Research on the changing trend of farmland area in China and its driving factors from 1996 to 2016

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Abstract. The paper was to research the changing trend of farmland area from 1996 to 2016. The original data of farmland area of China in these years were collected, data mining technology was used, and ARIMA model was chosen to predict each other between the two periods of 1996-2008 and 2008-2016, so the original farmland area data could be corrected and normalized. Then correlation analysis was used to study the driving factors. The trend research result showed, the farmland area decreased from 1996 to 2016, the decreasing rate was faster before 2004, and then it decreased slowly. The correlation analysis result showed, the added value proportion of primary industry, the total population, and the urban population were the most important driving factors, their coefficients were 0.959, -0.918 and -0.896 respectively. It could be concluded by the result that the industry configuration and the urbanization could affect the farmland area changing with the development of social economy.

1. Introduction
China is a great agricultural country, and the farmland is one very important resource which is related to food security. However, the vigorous demand for lands brings great challenge for farmland protection with the promotion of socialist modernization construction [1]. The research on farmland area change and its driving factors in China has always been one popular problem. The statement was refuted that China’s cultivated land has been descending since 1957 based on the analysis of the actual change of the cultivated land area [2]. The farmland area changing trend, spatial characteristics and the driving factors in China for a period of time before 2007 were studied [3-5]. And in different scales such as the scale of province or in some part of China, the dynamic change trend of farmland was studied [6-8]. Since 1980s, with the development and application of 3S technology, many scholars studied the farmland change using the RS images such as Landsat TM images [9, 10]. And the analysis approaches in the study of the driving forces of land use change in large regions were explored by using digital satellite remote sensing data of China [11]. Not only the changes in China’s cultivated land but also those in some provinces were analyzed based on remote sensing data such as Landsat TM/ETM+, NOAA, SPOT dataset [12, 13].

The statistic data sources of cultivated land in China are various, for example, the international organizations such as FAQ, WRI (the world resources institute), and different departments of China such as MLR (the ministry of land and resources), MOA (the ministry of agriculture), the bureau of statistics of PRC. However, the statistical data supplied by MLR are considered the most authoritative [14]. But the data from the MLR are not regularly entire in the demanded periods, and there was a jumping phenomenon with the farmland area from 2008 to 2009, that’s because the data of 2008 was
based on the first national land use survey, and the data of 2009 was based on the second national land use survey, that’s seemingly illogical. At present, most scholars analyze the farmland area change by the exiting data directly while ignoring the accuracy of the statistic data, or they just focused on some periods before 2008 or after 2009 evading the jumping years. Only a few scholars researched the farmland area in different historical periods [14, 15]. In this paper, the researched years included the years of before and after the second national land use survey. The method of data mining was introduced to analyze the relation between the two periods of the years before 2008 and the years after 2009, so the changing trend of China’s farmland area could be reflected more scientifically. At the same time, the driving factors were studied based on data normalization. And this is not found in the present research, which could be useful for studying China’s farmland changing trend.

2. Data and methods

2.1. Data acquisition

2.1.1. Data of farmland area in China
The farmland area of China, especially in the historical periods, has been hard for statistic for a long time. The national department of land management have been announcing the changing situation each year since 1986. In order to obtain the veracious statistical data of farmland in China, the first national land use survey was operated from 1984 to 1996. The survey result showed there was 1.95 billion mu (1 mu = 666.66 m²) of farmland in China by the day of Oct.31 1996 [15], which was considered the most credible result at that time [16]. Then, the farmland area of each year from 1996 to 2008 can all be obtained from the statistical bulletin of the year.

In order to obtain more veracious statistical data of farmland, the second national land use survey was operated from 2007 to 2009. The survey result showed there was 2.03 billion mu of farmland in China by the year of 2009 [15]. And since then the land use change survey has been operated each year. And the farmland area from 2007 to 2016 can be obtained from the national service platform of land use survey result. Because new methods and technologies were applied with the second national land use survey, some farmlands which were not found in the first survey were found in the second survey, and there was a jumping phenomenon with the farmland area from 2008 to 2009, which would be specially researched after a while for analyzing the changing trend of farmland area.

2.1.2. Data of driving factors
Land is closely related to the human social and economic development. The national farmland change is influenced by the geographical and climate conditions, social and economic development, flood and waterlogging disaster and so on [1]. For researching the driving factors influencing the farmland changing, three kinds of factors were introduced for comparison and selection. One kind were the comprehensive factors reflecting the national economic development, and they were the gross national income (GNI), the gross domestic product (GDP), the primary industry added value and its ratio, the second industry added value and its ratio, the third industry added value and its ratio, the gross agricultural output value, per capita GDP, industrial added value, architectural added value. Another kind were special factors reflecting the level of urbanization, and they were the national population, the urban population, and the rural population. The third kind was the special factors reflecting the natural disaster, and they were the damage area and the grain yield. There were in total of 17 factors which were used for analysis [17]. And data of all factors for the recent 20 years could be obtained from the web site of the national bureau of statistics.

2.2. Study methods
In this paper, the national farmland area data from 1996 to 2016 years were collected and analysed to study the changing trend, and the correlation analysis was operated to research the driving factors. While studying the changing trend of farmland from 1996 to 2016, according to the found jumping
phenomenon with the data from 2008 to 2009, the data mining technology was introduced. First, the farmland area of the year 2009 can be predicted with the data of 1996 to 2008. And the farmland area of the year 2008 can also be predicted reversely with the data of 2009 to 2016. Then, based on the predicted data and the practically collected data of the farmland of the years 2008 and 2009, the mathematical ratio relation between the farmland area of 2008 and 2009 could be analysed and obtained, so the jumping phenomenon could be solved with the ratio. At last, all the farmland data from 1996 to 2016 should be normalized for researching the changing trend more scientifically.

ARIMA (Autoregressive Integrated Moving Average) model was chosen for prediction with data mining, which was promoted by Box and Jenkins, it’s a very famous and useful time-sequence forecast method, and that’s just the needed one in this paper.

3. Analysis on the farmland area changing trend from 1996 to 2016

3.1. The analysis based on the original statistic data of farmland area

By collecting and analysing the original statistic data of farmland area for years of 1996-2016, the result showed that the national farmland area decreased year by year, as Figure 1, and the decreasing speed was the most quick from 2000 to 2004. While the farmland area jumped from 1.826 billion mu in 2008 to 2.031 billion mu in 2009. And after 2009, the farmland area decreased very slowly.

![Figure 1. Changing Trend for Farmland Area of 1966-2016 Based on Original Statistic Data](image1)

![Figure 2. Changing Trend for Farmland Area of 1966-2016 Based on Revised Statistic Data](image2)

China finished the first national land use survey in 1996, and the second in 2009, so the jumping phenomenon just happened in the division years of the twice land use survey. Whether the national farmland increased by about 200 million mu in the year of 2009 or not should be studied deeply. And by reviewing literatures [14, 15, 18], it could be concluded that the main reason was that more advanced technologies were introduced while the second land use survey, so some farmlands lost of statistic in the first land use survey were found in the second time, and the accuracy of the statistic result was improved. In this paper, the farmland data for the recent 20 years were based on twice different land use survey and different technology conditions. We can easily studied the changing trend in each period before or after the second land use survey, while all the data of farmland area must be revised and normalized if we want to study the continual time-sequence changing trend from 1996 to 2016, then they might be comparable.

3.2. Revision of farmland area based on data mining technology

Data mining technology is much useful for time-sequence prediction, and by that, in this paper, the farmland area of the year 2009 was predicted with the farmland data of the years from 1996 to 2008, the ratio \( \alpha \) between the farmland area of 2009 and that of 2008 could be obtained. And the farmland area of the year 2008 was also predicted reversely with the farmland data of the years from 2009 to...
2016, the ratio $\beta$ between the farmland area of 2009 and that of 2008 could also be obtained. Then, for reflecting the ratio more scientifically, we could get the ratio $\rho$ by the average of $\alpha$ and $\beta$.

SPSS software was used for prediction in this paper, by analyzing and comparing, the model of ARIMA was used in both of the prediction and the reverse prediction. The model used while predicting the farmland area of the year 2009 was ARIMA(1,1,2) ($r^2=0.975^{**}$), and the model used while predicting reversely the farmland area of the 2008 was ARIMA(1,1,4) ($r^2=0.966^{**}$), both of the two models were significant in the level of 0.01, with that, the predicted farmland area of the year 2009 was 1820.08 million mu, the reversely predicted farmland area of the year 2008 was 2030.98 million mu, so we can get $\alpha=0.996899887$, $\beta=0.999895617$, and then $\rho=0.998397752$, so we could use the $\rho$ value as the revision ratio of the data of the two different periods.

3.3. Trend analysis based on the revised data of farmland area

All the original farmland area data were revised with the ratio $\rho$ and normalized into relative values for reflecting the changing trend more scientifically. Based on the study of the previous paper, the relative farmland area of the years from 1996 to 2008 were calculated with the denominator of the farmland area of the year 2008, the relative farmland area of the years from 2009 to 2016 were calculated with the denominator of the farmland area of the year 2009 while revised by multiply the ratio $\rho$. Then the continual changing trend of farmland area from 1996 to 2016 could be obtained, shown as Figure 2, which showed the national farmland area decreased year by year. Before the 2004, the decreasing rate was faster, and after that the decreasing rate trends to be slower, especially after 2009, the farmland area trends to be stable.

4. Analysis on driving factors

A total of 17 factors were collected in this paper, and their descriptive statistical characters were shown in table 1. In order to study the driving factors, correlations between the farmland area and the factors were analysed, and then, by comparing the correlation coefficients shown as table 2, the driving factors could be chosen out.

| Factors | Min. | Max. | Ave. | Std. | Factors | Min. | Max. | Ave. | Std. |
|---------|------|------|------|------|---------|------|------|------|------|
| $x_1$   | 7078 | 74114| 30444.70 | 225956.60 | $x_{10}$ | 589.8 | 5398 | 2287.2 | 16332.77 |
| $x_2$   | 7181.4 | 74412.7 | 30571.87 | 226519.84 | $x_{11}$ | 2953 | 24786 | 11653.28 | 79508.29 |
| $x_3$   | 1387.8 | 6367.1 | 3124.07 | 17742.62 | $x_{12}$ | 439.3 | 4952.2 | 1962.3 | 15992.73 |
| $x_4$   | 8.556 | 19.325 | 12.11 | 3.28 | $x_{13}$ | 122389 | 138271 | 131047.71 | 4702.17 |
| $x_5$   | 3382.8 | 29623.6 | 13562.92 | 94949.58 | $x_{14}$ | 37304 | 79298 | 58413.24 | 12989.27 |
| $x_6$   | 39.810 | 47.559 | 45.33 | 2.00 | $x_{15}$ | 58973 | 85085 | 72634.48 | 8313.40 |
| $x_7$   | 2410.7 | 38422 | 13884.89 | 114605.84 | $x_{16}$ | 43070 | 62144 | 52326.48 | 5812.06 |
| $x_8$   | 33.569 | 51.634 | 42.56 | 4.47 | $x_{17}$ | 21770 | 54688 | 41009.48 | 10706.30 |
| $x_9$   | 1354 | 5928.8 | 2884.26 | 16570.35 |           |      |      |      |      |

*In the table, $x_1$ means the gross national income (GNI), billion yuan; $x_2$ means the gross domestic product (GDP), billion yuan; $x_3$ means the primary industry added value, billion yuan; $x_4$ means the proportion of primary industry added value, $\%$; $x_5$ means the second industry added value, billion yuan; $x_6$ means the proportion of second industry added value, $\%$; $x_7$ means the third industry added value, billion yuan; $x_8$ means the proportion of third industry added value, $\%$; $x_9$ means gross agricultural output value, billion yuan; $x_{10}$ means per capita GDP, billion yuan; $x_{11}$ means industrial added value, billion yuan; $x_{12}$ means architectural added value, billion yuan; $x_{13}$ means the national population, *10^4; $x_{14}$ means the urban population, *10^4; $x_{15}$ means the rural population, *10^4; $x_{16}$ means the grain yield, *10^4 t; $x_{17}$ means damage area, *10^3 ha; and the same as follows.
### Table 2. Correlation Coefficients between Original/Relative Farmland Area and Factors

| Relative data | Original data | Relative data | Original data | Relative data |
|---------------|--------------|--------------|--------------|--------------|
| $x_1$         | 0.649        | -0.746       | $x_9$        | 0.686        |
| $x_2$         | 0.652        | -0.745       | $x_{10}$     | 0.651        |
| $x_3$         | 0.663        | -0.736       | $x_{11}$     | 0.638        |
| $x_4$         | -0.274       | 0.959        | $x_{12}$     | -0.716       |
| $x_5$         | 0.647        | -0.774       | $x_{13}$     | 0.433        |
| $x_6$         | -0.519       | 0.259        | $x_{14}$     | -0.896       |
| $x_7$         | 0.649        | -0.717       | $x_{15}$     | -0.518       |
| $x_8$         | 0.433        | -0.819       | $x_{16}$     | 0.752        |
| $x_9$         | 1.000        |              | $x_{17}$     | -0.514       | 0.708 |

As shown in table 2, the correlation coefficients between the original farmland area and the factors were poor because of the jumping phenomenon. However, by analyzing the correlations between the revised farmland area and the factors, we could find, the proportion of the first industry added value had the best correlation with the farmland area, its coefficient was up to 0.959. The national total population was secondary to it, and its correlation coefficient was -0.918, then the urban population and the rural population were secondary to that sequentially, which means the first industry added value, the national total population, the urban population and the rural population were the most important driving factors. According to the research result, we could conclude that it was mainly the national industry structure and the urbanization construction that influence the farmland changing.

### 5. Conclusion and discussion

Land has both of its own natural and social characters, and it’s just all of the factors including society, economy, and policy factors that influence the statistics of farmland area for a long time. So it’s difficult for a long-time changing trend research. The period studied in this paper was across twice national land use survey, and there happened to be a jumping phenomenon, but this couldn’t reflect the boost of farmland area from 2008 to 2009. The reasons of the phenomenon were studied, that was mainly because RS, GIS and some other new technologies were applied in the second national land use survey, the survey and statistics were more standardized, so the accuracy was apparently promoted, which made the farmlands lost of statistics before found in the second land use survey. Therefore, in order to study the changing trend for a period across twice land use survey, the quantitative relation of the farmland area between the twice survey must be studied and obtained. In this paper, with data mining technology, revision and normalization of farmland area, the research result could reflect the changing trend more actually.

Research results showed China’s farmland area decreased year by year from 1996 to 2016, especially before 2004, the decreasing rate was fast, and after that year the decreasing rate tended to be slow. As to the driving factors, it’s the proportion of the primary industry added value in the aspect of the national industry structure and the national population, the urban population in the aspect of urbanization construction which were the main driving factors influencing the farmland changing. Because of the ecological restoration after the year of 1999, the farmland decreased rapidly [14, 19]. In 2004, the land management law was revised, which strengthened the protection and the requisition-compensation balance of farmland, and that’s much useful for retaining farmland. In this paper, only the farmland area data from 1996 to 2016 were used to study the changing trend, and in present time, China pay much attention to farmland protection, not only including the quantity, but including the land quality with core of productivity in order to realize the protection of the trinity of quantity, quality and ecology [20]. In the future research, the changing trend of farmland area would be studied deeply.

The years of 1966 to 2016 were introduced in this paper to study the changing trend because the demand of statistical data for longer-time sequence was difficult to be satisfied. In future research, based on the collected statistical data, the data mining, remote sensing interpretation and some other methods would be applied to compensate the lack of some factors, so we wish we could obtain a longer time-sequence changing trend.
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