Implementation Effect of Farmland Protection in Urumqi – Changji Economic Zone, China

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Abstract A multi-level evaluation index system is established with farmland protection as the target layer, farmland quantity, farmland quality and farmland sustainable development as the criterion layer. And the index layer includes the quantity change of farmland, per capita farmland area, multiple cropping index, total grain yield, unit grain yield, per capita grain security coefficient, and unit machinery dynamical input. Both expert evaluation method and factor analysis method are used to determine the weight of index. According to the data in farmland area, grain yield and economic development in Urumqi – Changji Economic Zone in the years 1996 – 2007, a comprehensive evaluation model of intensive farmland use in Urumqi – Changji Economic Zone is established after data standardization. The overall implementation effect of farmland protection policy is analyzed by integrating the farmland quantity, farmland quality and sustainable development. Result shows that implementation effect of farmland protection shows an upward trend in general in Urumqi – Changji Economic Zone in the years 1996 – 2007, with a fluctuation in the years 2000 – 2003 and a stable rising phase from 2004 till now. The maximum value is 0.779 in the year 2007; the minimum value is 0.242 in the year 1996; and the mean value in the years 1996 – 2007 is 0.454. Farmland protection at first strictly controls the farmland quantity, then pays attention to farmland quality, and finally focuses on the sustainable use of farmland.

Key words Farmland protection, Implementation effect, Urumqi – Changji Economic Zone, China

Urumqi – Changji Economic Zone is located in the the middle of northern foot of Tianshan Mountain and the south margin of Dzungaria Basin. Urumqi – Changji Economic Zone is the political, economical and cultural center of Xinjiang Uighur Autonomous Region, as well as the biggest industrial base and transportation hub of northwest China and an important commercial and trade city cluster in the western development strategy. In the Urumqi – Changji Economic Zone, there are the only large city of Xinjiang—Urumqi, the relatively developed counties and cities in Xinjiang—Urumq County, Changji City, Miquan City, Fukang City, Hutubi County and Manas County, and the state poverty counties— Qitai County, Jimsar County and Mori County. Since farmland protection is of important significance to the sustainable and healthy development of Urumqi – Changji Economic Zone, a multi – level evaluation index system is established. Based on the data of farmland area, grain yield, and economic development of Urumqi – Changji Economic Zone in the years 1996 – 2007, implementation effect of farmland protection in Urumqi – Changji Economic Zone is analyzed.

1 Construction of evaluation index system

1.1 Establishment of index evaluation system Implementation effect of farmland protection is a comprehensive, scientific and systematic evaluation system for the implementation effect of farmland protection based on the objective of land protection, which should not only fully grasp the effects of farmland protection on farmland, but also fully reflect the effects of farmland protection on economy, society and ecology[1]. Therefore, The following principles must be followed when establishing the evaluation index system for farmland protection implementation in Urumqi – Changji Economic Zone, that is the correlation and integrity, the representativeness and simplicity, the quantitative and regional nature, and the purpose and scientific nature[2-3].

The evaluation index system for farmland protection implementation in Urumqi – Changji Economic Zone is composed of three layers, which are target layer, criterion layer and index layer. Sustainable development of farmland is the ultimate goal of farmland protection, that is, the target layer of farmland protection implementation evaluation[4]. Criterion layer of farmland protection refers to the three aspects of farmland protection, including the dynamic equilibrium of farmland quantity, the dynamic equilibrium of farmland quality, and the sustainable development of farmland. Index layer of farmland protection selects the measurable indices that can correctly reflect the quantity change, the quality change and the sustainable development of farmland. It is assumed that the target layer is A; criterion layer is $A = \{A_1, A_2, A_3\}$, where A_1 is the farmland quantity, A_2 is farmland quality, and A_3 is the sustainable development of farmland. And index layer is $A_1 = \{A_{11}, A_{12}, A_{13}, A_{14}\}$; $A_2 = \{A_{21}, A_{22}, A_{23}, A_{24}\}$; $A_3 = \{A_{31}, A_{32}, A_{33}, A_{34}, A_{35}, A_{36}, A_{37}\}$[5]. Table 1 reports the index system.

1.2 Determination of index weight In the evaluation index system of farmland protection implementation in Urumqi – Changji Economic Zone, the importance degrees of indices to farmland protection goal are different. In order to reflect the influence degree of different indices on evaluation result, contribution degree of evaluation index to the general goal of farmland protection should be determined firstly, that is the weight

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of index. Both expert evaluation method and factor analysis method are used to reduce the error and to enhance the accuracy of the results[5].

Table 1 Index system of implementation evaluation of farmland protection

Target layer	Criterion layer	Index layer	Code	Description of index
Farmland protection A	Farmland quantity A_1	Quantity change of farmland // hm^2	A_{11}	Farmland area at the current year-farmland area at base period, reflecting the requisition-compensation balance of farmland
		Per capita farmland area // hm^2/people	A_{12}	Total farmland / total population, reflecting the variable quantity of per capita farmland area
		Multiple cropping index // %	A_{13}	Crop sowing area/ total farmland, reflecting the change of farmland utilization ratio
		Area of farmland turning into construction land // hm^2	A_{14}	Reflecting the implementation situation of farmland control of nonagricultural use
	Farmland quality A_2	Total grain yield // t	A_{21}	Reflecting the change of total grain yield during farmland protection
		Unit grain yield // kg/hm^2	A_{22}	Total grain yield /grain sowing area, reflecting the grain productivity during farmland protection
		Effective irrigation rate // %	A_{23}	Effective irrigation area / total area of farmland, reflecting the irrigation guarantee degree of farmland
		Use amount of chemical fertilizer per unit area // t/hm^2	A_{24}	Quantity of pure fertilizer /farmland area, reflecting the application change of chemical fertilizer in farmland
	Sustainable development A_3	Per capita grain security coefficient // %	A_{31}	(Total grain yield /total population)/400 kg, reflecting the grain security in a given region
		Unit machinery dynamical input // kw · h/hm^2	A_{32}	Agricultural mechanical power/farmland area, reflecting the machinery input in unit farmland
		Output value per unit land // × 10^4 yuan/hm^2	A_{33}	Total output of planting industry/farmland area, reflecting the average output of unit farmland area
		Per capita GDP // Yuan	A_{34}	Regional GDP/total population, reflecting the economic development level of a region
		Fixed assets investment per unit area // Yuan /hm^2	A_{35}	Fixed assets investment of primary industry/total farmland area, reflecting the improvement of farmland infrastructure
		Average wage of workers // Yuan	A_{36}	Reflecting the consuming ability of urban residents' income level to the products from farmland
		Per capita net income of farmer // Yuan	A_{37}	Reflecting the annual net income of rural residents

1.2.1 Expert evaluation method. A total of 8 experts are invited to evaluate the scores of criterion layer and index layer. Their weights are obtained by normalization processing.

Criterion layer:

$P=\{P_1,P_2,P_3\}=\{0.55,0.34,0.11\}$.

Index layer:

$P_1=\{P_{11},P_{12},P_{13},P_{14}\}=\{0.36,0.20,0.13,0.31\}$;

$P_2=\{P_{21},P_{22},P_{23},P_{24}\}=\{0.24,0.30,0.37,0.09\}$;

$P_3=\{P_{31},P_{32},P_{33},P_{34},P_{35},P_{36},P_{37}\}$
$=\{0.15,0.04,0.13,0.07,0.12,0.13,0.37\}$.

1.2.2 Factor analysis method. Factor analysis is to replace the various indices by the few and new quantitative indices (factors). These uncorrelated indices are the linear combination of the original indices and fully contain the information of original indices to achieve dimension reduction. According to the meaning, factor score coefficient is the contribution of index in sample to common factor; while variance contribution rate is the common factor's representative to all the sample variances. Therefore, the product of the factor score coefficient and relevant variance contribution rate is equal to the contribution of index in sample. Contribution of index divided by the sum of contributions is the weight of the index. Hence, the equation is

$$\omega_i=\frac{\sum_{i=1}^{n}\beta_{ji}e_j}{\sum_{j=1}^{m}\sum_{i=1}^{n}\beta_{ji}e_j}, \quad (1)$$

where $i=1,2,\cdots,n$; $j=1,2,\cdots m$, and e_j is the variance contribution of index j. DPS statistical analysis software is adopted to calculate the index weight vector of criterion layer by factor analysis method.

Weight of criterion layer is:

$P=\{P_1,P_2,P_3\}=\{0.20,0.27,0.53\}$.

Weight of index layer is:

$P_1=\{P_{11},P_{12},P_{13},P_{14}\}=\{0.24,0.28,0.20,0.28\}$;

$P_2=\{P_{21},P_{22},P_{23},P_{24}\}=\{0.15,0.29,0.27,0.29\}$;

$P_3=\{P_{31},P_{32},P_{33},P_{34},P_{35},P_{36},P_{37}\}$
$=\{0.08,0.15,0.15,0.16,0.15,0.16,0.15\}$.

1.2.3 Comprehensive weight. Weight by experts can qualitatively determine the importance degree of index. Since different experts have different knowledge structures, comprehension degree of corresponding index varies. Thus, it is difficult to achieve a unified view, leading to a certain degree of arbitrary when qualitatively determining the weight of index. Weight determination by factor analysis is based on the mathematical relationship among indices, which objectively reflects the relationship among indices. However, the strong correlation among indices leads to the deviation of weight index. In order to overcome the shortcomings and to exert the advantages, simple weighted average method should be adopted. The result of weighted average is as follows:

Criterion layer:

$P=\{P_1,P_2,P_3\}=\{0.375,0.305,0.320\}$.

Index layer:

$P_1=\{P_{11},P_{12},P_{13},P_{14}\}=\{0.300,0.240,0.165,0.395\}$;

$P_2=\{P_{21},P_{22},P_{23},P_{24}\}=\{0.195,0.295,0.320,0.190\}$;

$P_3=\{P_{31},P_{32},P_{33},P_{34},P_{35},P_{36},P_{37}\}$
$=\{0.115,0.095,0.140,0.115,0.135,0.145,0.260\}$.

2 Data Source and Research Method

2.1 Data source and standardization Data are from the 1997 – 2008 *Xinjiang Statistical Yearbook*, the 2005 – 2008 *Changji Statistical Yearbook*, and the 1997 – 2008 *Urumqi Statistical Yearbook*[6-8].

Different dimensions of original indices lead to the relatively great difference among indices, which is not conducive to proper evaluation. In order to unify the index dimension and to minimize the difference in magnitude, standardized treatment on original data is needed[9]. Standard equation for positive index is selected:

$$x'_{ij}=\frac{x_{ij}-x_{i\min}}{x_{i\max}-x_{i\min}}, \quad (2)$$

where x'_{ij} is the index value after standardization, x_{ij} is the index value before treatment, $x_{i\max}$ is the maximum value of index before treatment, and $x_{i\min}$ is the minimum value before treatment.

Equation for negative index, such as area of farmland turning into construction land (A_{14}) and use amount of chemical fertilizer per unit area (A_{24}), is:

$$x'_{ij}=\frac{x_{ij}-x_{i\max}}{x_{i\min}-x_{i\max}}. \quad (3)$$

According to the raw data and equations (2) and (3), farmland evaluation index score after standardization in Urumqi – Changji Economic Zone in the years 1996 – 2007 is obtained (Table 2).

Table 2 Farmland evaluation index score after standardization in Urumqi – Changji Economic Zone in the years 1996 – 2007

Code of index	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
A_{11}	0	0.272	0.624	0.904	0.972	0.990	1	0.725	0.694	0.717	0.716	0.749
A_{12}	1	0.953	0.944	0.89	0.141	0.031	0.565	0.4	0.302	0.178	0.054	0
A_{13}	0	0.067	0.075	1	0.966	0.153	0.229	0.233	0.268	0.324	0.487	0.566
A_{14}	0.359	0.557	0	0.371	0.983	1	0.794	0.831	0.942	0.774	0.979	0.948
A_{21}	0.707	0.826	0.957	1	0.551	0.156	0.628	0.1	0	0.433	0.878	0.581
A_{22}	0.080	0	0.349	0.394	0.313	0.029	0.299	0.303	0.084	0.212	0.44	1
A_{23}	0	0.037	0.208	0.31	0.357	0.377	0.179	0.2	0.363	0.436	0.679	1
A_{24}	1	0.942	0.847	0.856	0.822	0.637	0.413	0.384	0.232	0.218	0.158	0
A_{31}	0.891	0.937	1	0.977	0.304	0	0.538	0.115	0.012	0.26	0.502	0.281
A_{32}	0	0.043	0.061	0.081	0.054	0.105	0.253	0.357	0.494	0.628	0.778	1
A_{33}	0	0.132	0.166	0.191	0.312	0.36	0.368	0.495	0.706	0.808	0.897	1
A_{34}	0.008	0.015	0.032	0.083	0.065	0	0.665	0.465	0.59	0.731	0.801	1
A_{35}	0	0.046	0.106	0.045	0.113	0.099	0.117	0.256	0.36	0.574	0.772	1
A_{36}	0	0.029	0.057	0.088	0.157	0.239	0.326	0.427	0.506	0.601	0.753	1
A_{37}	0	0.111	0.211	0.241	0.305	0.363	0.484	0.628	0.700	0.742	0.890	1

2.2 Establishment of the overall evaluation model Evaluation index scores after standardization and the corresponding weights area are adopted to establish the overall evaluation model of farmland intensive land use in Urumqi – Changji Economic Zone and to carry out farmland protection. The calculation equation is:

$$F_j=\sum_{j=1}^{n}x'_{ij}\times P_{ij}, \quad (4)$$

$$F_{\text{Target}}=\sum_{j=1}^{3}F_j\times P_j, \quad (5)$$

where $j=1,2,3,4$ or $1,2,\cdots,7$; $i=1,2,\cdots,15$, F_j is the score of criterion layer, F_{Target} is the overall score of farmland protection implementation evaluation, x'_{ij} is the standardized value of index in index layer, P_{ij} is the weight of index in index layer, and P_j is the weight of criterion layer.

3 Result and analysis

3.1 Comprehensive evaluation analysis on implementation effect of farmland protection in Urumqi – Changji Economic Zone According to the comprehensive weight of index and the score of evaluation index mentioned above, equations (4) and (5) are used to calculate the comprehensive evaluation score of farmland protection implementation in Urumqi – Changji Economic Zone in the years 1996 – 2007.

Fig. 1 illustrates that the farmland protection implementation shows an upward trend in general in Urumqi – Changji Economic Zone in the years 1996 – 2007, with a fluctuation in the years 2000 – 2003 and a stable rising phase from 2004 till now. The maximum value is 0.779 in the year 2007; the minimum value is 0.242 in the year 1996; and the mean value in the years 1996 – 2007 is 0.454. According to the composition of

score, farmland quantity has the highest score in the years 1997, and 1999 – 2004. Thus, farmland quantity protection takes a leading role in the overall work of farmland protection. In the years 1996 – 1998, score of farmland quantity is relatively high, and farmland quantity protection plays an important role in farmland protection. In the years 2005 – 2007, since farmland sustainable development has the highest score, farmland sustainable development takes a leading role. According to the development trend of farmland protection, farmland protection in Urumqi – Changji Economic Zone at first strictly controls the quantity of farmland, then pays attention to the quality of farmland, and gradually turns to the sustainable use of farmland. In the years 1996 – 2001, farmland protection in Urumqi – Changji Economic Zone mainly focuses on the quantity and quality protection of farmland. In the years 2002 – 2006, it pays attention to the quantity protection of farmland and the sustainable use. And in the years 2007, farmland protection is mainly the quality protection and the sustainable use of farmland.

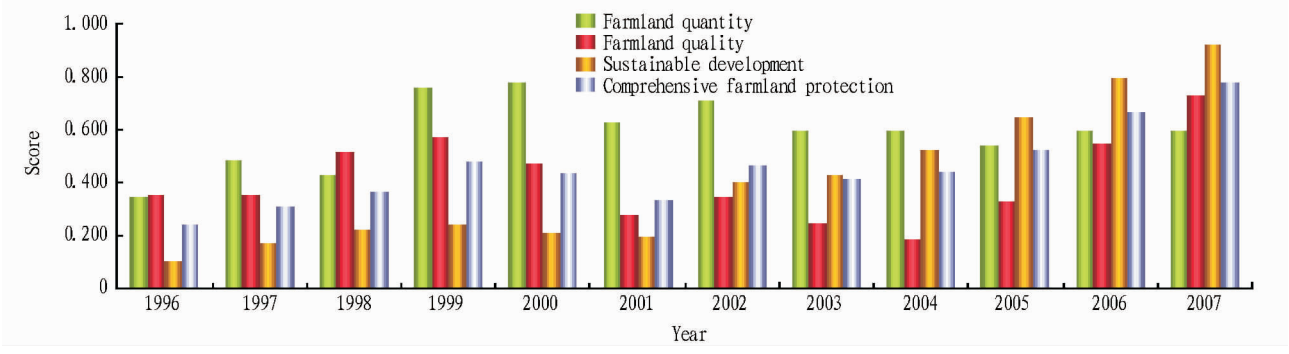

Fig. 1 Comprehensive evaluation score of farmland protection implementation in Urumqi – Changji Economic Zone in the years 1996 – 2007

According to the criterion layer of farmland protection, both quantity and quality protection of farmland have certain fluctuation. And fluctuation of farmland quantity is greater with its maximum value (0.775) in the year 2000 and the minimum value (0.346) in the year 1996. The average score is 0.588 in the years 1996 – 2007. Score of farmland quality protection is at a basically upward stage in the years 1996 – 1999, a decreasing stage in the years 2000 – 2004, and a stable stage in the years 2005 – 2007. In general, farmland quality protection has experienced the increase, then decrease, and again increase periods. To be specific, the years 1996 – 1999 are the first increase period for farmland quality protection; the years 2000 – 2004 are the decrease period; and the years 2005 – 2007 are the second increase period, with its maximum value (0.728) in the year 2007 and the minimum value (0.185) in the year 2004. Sustainable development of farmland in Urumqi – Changji Economic Zone shows an upward trend in general. In other words, the sustainability of farmland use gradually increases, with its maximum value (0.922) in the year 2007 and the minimum value (0.103) in the year 1996.

3.2 Index analysis of farmland protection within the criterion layer in Urumqi – Changji Economic Zone

3.2.1 Analysis of farmland quantity index. Fig. 2 illustrates the score of farmland quantity index in Urumqi – Changji Economic Zone in the years 1996 – 2007, based on the score of evaluation index A_{11} – A_{14} in Table 2.

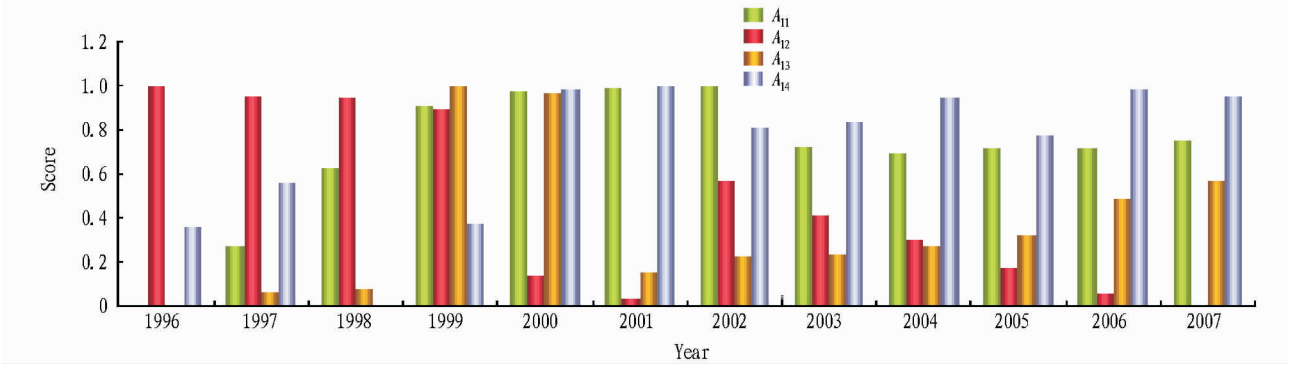

Fig. 2 Score of farmland quantity index in Urumqi – Changji Economic Zone in the years 1996 – 2007

Fig. 2 illustrates that the area of farmland turning into construction land (A14) has the greatest average score of 0.712, followed by the quantity change of farmland (A_{11}) and the per capita farmland area (A_{12}), which are 0.697 and 0.455 respectively. And the multiple cropping index (A_{13}) is the smallest (0.364). Higher average score indicates more significant effect of protection. Therefore, it can be concluded that farmland quantity protection in Urumqi – Changji Economic Zone has obtained significant achievements in controlling the transformation from farmland to construction land and in maintaining the area of farmland, but has no significant effects in the two aspects of per capita farmland area and multiple cropping index from the year 1996 to 2007. In the years 1996 – 1999, score of per capita farmland area is relatively high, indicating that the

contribution rate of per capita farmland area to farmland quantity protection is relatively great. In the years 1999 – 2000, score of multiple cropping index is relatively great, indicating that the contribution rate of multiple cropping index to farmland quantity protection is relatively great. In the years 2000 – 2002, quantity change of farmland has a relatively high score, showing that the contribution rate of farmland area to farmland quantity protection is relatively great. In the years 2003 – 2007, area of farmland turning into construction land has a relative high score, showing that the transformation control from farmland to construction land is relatively well.

3.2.2 Analysis of farmland quality index. Based on the scores of A_{21} – A_{24} in Table 2, Fig. 3 shows the score of farmland quality index in Urumqi – Changji Economic Zone in the years 1996 – 2007.

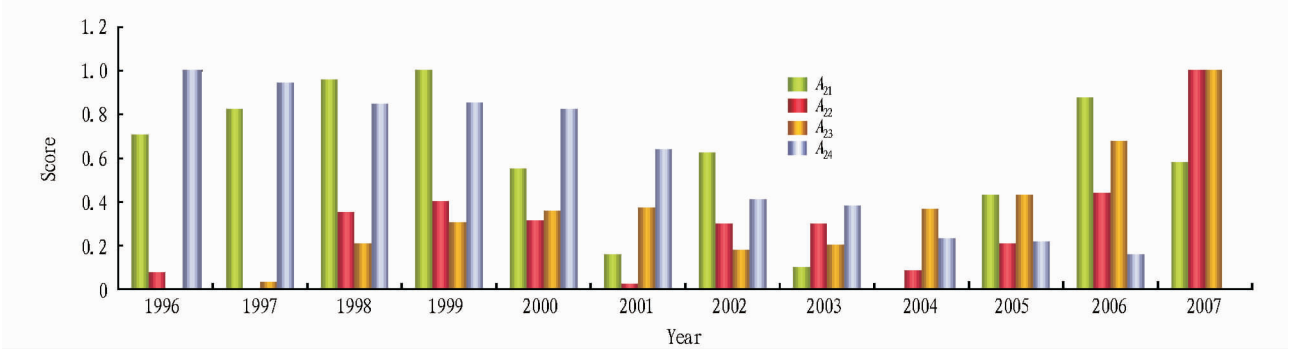

Fig. 3 Score of farmland quality index in Urumqi – Changji Economic Zone in the years 1996 – 2007

Fig. 3 shows that among the indices of farmland quality, total grain yield (A_{21}) has relatively high scores in the years 1996 – 1999 and 2006; unit grain yield (A_{22}) has a relatively high score in 2007; effective irrigation rate (A_{23}) has relatively high scores in 2006 and 2007; and use amount of chemical fertilizer per unit area (A_{24}) has relatively high scores in 1996 – 2000. According to the average score of index, total grain yield has a high score of 0.568, followed by use amount of chemical fertilizer per unit area (0.542) and effective irrigation rate (0.346). And unit grain yield has the smallest average score, which is only 0.292. According to the contribution of index to farmland quality protection, in the years 1996 – 1999, score increase of farmland quality protection is mainly due to the increase of total grain yield and effective irrigation rate. In the years 2000 – 2004, score decline of farmland quality is mainly due to the decrease of total grain yield and the increase of use amount of chemical fertilizer per unit area. In the years 2005 – 2007, score increase of farmland quality is mainly caused by the raise of unit grain yield and the effective irrigation rate. The change process of farmland quality shows that increase of farmland quality is at first the raise of total grain yield, then the unit grain yield, and finally the integration of unit grain yield and farmland infrastructure improvement.

3.2.3 Analysis of farmland sustainable use index. Based on the scores of A_{31} – A_{37} in Table 2, Fig. 4 shows the score of farmland sustainable use index in Urumqi – Changji Economic Zone in the years 1996 – 2007.

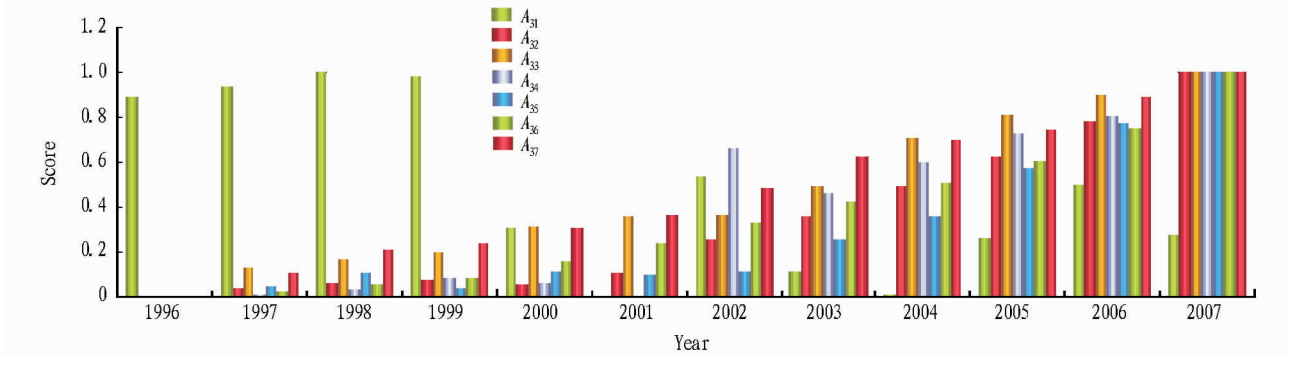

Fig. 4 Score of farmland sustainable use index in Urumqi – Changji Economic Zone in the years 1996 – 2007

Fig. 4 illustrates that among the indices of farmland sustainable use, per capita grain security coefficient (A_{31}) has the highest average score of 0.485, followed by per capita net income of farmer (A_{37}) and output value per unit land (A_{33}), which are 0.473 and 0.453, respectively. Fixed assets investment per unit area (A_{35}) has the smallest score of 0.291. Except the per capita grain security coefficient, all the indices are basically on the rise. And per capita grain security coefficient rises slowly at first, and then heads into a steep dive, and finally shows strong fluctuations.

4 Conclusion

In general, implementation effect of farmland protection in Urumqi – Changji Economic Zone tends to go better. Farmland protection at first strictly controls the farmland quantity, then pays attention to farmland quality, and finally focuses on the

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neck of e-commerce development is logistics. Because of the scattering characteristics of modern agriculture, and most of the products requiring fresh protection, all of which results in backward development of logistics construction. How to solve the problem of logistics is the key to e-commerce development. So, construct actively the logistics web sites covering Suzhou, build a logistics base composing collection, trading, distribution, processing and information flows to afford logistics service to products sales of the local.

3.6 Accelerating the e-commerce training course of farmers and attracting e-commerce talents The main body of agricultural e-commerce is farmers, agricultural industries and products trading agents. It may play an important part in accelerating the development of e-commerce to conduct e-commerce training to the main body, spreading among the main body the knowledge of network and e-commerce in a planned strategy.

Of course, the development of e-commerce cannot get devoid of knowledge of modern agricultural products, knowledge of business and network. So, the government should function as a guide, formulating beneficial policies to attract e-commerce experts and e-commerce students to get involved in e-commerce job in rural areas[9].

4 Conclusion

Agricultural e-commerce is based on information technology and network, managing the whole process of production, supply and sales of agricultural products. As a newly business mode, agricultural e-commerce is able to improve the sharp contradictions existing in circulation of agricultural market. Stimulating the rapid development of traditional agriculture with information is helpful to accelerate the industrialization of agriculture, upgrade the scientific management of modern agricultural industries. Suzhou modern agriculture is mainly industrialized agriculture, tourism agriculture, leisure agriculture and featured agriculture. By applying e-commerce, it has some practical significance to accelerate the development of modern agriculture and construction of new rural areas.

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sustainable use of farmland. According to the criterion layer of farmland protection, farmland quantity protection in Urumqi – Changji Economic Zone has obtained significant achievements in controlling the transformation from farmland to construction land and in maintaining the area of farmland, but has no significant effects in the two aspects of per capita farmland area and multiple cropping index from the year 1996 to 2007. The change process of farmland quality shows that increase of farmland quality is at first the raise of total grain yield, then the unit grain yield, and finally the integration of unit grain yield and farmland infrastructure improvement. Sustainable development of farmland shows an upward trend in general, that is, the sustainability of farmland use gradually increases.

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