Quest Journals
Journal of Research in Applied Mathematics
Volume 8 ~ Issue 6 (2022) pp: 71-78
ISSN(Online) : 2394-0743 ISSN (Print): 2394-0735
www.questjournals.org

Research Paper

Research on the Output of Main Agricultural Products in Henan Province Based on the Entropy Weight TOPSIS Method

Yongwei Yang, Mengjie Lv, Qiqi Li
(School of Mathematics and Statistics, Anyang Normal University, Anyang 455000, China)

ABSTRACT: *This paper takes the output levels of main agricultural products in 18 cities in Henan Province as the research topic. Based on the relevant data on the output of main agricultural products in various cities in Henan Province in 2020, we have constructed a total of 8 agricultural product output index evaluation systems including grain, vegetables, melons and fruits, and other categories. First, the entropy weight TOPSIS method is used to evaluate the output level of main agricultural products in 18 cities in Henan Province, and the evaluation results are analyzed by the method of systematic clustering. Finally, some targeted suggestions are put forward for the future development direction of agricultural products in various cities of Henan Province.*
KEYWORDS: *The entropy weight TOPSIS method, Cluster analysis, Agricultural production*

Received 12 June, 2022; Revised 25 June, 2022; Accepted 27 June, 2022

I. INTRODUCTION

Agriculture is the foundation of the national economy, and food is the top priority. Borsato, Tarolli and Marinello provided a combined analysis of different footprint approaches to allow comparison of different agricultural and livestock products regarding the efficiency of resource exploitation [1]. To achieve sustainable development, agriculture is one of the main fields to be considered and it is key to address economic, environmental and ethical problems. Sánchez-Bravo et al.carried out with more than 3600 consumers in 6 countries (Brazil, China, India, Mexico, Spain and USA) [2]. Participants were asked questions organized in two main topics: general sustainability and willingness to pay on different food categories. The main conclusion is that consumers are not fully aware of the importance of sustainability; in general, consumers tend to associate sustainable production with just organic farming and higher quality. In 2022, the No. 1 document of the Central Committee of China proposed to firmly adhere to the bottom line of national food security, ensure the stability of the grain planting area, and maintain the output above 130 million kilograms. Henan Province is a large agricultural province and is known as the "granary of China". The output of major agricultural products in various cities in Henan Province is of great significance to its economic development.

In order to better grasp the production situation of the main agricultural products in the cities of Henan Province and promote the economic development of the cities in Henan Province, it is very necessary to establish an evaluation model of the main agricultural product output levels of the cities in Henan Province. The research results of the main agricultural product output in Henan Province in this paper can not only provide a theoretical basis for Henan Province to formulate reasonable agricultural policies in the future, but also encourage Henan Province to improve agricultural product planting capacity and explore more advanced planting technology, which is conducive to accelerating the development of agricultural products.

II. EVALUATION INDEX SYSTEM OF AGRICULTURAL PRODUCTS

According to the reviewed literature, the evaluation system of the production level of main agricultural products in various cities in Henan Province can be used as the main basis for measuring the production level of agricultural products in various cities in Henan Province, including 8 evaluation indicators in three categories: grain, vegetables and fruits, and others. According to the "Henan 2021 Statistical Yearbook" by the Henan Provincial Bureau of Statistics, we collect the original data related to the output of major agricultural products in various cities in Henan Province in 2020, as shown in Table 1.

Table 1: Output of Main Agricultural Products in Henan Province in 2020 (unit: 10,000 tons)

Cities	Wheat	Corn	Beans	Vegetables and Edible Mushrooms	Fruits	Peanuts	Cotton	Chinese Herbal Medicine
Zhengzhou	71.18	66.15	1.02	219.84	24.22	11.33	0.06	0.12
Kaifeng	194.20	101.26	2.69	833.56	256.90	50.14	0.82	0.32
Luoyang	121.71	98.82	6.36	277.19	21.56	9.95	0.36	8.57
Pingdingshan	120.70	101.23	3.86	236.63	23.71	12.73	0.06	2.69
Anyang	207.28	168.22	1.06	500.07	80.31	22.16	0.21	0.83
Hebi	67.95	57.68	0.09	43.47	0.86	5.74	0.05	1.06
Xinxiang	279.15	188.82	3.48	322.66	22.75	34.44	11.00	0.93
Jiaozuo	116.35	92.82	1.45	199.65	16.63	13.26	0.02	35.94
Puyang	169.03	103.95	7.09	267.31	24.93	9.22	0.09	1.29
Xuchang	170.04	103.95	13.82	153.62	11.69	4.95	0.07	11.39
Luohe	110.69	65.89	10.19	201.74	46.10	6.24	0.02	0.10
Sanmenxia	35.55	28.70	4.26	124.08	10.58	1.49	0.08	6.91
Nanyang	422.39	232.58	7.47	1153.04	135.76	155.50	0.12	65.51
Shangqiu	447.35	274.32	12.24	1034.75	284.29	39.23	0.24	3.23
Xinyang	149.61	11.55	1.14	445.32	93.25	29.12	0.08	3.14
Zhoukou	548.21	351.99	19.65	1088.08	396.27	41.22	0.38	26.27
Zhumadian	508.86	262.06	5.62	489.05	111.50	147.99	0.01	7.06
Jiyuan	12.87	11.04	0.27	22.31	0.30	0.22	0.03	0.31

The first-level indicators included in the index system are: grain, vegetables and fruits, and other categories. The second-level indicators included in the first-level indicators are: wheat, corn, beans, vegetables and edible fungi, fruits, peanuts, cotton, and Chinese herbal medicine. The secondary indicators are numbered, and the evaluation system of major agricultural products in Henan Province is shown in Table 2.

Table 2: The Evaluation System of the output of Main Agricultural Products in Henan Province

First-level Indicators	Number	Second-level Indicators
Grain	X_1	Wheat
	X_2	Corn
	X_3	Beans
Vegetables and Fruits	X_4	Vegetables and Edible Mushrooms
	X_5	Fruits
Others	X_6	Peanuts
	X_7	Cotton
	X_8	Chinese Herbal Medicine

III. THE MODEL OF AGRICULTURAL PRODUCTS BASED ON THE ENTROPY WEIGHT-TOPSIS METHOD

The essence of entropy weight-TOPSIS method is the combination of entropy weighting method and TOPSIS method. Entropy weighting method is an objective weighting method, and its principle is to determine its indicators according to the actual data of each indicator and information entropy Weight [3]. The TOPSIS method is a method of sorting according to the proximity of the evaluation object to the idealized target [4-5]. Research on the production level of agricultural products in various cities in Henan Province, considering the influence of various factors, the following assumptions are given:

(1) Suppose that in 2020, the output of major agricultural products in Henan province will be affected by the weather and the degree of natural disasters is basically the same.

(2) Suppose that the number of agricultural labor number and mechanization input level in Henan province are basically the same.

The following is a description of the symbols in the model building.

Table 3: The representative meanings of symbols

Symbols	Representative Meanings
X_i	the *i*-th evaluation index
X	Evaluation index matrix
X_{max}	The most satisfactory items of the different schemes among the evaluation indicators.
X_{min}	The most unsatisfactory items of the different schemes in the evaluation indicators.
X_{ij}	The element in the ith row and jth column of the evaluation matrix *X*.
B	Normalized matrix
b_{ij}	The element in the *i*-th row and *j*-th column of the normalized matrix *B*.
f_{ij}	Characteristic weight
F	Entropy weight matrix
M_j	The entropy value of the *j*-th evaluation index
w_j	The modified entropy value of the j-th evaluation index
W	Weight coefficient
C	Weighted normative evaluation matrix
x_j^+	The *j*-th attribute value of the positive ideal solution
x_j^-	The *j*-th attribute value of the negative ideal solution
D_i^+	The distance between the *i*-th evaluation object and the positive ideal solution
D_i^-	The distance between the *i*-th evaluation object and the negative ideal solution
T_i	The relative closeness of the *i*-th evaluation object

3.1 Construction of Evaluation Index Matrix

The output of main agricultural products in various cities in Henan Province is shown in Table 1. The 18 cities in Henan Province have 8 evaluation indexes for the output of wheat, corn, beans, vegetables and edible fungi, fruits, peanut, cotton and Chinese herbal medicine, so the evaluation matrix X was obtained. The

*Corresponding Author: Yongwei Yang

most satisfactory item $X_{\max}$ and the least satisfactory item $X_{\min}$ of different schemes were found in the evaluation matrix X.

$$X=\begin{bmatrix}
71.18 & 66.15 & 1.02 & 219.84 & 24.22 & 11.33 & 0.06 & 0.12\\
194.2 & 101.3 & 2.69 & 833.56 & 256.9 & 50.14 & 0.82 & 0.32\\
121.7 & 98.82 & 6.36 & 277.19 & 21.56 & 9.950 & 0.36 & 8.57\\
120.7 & 101.2 & 3.86 & 236.63 & 23.71 & 12.73 & 0.06 & 2.69\\
207.3 & 168.2 & 1.06 & 500.07 & 80.31 & 22.16 & 0.21 & 0.83\\
67.95 & 57.68 & 0.09 & 43.470 & 0.860 & 5.740 & 0.05 & 1.06\\
279.2 & 188.8 & 3.48 & 322.66 & 22.75 & 34.44 & 11.0 & 0.93\\
116.4 & 92.82 & 1.45 & 199.65 & 16.63 & 13.26 & 0.02 & 36.0\\
169.0 & 104.0 & 7.09 & 267.31 & 24.93 & 9.220 & 0.09 & 1.29\\
170.0 & 104.0 & 13.8 & 153.62 & 11.69 & 4.950 & 0.07 & 11.4\\
110.7 & 65.89 & 10.2 & 201.74 & 46.10 & 6.240 & 0.02 & 0.10\\
35.55 & 28.70 & 4.62 & 124.08 & 10.58 & 1.490 & 0.08 & 6.91\\
422.4 & 232.6 & 7.47 & 1153.0 & 135.8 & 155.5 & 0.12 & 65.5\\
447.4 & 274.3 & 12.2 & 1034.8 & 284.3 & 39.23 & 0.24 & 3.23\\
149.6 & 11.55 & 1.14 & 445.32 & 93.25 & 29.12 & 0.08 & 3.14\\
548.2 & 352.0 & 19.6 & 1088.1 & 396.3 & 41.22 & 0.38 & 26.3\\
508.9 & 262.1 & 5.62 & 489.05 & 111.5 & 148.0 & 0.01 & 7.06\\
12.87 & 11.04 & 0.27 & 22.31 & 0.300 & 0.220 & 0.03 & 0.31
\end{bmatrix}$$

3.2 Standardized Processing of Evaluation Indicators

(1) Since the indicators are all extremely large indicators, there is no need for consistent processing.
(2) Normalization processing,

$$b_{ij}=\frac{X_{ij}-X_{\min}}{X_{\max}-X_{\min}}.$$

The matrix X was normalized to obtain the matrix B.

$$B=\begin{bmatrix}
0.110 & 0.163 & 0.049 & 0.176 & 0.062 & 0.073 & 0.007 & 0.002\\
0.339 & 0.266 & 0.134 & 0.715 & 0.646 & 0.323 & 0.075 & 0.005\\
0.204 & 0.258 & 0.321 & 0.226 & 0.055 & 0.064 & 0.034 & 0.131\\
0.202 & 0.265 & 0.194 & 0.190 & 0.061 & 0.082 & 0.007 & 0.041\\
0.363 & 0.460 & 0.051 & 0.422 & 0.203 & 0.142 & 0.020 & 0.013\\
0.104 & 0.138 & 0.002 & 0.021 & 0.003 & 0.037 & 0.006 & 0.017\\
0.496 & 0.520 & 0.174 & 0.266 & 0.058 & 0.221 & 0.996 & 0.015\\
0.194 & 0.240 & 0.071 & 0.158 & 0.043 & 0.085 & 0.003 & 0.547\\
0.292 & 0.273 & 0.358 & 0.217 & 0.064 & 0.060 & 0.009 & 0.020\\
0.294 & 0.273 & 0.700 & 0.117 & 0.031 & 0.032 & 0.007 & 0.174\\
0.184 & 0.162 & 0.515 & 0.160 & 0.117 & 0.041 & 0.003 & 0.002\\
0.044 & 0.053 & 0.214 & 0.091 & 0.028 & 0.010 & 0.008 & 0.105\\
0.762 & 0.648 & 0.377 & 0.996 & 0.342 & 0.996 & 0.012 & 0.996\\
0.809 & 0.770 & 0.619 & 0.892 & 0.715 & 0.252 & 0.023 & 0.050\\
0.256 & 0.003 & 0.055 & 0.347 & 0.235 & 0.187 & 0.008 & 0.048\\
0.996 & 0.996 & 0.996 & 0.939 & 0.996 & 0.264 & 0.035 & 0.400\\
0.923 & 0.734 & 0.283 & 0.412 & 0.218 & 0.948 & 0.002 & 0.108\\
0.002 & 0.002 & 0.011 & 0.002 & 0.002 & 0.002 & 0.004 & 0.005
\end{bmatrix}$$

3.3 The Weight Coefficient is Determined by the Entropy Value Method

In the comprehensive evaluation index system, it is necessary to consider the importance of the eight evaluation indicators of wheat, corn, beans, vegetables and edible mushrooms, melons and fruits, peanuts, cotton, and Chinese herbal medicines on the production level of agricultural products in each city. In order to highlight the local differences in the production level of agricultural products in various cities in Henan Province, the entropy value method is used to calculate the characteristic proportion, and the entropy weight matrix is obtained. Then, the entropy value is calculated and corrected, and finally the entropy weight of the entropy value of each evaluation index is obtained, that is, the weight coefficient of the eight evaluation indexes.

(1) Calculation of Eigenvalue Proportion

$$f_{ij} = \frac{1 + b_{ij}}{\sum_{i=1}^{m} \left(1 + b_{ij}\right)} .$$

The entropy weight matrix can be obtained by calculation:

$$F = \begin{bmatrix} 0.017 & 0.026 & 0.010 & 0.028 & 0.016 & 0.019 & 0.005 & 0.001 \\ 0.052 & 0.043 & 0.026 & 0.112 & 0.164 & 0.085 & 0.060 & 0.002 \\ 0.031 & 0.041 & 0.063 & 0.035 & 0.014 & 0.017 & 0.027 & 0.049 \\ 0.031 & 0.043 & 0.038 & 0.030 & 0.015 & 0.021 & 0.005 & 0.015 \\ 0.055 & 0.074 & 0.010 & 0.066 & 0.051 & 0.037 & 0.016 & 0.005 \\ 0.016 & 0.022 & 0.000 & 0.003 & 0.001 & 0.010 & 0.004 & 0.006 \\ 0.076 & 0.084 & 0.034 & 0.042 & 0.015 & 0.058 & 0.791 & 0.005 \\ 0.030 & 0.039 & 0.014 & 0.025 & 0.011 & 0.022 & 0.002 & 0.204 \\ 0.044 & 0.044 & 0.070 & 0.034 & 0.016 & 0.016 & 0.007 & 0.007 \\ 0.045 & 0.044 & 0.137 & 0.018 & 0.008 & 0.008 & 0.006 & 0.065 \\ 0.028 & 0.026 & 0.101 & 0.025 & 0.030 & 0.011 & 0.002 & 0.001 \\ 0.007 & 0.009 & 0.042 & 0.014 & 0.007 & 0.003 & 0.007 & 0.039 \\ 0.116 & 0.104 & 0.074 & 0.156 & 0.087 & 0.261 & 0.009 & 0.372 \\ 0.123 & 0.124 & 0.121 & 0.140 & 0.181 & 0.066 & 0.018 & 0.019 \\ 0.039 & 0.001 & 0.011 & 0.059 & 0.060 & 0.049 & 0.007 & 0.018 \\ 0.151 & 0.160 & 0.194 & 0.147 & 0.253 & 0.069 & 0.028 & 0.149 \\ 0.140 & 0.118 & 0.055 & 0.065 & 0.071 & 0.248 & 0.002 & 0.040 \\ 0.000 & 0.000 & 0.002 & 0.000 & 0.001 & 0.001 & 0.003 & 0.002 \end{bmatrix} .$$

(2) Calculation of the entropy value

$$M_j = \frac{-\left(\sum_{i=1}^{m} f_{ij} \ln f_{ij}\right)}{\ln m}, (i = 1, 2, \cdots, m; j = 1, 2, \cdots, n) .$$

The entropy value can be obtained by calculation:

$$M = [0.889 \quad 0.887 \quad 0.845 \quad 0.874 \quad 0.771 \quad 0.773 \quad 0.346 \quad 0.667] .$$

(3) Correction of entropy weight for the *i*-th evaluation index

$$w_j = \frac{1 - M_j}{n - \sum_{j=1}^{n} M_j} ,$$

Where $0 \le w_j \le 1$, and $\sum_{i=1}^{n} w_j = 1$.

(4) Weight coefficient $W = (w_j)_{1n}$.

The entropy weight of the entropy value of each evaluation index:

$$W = [0.057 \quad 0.059 \quad 0.075 \quad 0.065 \quad 0.118 \quad 0.117 \quad 0.337 \quad 0.172] .$$

3.4 Establishment and Solution of the Comprehensive Evaluation Model

Based on the above results, we weight the evaluation matrix. Finally, the TOPSIS method is used to determine the positive and negative ideal solutions, respectively. The relative closeness of the entropy weight of the comprehensive evaluation index of the main agricultural product output level in 18 cities was calculated.

(1) Weighted normative evaluation matrix

$$C = \left[b_{ij}\right]_{mn} \times \left[w_j\right]_{1\times n} = \left[c_{ij}\right]_{mn} .$$

After calculation, the weighted normative evaluation matrix can be obtained as:

$$C = \begin{bmatrix} 0.0063 & 0.0095 & 0.0037 & 0.0114 & 0.0073 & 0.0086 & 0.0022 & 0.0004 \\ 0.0194 & 0.0156 & 0.0101 & 0.0466 & 0.0762 & 0.0378 & 0.0254 & 0.0009 \\ 0.0117 & 0.0151 & 0.0241 & 0.0417 & 0.0065 & 0.0075 & 0.0113 & 0.0225 \\ 0.0116 & 0.0155 & 0.0145 & 0.0124 & 0.0072 & 0.0096 & 0.0022 & 0.0071 \\ 0.0208 & 0.0269 & 0.0039 & 0.0275 & 0.0239 & 0.0167 & 0.0068 & 0.0023 \\ 0.0060 & 0.0081 & 0.0002 & 0.0013 & 0.0004 & 0.0044 & 0.0019 & 0.0029 \\ 0.0284 & 0.0305 & 0.0131 & 0.0173 & 0.0069 & 0.0259 & 0.3358 & 0.0025 \\ 0.0111 & 0.0141 & 0.0053 & 0.0103 & 0.0051 & 0.0100 & 0.0010 & 0.0940 \\ 0.0167 & 0.0160 & 0.0269 & 0.0142 & 0.0075 & 0.0070 & 0.0031 & 0.0035 \\ 0.0168 & 0.0160 & 0.0525 & 0.0076 & 0.0036 & 0.0038 & 0.0025 & 0.0299 \\ 0.0105 & 0.0095 & 0.0387 & 0.0104 & 0.0138 & 0.0047 & 0.0010 & 0.0003 \\ 0.0025 & 0.0031 & 0.0161 & 0.0060 & 0.0033 & 0.0012 & 0.0028 & 0.0181 \\ 0.0436 & 0.0379 & 0.0283 & 0.0649 & 0.0403 & 0.1165 & 0.0040 & 0.1713 \\ 0.0463 & 0.0450 & 0.0465 & 0.0581 & 0.0843 & 0.0294 & 0.0077 & 0.0085 \\ 0.0146 & 0.0002 & 0.0042 & 0.0243 & 0.0277 & 0.0219 & 0.0028 & 0.0083 \\ 0.0570 & 0.0583 & 0.0748 & 0.0612 & 0.1174 & 0.0309 & 0.0120 & 0.0687 \\ 0.0528 & 0.0429 & 0.0212 & 0.0269 & 0.0331 & 0.1109 & 0.0007 & 0.0185 \\ 0.0001 & 0.0001 & 0.0008 & 0.0001 & 0.0002 & 0.0002 & 0.0013 & 0.0009 \end{bmatrix}.$$

(2) Determine the positive and negative ideal solutions.

Let the *j*-th property value of the positive ideal solution x^+ be x_j^+, and the *j*-th property value of the negative ideal solution x^- be x_j^-, then

$$x_j^+ = \max\{x_{1j}, x_{2j}, \cdots, x_{mj}\},\ j = 1, 2, \cdots, n\ ;$$

$$x_j^- = \min\{x_{1j}, x_{2j}, \cdots, x_{mj}\},\ j = 1, 2, \cdots, n\ .$$

The positive and negative ideal solution matrices are calculated as:

$$X^+ = [0.0570\quad 0.0583\quad 0.0748\quad 0.0649\quad 0.1174\quad 0.1165\quad 0.3358\quad 0.1713],$$

$$X^- = [0.0001\quad 0.0001\quad 0.0002\quad 0.0001\quad 0.0002\quad 0.0002\quad 0.0007\quad 0.0003].$$

(3) Calculate the distance.

D_i^+ and D_i^- are the distances between each evaluation object and the positive and negative ideal solutions, respectively, and the calculation formulas are as follows:

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (x_{ij} - x_j^+)^2},\ i = 1, \cdots, n\ ;$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} (x_{ij} - x_j^-)^2},\ i = 1, \cdots, n\ .$$

The distance matrices between between each evaluation object and the positive and negative ideal solutions, respectively:

$$D^+ = [0.4209\quad 0.3756\quad 0.4008\quad 0.4149\quad 0.4053\quad 0.4253\quad 0.2379\quad 0.3923\quad 0.1438$$
$$0.4909\quad 0.4164\quad 0.4167\quad 0.3446\quad 0.3974\quad 0.4077\quad 0.3503\quad 0.3839\quad 0.4295],$$

$$D^- = [0.197\quad 0.1032\quad 0.0429\quad 0.0302\quad 0.0527\quad 0.0111\quad 0.3394\quad 0.0966\quad 0.0394$$
$$0.0650\quad 0.0446\quad 0.0252\quad 0.2295\quad 0.1330\quad 0.0459\quad 0.1881\quad 0.1394\quad 0.0011].$$

(4) Calculate the relative closeness of the evaluation objects, and then sort the evaluation objects according to the relative closeness.

The formula for calculating the relative closeness of each evaluation object is:

$$T_i = D_i^- / (D_i^- + D_i^+),\ i = 1, \cdots, m\ ,$$

where, the larger T_i is, the better object is, and $0 < T_i < 1$.

From the above formula, the relative closeness of the comprehensive evaluation objects of the main agricultural product output levels of 18 cities in Henan Province can be calculated as follows:

$$T_i = [0.0448 \quad 0.2156 \quad 0.0967 \quad 0.0678 \quad 0.1151 \quad 0.0255 \quad 0.5879 \quad 0.1977 \quad 0.0869$$
$$0.1348 \quad 0.0968 \quad 0.0570 \quad 0.3998 \quad 0.2596 \quad 0.1012 \quad 0.3494 \quad 0.2664 \quad 0.0025].$$

According to the principle of entropy weight TOPSIS, the larger the value of relative closeness, the better the test object. For this reason, we can rank the production levels of main agricultural products in 18 cities in Henan Province, and get the relative production levels of main agricultural products in 18 cities in Henan Province. The corresponding situation of closeness and the final ranking of the output level of main agricultural products in 18 cities in Henan Province are shown in Table 4.

Table 4: The relative closeness and ranking of the output levels of main agricultural products in 18 cities in Henan Province

Cities	Zhengzhou	Kaifeng	Pingding shan	Luoyang	Anyang	Hebi	Xinxiang	Jiaozuo	Puyang
T_i	0.0448	0.2156	0.0678	0.0967	0.1151	0.0255	0.5879	0.1977	0.0869
Rank order	16	6	14	12	9	17	1	7	13
Cities	Xuchang	Luohe	Sanmen xia	Nanyang	Shangqiu	Xinyang	Zhoukou	Zhuma dian	Jiyuan
T_i	0.1384	0.0968	0.0570	0.3998	0.2596	0.1012	0.3494	0.2664	0.0025
Rank order	8	11	15	2	5	10	3	4	18

3.5 Phylogenetic Clustering

We use SPSS software to perform cluster analysis on the weighted results, which can classify the production levels of main agricultural products in 18 cities in Henan Province. The operation steps of SPSS are: import data → classify → systematic clustering → select variables → election case annotation based on statistics: centralized planning → pedigree map → inter-group connection and squared Euclidean distance → OK. The obtained results are shown in Figure 1.

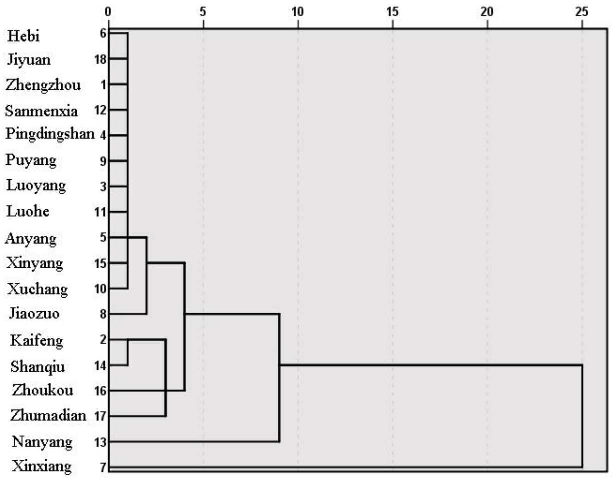

Figure 1: Genealogy diagram using intergroup connections

From the pedigree diagram in Figure 1, it can be found that it is more appropriate to divide the output levels of main agricultural products in Henan Province into four categories. The classification results are shown in Table 5.

Table 5: Classification results

Categories	Cities
The first category	Xinxiang
The second category	Nanyang

The third category	Kaifeng, Shangqiu, Zhoukou, Zhumadian
The fourth category	Jiyuan, Hebi, Puyang, zhengzhou, etc.

3.6 Result Analysis

The first category of cities is Xinxiang City. The output of main agricultural products in Xinxiang City ranks first in Henan Province and ranks first in terms of comprehensive index. From the perspective of various indicators, the output of wheat, corn, peanuts and cotton in Xinxiang City is considerable, while the output of melons, fruits and Chinese herbal medicines is slightly lacking.

The second category of city is Nanyang City. The peanut output of Nanyang City is much higher than that of other cities, which has made a huge contribution to the output of oil crops in Henan Province. At the same time, the output of wheat, corn, and Chinese herbal medicine in Nanyang City is also very considerable, but the output of cotton is less.

The third category of cities is Kaifeng, Shangqiu, Zhoukou, and Zhumadian. The comprehensive index of these cities ranks 3 to 6, and the comprehensive output of their main agricultural products is higher than the average level of the comprehensive production of main agricultural products in various cities in Henan Province. The output of agricultural products in each city has its own advantages. The output of grain agricultural products in Zhoukou City and Zhumadian City is significantly higher than that in other cities; the output of vegetables, melons and fruits in Kaifeng City and Shangqiu City is more obvious.

The comprehensive level of production of major agricultural products in the fourth category of cities is generally low, such as Jiyuan City, Hebi City, Puyang City and Zhengzhou City. There are many reasons for the low comprehensive level of production of major agricultural products in these cities. For example, the planting area of agricultural products in Jiyuan City and Hebi City is limited. Zhengzhou City is the provincial capital and focuses on the development of emerging technology industries. At the same time, the output of agricultural products is also affected by geographical and climatic factors.

3.7 Suggestions for the Agricultural Development of Cities in Henan

Nanyang City and Zhumadian City have advantageous geographical locations and large arable land, which provide good basic conditions for the development of agricultural products. Located in the middle and lower reaches of the Yellow River, Kaifeng City has abundant natural resources and can vigorously grow watermelons and peanuts. It can be found that cities with higher levels of agricultural output have better natural resource conditions and geographical advantages. Cities in Henan province should make good use of their own geographical location, climate conditions and other objective factors to actively develop agricultural production. At the same time, they should also strengthen the investment in agricultural science and technology, apply scientific and technological achievements to agriculture, and improve the comprehensive agricultural productivity. In addition to the six cities with high agricultural output level, other cities in Henan Province have also made irreplaceable contributions to the development of agricultural products in Henan Province.

IV. CONCLUSION

Based on the relevant data on the output of main agricultural products in various cities in Henan Province in 2020, this paper constructs an index evaluation system for agricultural product output. Then, the entropy weight TOPSIS method is used to evaluate and analyze the production levels of main agricultural products in 18 cities in Henan Province, and some pertinent suggestions are put forward.

ACKNOWLEDGEMENT

The works described in this paper are partially supported by The 2022 College Students' Innovation and Entrepreneurship Training Program project (No. 202210479046).

REFERENCES

[1]. E. Borsato, P. Tarolli and F.Marinello, Sustainable patterns of main agricultural products combining different footprint parameters. Journal of Cleaner Production, 2018, **179**: p. 357-367.

[2]. P. Sánchez-Bravo, et al., Consumer understanding of sustainability concept in agricultural products. Food Quality and Preference, 2021, **89**: https://doi.org/10.1016/j.foodqual.2020.104136

[3]. W. Li, P. Yi and D. Zhang, Sustainability evaluation of cities in northeastern China using dynamic TOPSIS-entropy methods. Sustainability, 2018, **10**(12): p. 1-15.

[4]. H. Liu and K. You, Study on optimization of filter press dewatering process by entropy weighting method improved TOPSIS and gray correlation analysis. Coal Preparation Technology, 2022. **50**(2): p. 26-31.

[5]. W. Qing and Y. Wang, An evaluation of public safety perception of urban chinese residents based on TOPSIS-entropy method. Mathematics in Practice and Theory, 2018, **48**(24): p. 126-133.