: low intensive use, general intensive use, medium intensive use and efficient intensive use with the natural discontinuous point classification method. See table 5 for classification standards of intensive intervals.
Table 2. Standardized values of evaluation indexes of intensive use of cultivated land in Jinan from 2005 to 2016

| Year | Labor input | Fertilizer application amount | Amount of mechanical power input | Multiple crop index | Effective irrigation rate | Cultivation index | GDP per hectare | Grain yield per hectare | Labor output value | Labor force index | Arable land per capita | Food security factor |
|------|-------------|-------------------------------|----------------------------------|---------------------|--------------------------|------------------|----------------|------------------------|-------------------|----------------|------------------------|---------------------|
| 2005 | 0.00        | 0.00                          | 0.00                             | 0.72                | 0.00                     | 0.74             | 0.00           | 0.00                   | 0.00              | 0.24           | 1.00                   | 0.01                |
| 2006 | 0.22        | 0.43                          | 0.05                             | 1.00                | 0.22                     | 0.26             | 0.06           | 0.29                   | 0.05              | 0.08           | 0.70                   | 0.00                |
| 2007 | 0.34        | 0.63                          | 0.17                             | 0.91                | 0.33                     | 0.00             | 0.12           | 0.35                   | 0.11              | 0.07           | 0.57                   | 0.05                |
| 2008 | 0.21        | 0.70                          | 0.27                             | 0.58                | 0.29                     | 0.23             | 0.24           | 0.78                   | 0.26              | 0.00           | 0.67                   | 0.16                |
| 2009 | 0.51        | 0.84                          | 0.38                             | 0.78                | 0.26                     | 0.30             | 0.30           | 0.82                   | 0.30              | 0.81           | 0.72                   | 0.38                |
| 2010 | 0.53        | 0.93                          | 0.52                             | 0.81                | 0.33                     | 0.32             | 0.44           | 0.68                   | 0.46              | 0.82           | 0.70                   | 0.43                |
| 2011 | 0.66        | 1.00                          | 0.63                             | 0.87                | 0.40                     | 0.22             | 0.38           | 1.00                   | 0.59              | 0.92           | 0.62                   | 0.94                |
| 2012 | 0.76        | 0.89                          | 0.70                             | 0.60                | 0.59                     | 0.21             | 0.67           | 0.92                   | 0.67              | 1.00           | 0.56                   | 0.86                |
| 2013 | 0.80        | 0.88                          | 0.77                             | 0.51                | 0.57                     | 1.00             | 0.83           | 0.16                   | 0.84              | 0.51           | 0.66                   | 1.00                |
| 2014 | 0.85        | 0.87                          | 0.88                             | 0.24                | 0.84                     | 0.86             | 0.88           | 0.46                   | 0.89              | 0.57           | 0.30                   | 1.00                |
| 2015 | 0.96        | 0.77                          | 1.00                             | 0.96                | 0.70                     | 0.95             | 0.95           | 0.49                   | 0.95              | 0.46           | 0.16                   | 1.00                |
| 2016 | 1.00        | 0.70                          | 0.19                             | 0.03                | 1.00                     | 0.61             | 1.00           | 0.36                   | 1.00              | 0.13           | 0.00                   | 0.92                |

Table 3. Standardized evaluation indexes of intensive use of cultivated land in regions in 2016

| Year | Labor input | Fertilizer application amount | Amount of mechanical power input | Multiple crop index | Effective irrigation rate | Cultivation index | GDP per hectare | Grain yield per hectare | Labor output value | Labor force index | Arable land per capita | Food security factor |
|------|-------------|-------------------------------|----------------------------------|---------------------|--------------------------|------------------|----------------|------------------------|-------------------|----------------|------------------------|---------------------|
| Urban area | 0.83     | 0.14                          | 1.00                             | 0.18                | 0.55                     | 0.00             | 0.00           | 0.00                   | 0.00              | 0.00           | 0.00                   | 0.00                |
| Licheng    | 1.00     | 0.35                          | 0.65                             | 0.19                | 0.66                     | 0.05             | 1.00           | 0.12                   | 0.46              | 0.72           | 0.23                   | 0.07                |
| Changqing  | 0.16     | 0.00                          | 0.00                             | 0.23                | 0.00                     | 0.35             | 0.11           | 0.44                   | 0.46              | 0.80           | 0.66                   | 0.39                |
| Pingan     | 0.14     | 0.24                          | 0.22                             | 1.00                | 0.07                     | 0.55             | 0.56           | 0.18                   | 1.00              | 0.84           | 0.71                   | 0.38                |
| Jiyang     | 0.04     | 0.54                          | 0.41                             | 0.39                | 0.70                     | 0.97             | 0.29           | 0.64                   | 0.89              | 1.00           | 1.00                   | 0.85                |
| Shanghe    | 0.00     | 1.00                          | 0.04                             | 0.43                | 1.00                     | 1.00             | 1.00           | 0.85                   | 0.88              | 0.97           | 1.00                   | 1.00                |
| Zhangqiu   | 0.31     | 0.59                          | 0.24                             | 0.00                | 0.62                     | 0.54             | 0.44           | 0.43                   | 0.62              | 0.93           | 0.60                   | 0.50                |

Table 5. Classification standard of intensive use of farmland in Jinan

| Classification | Low intensive use | General intensive use | Medium intensive use | Efficient intensive use |
|----------------|-------------------|-----------------------|----------------------|------------------------|
| Classification standard | ≤0.319201 | 0.319201-0.478501 | 0.478501-0.686101 | ≥0.686101 |

Table 4. Comprehensive weight of evaluation indexes

| Target layer | Criterion layer | Criterion layer weight | Index level | The comprehensive weights |
|--------------|-----------------|------------------------|-------------|---------------------------|
| Intensive use level of cultivated land | Input intensity | 0.1265 | Fertilizer application quantity | 0.0254 |
| | Input of labor force | 0.0357 | Input of mechanical power | 0.0654 |
| | cropping index | 0.0990 | Effective irrigation rate | 0.0568 |
| | Utilization degree | 0.2039 | Land reclamation index | 0.0481 |
| | GDP per hectare | 0.1579 | Grain yield per hectare | 0.0707 |
| | Labor output value | 0.1582 | Labor force index | 0.0703 |
| | Labor force index | 0.1559 | Per capita cultivated area | 0.0565 |
| | Sustainable condition | 0.2827 | Food security factor | 0.1559 |

5. Results and analysis

5.1. Determination of intensive utilization degree of cultivated land
According to the basic data of arable land, this paper used the method above to determine the comprehensive weight and so on through the index data standardization, analytic hierarchy process (AHP) and entropy value method. Intensive utilization degree of cultivated land in Jinan from 2005 to 2016 is shown in table 6, and the intensive utilization degree of cultivated land in all regions of Jinan in 2016 is shown in table 7.

5.2. Time change characteristics of intensive utilization of farmland in Jinan

5.2.1. Time change characteristics of comprehensive factors of intensive utilization of farmland in Jinan

(1) Input intensity of cultivated land: It can be seen from figure 2 that from 2005 to 2016, the investment intensity of cultivated land in Jinan showed the tendency of rising, with significant differences in each year. The minimum input intensity level in 2005 was close to 0, and the labor input, fertilizer input and mechanical power input in the evaluation indexes of cultivated land input intensity were all at the lowest level in 2005. In 2006–2007 and 2008–2009, the increase was more noticeable. With the continuous increase of fertilizer input, labor force and mechanical power, it reached its peak at 0.1192 in 2015.

| Year | Input intensity | Utilization degree | Output benefit | Sustainable condition | Intensive use level of cultivated land |
|------|----------------|--------------------|---------------|-----------------------|----------------------------------------|
| 2005 | 0              | 0.1068             | 0             | 0.0775                | 0.1843                                 |
| 2006 | 0.022          | 0.1245             | 0.0386        | 0.0455                | 0.2305                                 |
| 2007 | 0.0397         | 0.1087             | 0.061         | 0.044                 | 0.2533                                 |
| 2008 | 0.0429         | 0.0848             | 0.1342        | 0.0624                | 0.3242                                 |
| 2009 | 0.0647         | 0.1061             | 0.1525        | 0.1574                | 0.4808                                 |
| 2010 | 0.0766         | 0.1145             | 0.1904        | 0.164                 | 0.5455                                 |
| 2011 | 0.0906         | 0.1197             | 0.2554        | 0.2465                | 0.7122                                 |
| 2012 | 0.0957         | 0.103              | 0.2766        | 0.2368                | 0.7121                                 |
| 2013 | 0.1017         | 0.1108             | 0.2764        | 0.1989                | 0.6879                                 |
| 2014 | 0.11           | 0.1127             | 0.3135        | 0.2126                | 0.7488                                 |
| 2015 | 0.1192         | 0.0883             | 0.3351        | 0.1975                | 0.7401                                 |
| 2016 | 0.0659         | 0.0894             | 0.3416        | 0.1533                | 0.6503                                 |

| Region | Input intensity | Utilization degree | Output benefit | Sustainable condition | Intensive use level of cultivated land |
|--------|----------------|--------------------|---------------|-----------------------|----------------------------------------|
| Urban area | 0.0985         | 0.0488             | 0.0000        | 0.0000                | 0.1473                                 |
| Licheng  | 0.0872         | 0.0582             | 0.2389        | 0.0752                | 0.4596                                 |
| Changqing | 0.0058         | 0.0397             | 0.1202        | 0.1534                | 0.3192                                 |
| Pingyin  | 0.0260         | 0.1292             | 0.2594        | 0.1584                | 0.5731                                 |
| Jiyang   | 0.0420         | 0.1250             | 0.2308        | 0.2598                | 0.6577                                 |
| Shanghe  | 0.0281         | 0.1478             | 0.2376        | 0.2725                | 0.6861                                 |
| Zhangqiu | 0.0419         | 0.0609             | 0.1978        | 0.1779                | 0.4785                                 |
Figure 2. Evaluation results of intensive utilization of cultivated land in Jinan from 2005 to 2016

(2) Utilization degree of cultivated land: According to the processing results of the evaluation indexes in figure 2, the change of farmland utilization degree in Jinan from 2005 to 2016 showed a decrease in volatility, among which the multiple seed index, effective irrigation rate and reclamation index in 2008 were all at a low level in 12 years, leading to the lowest farmland utilization degree in that year. From 2008 to 2011, with the increase of reclamation index and multiple cropping index, the intensive utilization degree of cultivated land was on the rise and then decreased slightly. In 2006, the reseeding index was the highest, and the degree of cultivated land utilization was the largest, 0.1245.

(3) Output benefits: As shown in figure 2, the dynamic change of the intensity of output benefit from 2005 to 2016 was rising on the whole. Under the influence of climate change and other impacts, grain output was cut in 2005. The total output value of the planting industry and grain output was relatively low. In 2008 and 2011, the average output value of grain per unit area and per unit area increased significantly, so they were both significantly higher than the previous year, with 0.1342 and 0.2554 respectively. In 2016, the average output value of labor and land reached the maximum, and the output benefit of cultivated land was also the highest, 0.3416.

(4) Sustainability condition: According to figure 2, the sustainable situation of cultivated land in Jinan showed a fluctuating trend which first declined, then rose and then declined from 2005 to 2016. It was affected by the labor force index and the low per capita cultivated land area, with the lowest in 2007. During the five years from 2007 to 2011, the per capita grain output increased continuously, and the sustainable condition of farmland continued to grow. The maximum value reached in 2011 was 0.2465. Since then, with the continuous decrease of per capita area, the sustainable condition of cultivated land showed a downward trend.

5.2.2. Time change characteristics of intensive use degree of farmland in Jinan

It can be seen from figure 2 and above analysis results that the change trend of intensive utilization level of cultivated land in Jinan from 2005 to 2016 was generally on the rise. With the development of social economy and the improvement of agricultural tillage technology, from 2005 to 2011, the input intensity and output efficiency of cultivated land increased continuously, and the overall intensive utilization rate continued to rise, which increased rapidly. Affected by the sustainable situation of cultivated land, intensive utilization level of cultivated land decreased from 2011 to 2013, increased to the maximum in 2014, and then decreased slightly. In 2016, the decrease was greater than that of the previous year, mainly because of the large gap between the intensity of farmland input and the sustainable situation.

5.3. Spatial variation analysis of intensive use of farmland in Jinan
5.3.1. Spatial change characteristics of comprehensive factors of intensive utilization of farmland in Jinan

Figure 3. Evaluation results of intensive utilization of cultivated land in all regions in Jinan in 2016

1) Intensity of farmland input: As shown in figure 3, input of mechanical power and the labor force of unit cultivated land in the urban area was at a relatively high level. The input intensity of cultivated land was the highest, reaching 0.0985. The lowest area was Changqing, which was 0.0058, mainly affected by topography, mountainous and hilly, and difficult to farm with machinery. The intensity of investment in Pingyin, Jiyang, Shanghe and Zhangqiu was close. The main reason for the greater intensity of investment in the urban area was less land area, higher economic development, and sufficient capital and technology.

2) Degree of cultivated land utilization: The utilization degree of cultivated land was highest in Shanghe, 0.1478. The second was Jiyang and Pingyin with 0.1250 and 0.1292, respectively. Changqing was the smallest, 0.0397. The main reasons for the high degree of utilization in Shanghe, Jiyang and Pingyin were the large cultivated land area, the relatively flat terrain, the convenient machine tillage operation and the relatively perfect agricultural facilities conditions. The low level of utilization in Changqing was mainly affected by the mountain topography, difficult tillage and poor soil quality.

3) Farmland utilization benefit: The output benefit of cultivated land was the highest in Pingyin, reaching 0.2594, while Licheng, Jiyang and Shanghe were slightly lower than Pingyin, with 0.2389, 0.2308 and 0.2376, respectively. The least productive use of farmland was in the urban area. Urban area was mainly used for urban construction, with a small total area of cultivated land, a small total agricultural production and grain output. Pingyin had the highest average output value and better output efficiency.

4) Sustainable condition of cultivated land: The sustainable state of farmland in each region of Jinan was highest in Shanghe, reaching 0.2725. Jiyang was second with 0.2594, mainly because the cultivated land area of Shanghe was large and the food security coefficient was the highest. The sustainable condition of urban areas was the lowest, mainly because the per capita cultivated land area and labor force index in this region occupied the lowest level in the whole city, and the food security coefficient was at a low level compared with other regions.

5.3.2. Spatial variation characteristics of intensive utilization degree of cultivated land in Jinan

According to the grading standard of cultivated land intensive use degree and the result of ArcGIS10.2, the distribution diagram of regional intensive use degree and grade in Jinan in 2016 was obtained, as shown in figure 4 and table 7.
It can be seen from the figure that there were three areas of farmland intensive level and efficient utilization in Jinan in 2016, namely, Shanghe, Jiyang and Pingyin, with an intensive degree of 0.6861, 0.6577 and 0.5731. The cultivated land area was relatively wide, with fewer restrictions on topographic factors, making it convenient for machine farming. These areas developed modern agriculture and characteristic agriculture energetically, the investment of farmland increased ceaselessly. There were two medium-intensive regions in the intensive level, namely Zhangqiu and Licheng, with the intensive degree of 0.4785 and 0.4596. Although these two regions had a large area of cultivated land, they had a large investment in urban construction and economic development, and the intensive degree of cultivated land was relatively small. The intensive use level of cultivated land in Changqing was a general intensive level, and the intensive degree was 0.3192. This area was a mountainous area in the south of Jinan city, with relatively small cultivated land area, great difficulty in machine farming and low land utilization rate. The lowest intensive utilization level of cultivated land is the urban area, which was 0.1473, mainly related to the small area of cultivated land in urban area. The type of land use was mainly urban construction land, and the intensity of agricultural input was small.

6. Conclusions

On the basis of systematic analysis of domestic and foreign research, this paper constructs the evaluation index system of Jinan cultivated land intensive utilization, then analyzes the dynamic change of the intensive utilization level of cultivated land from 2005 to 2016 and the spatial difference of regional cultivated land intensive utilization level in 2016. The main conclusions are as follows:

(1) Based on the time scale of the target layer, through the time dynamic analysis of the intensive utilization level of farmland in Jinan, it can be known that from 2005 to 2016, the overall intensive utilization level of farmland in Jinan was on the rise.

(2) From the time scale of the criterion layer, the input intensity and output efficiency of cultivated land were the worst in 2005, which both closed to 0. The highest input intensity of cultivated land was 0.1192 in 2015, and the highest output benefit was 0.3416 in 2016. The highest and lowest degree of...
farmland utilization were 0.1245 in 2006 and 0.0848 in 2008, respectively. In the 12 years, all the others showed an upward trend except the sustainable situation of farmland fluctuated greatly.

(3) Based on the spatial scale of the target layer, the high-efficient and intensive farmland utilization in Jinan in 2016 were Shanghe, Jiyang and Pingyin, and intensive utilization levels were 0.6861, 0.6577 and 0.5731, respectively. On the whole, the intensity of cultivated land utilization in Jinan is low and the potential for improvement is great.

(4) From the perspective of the spatial scale of the criterion layer, the input intensity of farmland in all regions of Jinan in 2016 was the largest in urban areas and the smallest in Changqing, which were 0.0985 and 0.0058, respectively. Shanghe, Jiyang and Pingyin had high input intensity, output efficiency, utilization degree and sustainable condition. The lowest output efficiency and sustainability of cultivated land were in urban areas, which both closed to 0. The highest were in Pingyin and Shanghe, with 0.2594 and 0.2725, respectively.

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References
[1] Yu Y H and Li Z J 2017 Temporal and spatial variation of cultivated land use intensity and policy implications in Shandong Province China Land Sciences vol 31 pp 53-60
[2] Wang G G, Liu Y S and Chen Y F 2014 Dynamic trends and driving forces of land use intensification of cultivated land in China Acta Geographica Sinica vol 69 issue 7 pp 907-15
[3] Liu X W 2006 Overview of intensive use of land resources in China Land and Resource Information vol 3 pp 7-13
[4] Wu Y L, Feng Z L and Zhou Y 2011 Co-integration analysis on driving factors of intensive cultivated land use based on perspective of farmers: A case study of Hubei Province China Population Resources and Environment vol 21 issue 11 pp 67-72
[5] Xue W 2014 It is imperative to vigorously promote the transformation of land use patterns Resources Guide vol 6 p 1
[6] Yang P, Liu Y S, Guo L Y and Li Y H 2013 Spatial-temporal characteristics for rural hollowing and cultivated land use intensive degree: Taking the Circum-Bohai Sea region in China as an example Progress in Geography vol 32 issue 2 pp 181-90
[7] Zhang Y, Deng C X, Xie B G, Li X Q and Liu L K 2011 Fuzzy comprehensive evaluation of intensive use of cultivated land in the three cities of Dongting Lake in Hunan Province Journal of Wuling vol 6 pp 82-6
[8] Wang F X and Sun Z Y 2017 Spatial difference and influencing factors of cultivated land utilization intensive degree in Shandong Province Shandong Agricultural Sciences vol 11 pp 168-72
[9] Qiao G T, He G, Zhu Y N and Heng L W 2017 Calculation of actual contribution rate in complex system Statistics & Decision vol 10 pp 22-5
[10] Guo H H, Zhang X C and Li S C 2016 Improvement of the method to standardize moderate indicators in the evaluation of intensive land use: Population density as an example Scientia Geographica Sinica vol 36 issue 3 367-74
[11] Kong F W, Zheng W B and Yang Y 2011 Analysis on connotation and evaluation indicator of urban land intensive use Territory & Natural Resources Study vol 5 pp 18-9
[12] Qiao L 2012 Research on the farmland sustainable Uutilization of Heilongjiang Province Territory & Natural Resources Study vol 4 pp 16-7