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Comprehensive Benefit Analysis of Shouxian Straw Resources based on AHP

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Abstract

The comprehensive utilization of straw resources is of great significance to country's construction of agricultural ecological circular economy,however, different grain production areas due to differences in geographical and economic factors have led to the diversification of regional straw utilization methods. In order to maximize the comprehensive utilization efficiency, various localities adopt appropriate methods according to local conditions. This article takes Shouxian area in Anhui Province as an example, uses expert scoring and fuzzy evaluation methods to compare and analyze comprehensive benefits, explore the mechanism of suitable local approaches, and provide reference for the comprehensive utilization of crop straw in other regions.

Keywords

Comprehensive Utilization Of Straw, Expert Scoring Method, Fuzzy Evaluation Method, Comprehensive Benefit.

1. Introduction

As one of the main grain producing areas in the country, Anhui Province has an annual grain production of 40 million tons and an average annual straw collection amount of about 48 million tons. Although the comprehensive utilization rate of straw in province has reached about 87%, about 20% of the straw resources are still unused. This phenomenon is mainly due to the lack of in-depth understanding of local climate environmental conditions, resource allocation, agricultural structure, income level and farmers' cognition. In addition, the policy formulation is not clear, the technology promotion is not comprehensive, and the departmental inspectors are not strong enough to punish, resulting in the straw being burned or stacked in the field at will. These not only caused increased air pollution and waste of resources, but also damaged the local soil ecological environment, which is not conducive to the planting of the next crops. Therefore, vigorously encouraging and continuing to guide the development of the straw industry is an important measure to promote the sustainable development of the agricultural economy and increase the income of local residents. As an economically backward agricultural county in Anhui, Shouxian has 1.8165 million mu of arable land, 3.705 million mu of crop planting area, and an annual output of 1.6 million tons of straw, accounting for 2.8% of the province's total straw resources, the theoretical amount of crop straw can be collected is 1.364 million tons. Therefore, the study of Shouxian area has certain reference value for the study of straw utilization in Anhui Province. This article analyzes the benefits of the three main comprehensive utilization methods of straw in Shouxian area and obtains the best utilization method in the area, which provides a reference basis for the straw industry in this area.

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2. Summary of Domestic and Foreign Research Literature

2.1. Research Status of Straw Utilization

2.1.1. Returning of Straw to Field

At present, among the straw processing methods in my country, the utilization rate of straw returning to the field is relatively high. Zhao Debing (2017) [1] believes that returning straw to the field can effectively solve the problems of air pollution and environmental damage caused by straw burning. Moreover, the organic matter in the straw can improve the soil, thereby promoting the growth of crops. Relevant studies have shown that returning straw to the field can cause changes in soil structure,porosity,moisture and etc. It also affects the growth and development of crops to a certain extent. The changes and effects brought by different ways of returning straw to the field are also different. In some economically backward areas, due to the low degree of agricultural mechanization and backward mechanical level, the technology of returning straw to the field is not mature enough. After returning to the field, it is easy to cause an imbalance in the proportion of carbon and nitrogen in the soil, and cause pests and diseases. What's more, straw rot is also difficult in some areas.

The technology of returning straw to the field has been deeply studied and widely used abroad. Farms in developed countries generally harvest the whole straw and crush it before returning it to the field. The research of Ferrieretal (2005) [2] shows that straw mulching to the field protects the farmland from natural disasters to a greater extent. Glab T, kulig (2008) [3] believed that soil aggregates increased significantly when straw returned to the field, and Hamido proposed that straw mulching could increase soil moisture.

2.1.2. Organic Fertilizer of Straw

Straw organic fertilizer is to collect the straw first, and add the required manure and biological bacteria according to the corresponding method during the storage process, which can make the straw ferment and finally form organic fertilizer. This method has obvious effects in increasing soil nutrients and preventing diseases and pests.

However, due to the complicated process of making straw into fertilizer, the factory generally collects and processes the straw. Therefore, Shi Qiaodan (2019)[4] believes that there are some areas in this process that need to be improved, such as the need to increase the intensity of government policies, arrange for a special team to collect and comprehensively use the straw in each township. In addition, it is necessary to increase publicity to let residents in various places have a deep understanding of the hazards of straw burning and promote environmental protection; What's more, the plant's straw fertilizer production process needs to establish a system so that the straw collection,bundling,crushing and production processes can be mechanized to speed up the fertilizer production. Finally, it is necessary to supervise the waste discharge of enterprises. While banning the burning of straw and protecting the environment, the production of straw fertilizer should not damage the environment again. Baudoine (2009) [5] conducted research and found that the nitrogen,phosphorus and potassium contained in straw can improve soil quality by increasing organic matter. Abdullah (2009) [6] believes that straw fertilizer can enhance soil fertility by enhancing soil enzyme activity.

2.1.3. Energisation of Straw

Energy utilization of straw is an innovative form of comprehensive utilization of straw. Energy is a major factor restricting future development. Energy utilization of straw can alleviate the threat and pressure caused by the shortage of fossil fuels. Among the straw processing methods, Zhou Quanzeng (2009) [7] believes that the return of straw to the field and straw fertilizer cannot solve the waste of materials caused by the complete consumption of straw, so new technologies are needed to process straw. Liu Peng (2010)[8] believes that straw energy conversion is an ideal treatment method. It not only consumes a large amount of straw, but also does not emit carbon dioxide, which meets the needs of economic development. Some scholars have conducted research on the methods of energy conversion of straw and found that the final products mainly include fuel,biogas,ethanol,diesel,etc. In addition, straw can also be used for power generation. Zhu Wen (2016) [9] found in research that the commonly used straw energy utilization technologies in the country mainly include fermentation of biogas,liquefaction to oil,combustion for power generation,molding fuel,gasification of gas, etc. Fermentation of biogas is the use of biogas bacteria to ferment straws to form biogas in a suitable environment. Straw power generation is to use it as a combustion raw material for power generation, mainly including direct combustion, mixed combustion and gasification combustion. Straw can also be used as solid, liquefied and gasified fuel. Generally, factories use straw liquefaction to produce ethanol or diesel, while straw gasification is generally used to produce combustible gases such as methane,hydrogen and carbon monoxide. In developed countries, renewable energy technologies have taken the lead. As early as 2005, the German Ministry of Environment used straw biogas and straw power generation as new energy utilization methods [10]. F.Monforti (2013) [11] pointed out in the study that the straw produced from 8 corn fields can provide fuel for about 850 factories.

2.2. Research Status of Comprehensive Utilization of Straw

2.2.1. Analysis of Economic Benefits

The first is the way of returning straw to the field. Sun Renjie [12] (2018) believes that the direct return of crop stalks to the field after being mechanically crushed is the more convenient and direct way to use straws, and it also brings the best economic benefits. At the same time, it can supplement and balance soil nutrients to achieve the purpose of improving soil [12].This method can fully improve resource utilization and save costs, which is of great significance to the improvement of the basic fertility of cultivated land and the sustainable development of agriculture.

The second is the energy use of straw. Wang Bo (2020) [13] believes that the energy use of straw can coordinate various forms of utilization. Straw molded fuel can be used as an independent energy terminal product or as a semi-finished product for other energy applications. It can expand the raw material supply radius of other energy utilization methods, form a stable raw material supply chain and high-efficiency industrial clusters, improve the overall efficiency of straw energy utilization, and increase economic benefits.

2.2.2. Analysis of Social Benefits

First of all, returning crop straws to the field has many benefits to the soil. Yu Chunyan (2010) [14] believes that in improving soil fertility, returning corn straws to the field can effectively increase soil activity and soil organic matter content, which can increase soil fertility. In terms of soil conservation and water saving, when the precipitation in Jilin Province is concentrated and large, returning corn straws to the field can delay the rate of water infiltration, reduce surface runoff and effectively prevent ineffective evaporation in the field, which guarantees water use efficiency and improves soil water storage capacity. In terms of increasing soil porosity, returning corn straws to the field will affect the bulk density of the surface soil, thereby loosening the soil and improving soil aeration capacity. In terms of low temperature resistance, corn straws have better shading properties, it can be cooled by the effect of reverse radiation when the outside temperature rises, and can have a heat preservation effect when the temperature drops. Returning corn straws to the field has obvious social benefits. Its essence is to follow the internal laws, maintain the balance of the agricultural ecosystem and realize the sustainable use of land productivity.

Secondly, straw power generation projects not only affect the power industry, but also affect society and all aspects of life. Cui Xiaoxue (2019)[15] believes that straw power generation projects need to collect and store a large amount of straw resources, which can not only reduce the environmental hazards caused by straw burning, but also improve the random stacking of straw and the appearance of the village. Recycling the plant ash produced after the burning of straw is used for cultivating fertilizer, which is beneficial to the development of recycling of straw resources. In addition, the lack of electricity seriously affects people's lives, the straw power generation project can solve this problem.

2.2.3. Environmental Benefit Analysis

The first is the use of straw as energy. Zhu Jianchun (2014)[16] believes that idle or even wasted corn straws used for power generation not only improve the environmental pollution caused by incineration, but also play a role in protecting the ecological environment,which is compatible with the use of corn straws for power generation and sustainable development.

The second is the return of straw to the field. Yan Yang (2019) [17] believes that the return of corn straws to the field will affect the soil respiration in the early stage, but will reduce the soil respiration in the later stage. Over time, the farmland with corn straws will reduce the carbon dioxide emitted from the farmland to the atmosphere. Returning corn straws to the field not only increases soil carbon supply, accelerates the emission of nitrogen dioxide and denitrification, but also reduces the loss of denitrification nitrogen. Allelochemicals will be produced during the decomposition of corn straws to prevent denitrification.Corn straws can replace part of chemical fertilizers, reduce the amount of chemical fertilizers used, prevent environmental pollution due to straw burning, reduce farmers' production costs and related costs for processing straw. Covering the ground with corn straws can reduce soil erosion and inhibit the formation of "sand storms."

2.3. Literature Review

In the past, straw was directly incinerated, but with the increase of awareness of environmental protection and the improvement of technical level, the treatment of straw has been significantly improved. At present, the treatment methods of straw in our country mainly include straw return to field, straw fertilizer and straw energy. Through these treatment methods, the use of resources can be effectively achieved, while the quality of the soil and the growth of crops can be improved. Energisation can produce various products, such as ethanol, diesel or methane, so as to provide more energy for residents' lives. The benefits of comprehensive utilization of straw mainly include economic, social and ecological benefits. The structure can be constructed through the analytic hierarchy process to evaluate the comprehensive utilization benefits of the results.

3. Utilization Status of Straw Resources

3.1. Total Theoretical Collection of Straw in Shouxian

In recent years, with the expansion of planting area, the total amount of straw resources of agricultural and sideline products in Shouxian county is also rising.The calculation of straw collectable yield is generally calculated by crop yield and its respective grass to grain ratio. In the determination of the ratio of grain to grass, it is excluded that the crops in the region are affected by environmental and geographical factors, because the stubble degree of different crops and crop grains are different. Based on the data provided by the field survey and relevant enterprises, and referring to the "agricultural technical and economic manual", the ratio of grain to grass of three crops was obtained.Secondly, referring to the crop yield data of “Huainan statistical yearbook”2015-2019, combined with the data provided by the existing literature, the straw collection coefficient is 0.89-0.93.The median value is 0.91. The theoretical straw resources collected in Shouxian shown in table1.

The calculation of straw yield is based on the yield of crops and the ratio of grass to grain. The formula is as follows:

$$S=\sum_{i=1}^{k} S_i X_i d_i$$

S -Total yield of straw collectable (t)

i -Straw collection years

S_i -Crop yield in year i

X_i -Grain grass ratio in year i

d_i -Utilization coefficient of straw collection in year i

Table 1. The total yield of straw that can be collected in Shouxian in recent five years from 2014 to 2018

year	Wheat	rice	soybean	rape	cotton	total
2018	522300	1142200	15800	24600	7656	1712556
2017	392100	922000	15000	26400	7400	1364000
2016	694632	846531	16149	27688	8000	1593000
2015	738131	971136	17041	34860	6896	1768064
2014	680000	574320	13500	32400	5470	1305690

It can be seen that the total straw collection amount in Shouxian from 2014 to 2017 showed an increasing trend. In 2018, it has reached 1712556t, including 1142200t of rice and 522300t of wheat.Combined with the regional characteristics of crop planting in various regions of the country, it can be seen that Shouxia is located in the Huaihe River Basin, with superior geographical and climatic characteristics, and has a large area of agricultural underlayer, which is a typical representative of the Huang Huai ecological region in China. The amount of grain straw collection is mainly wheat and rice.In order to comprehensively promote the transformation of ecological economy in Shouxian , in recent years, the local government has introduced relevant enterprises and technical talents, established a demonstration base for comprehensive utilization of straw, implemented the policy subsidy and reward and punishment system, and vigorously promoted the development of comprehensive utilization of straw.As of 2018, breakthrough progress has been made by Shouxian. The straw collection amount of the whole county has reached 1712556t, and the utilization rate has reached more than 93%, an increase of about 3.0% over the previous year. In the future development process of comprehensive utilization of straw, the government should take advantage of the advantages and avoid the disadvantages, develop the advantageous industries in the region, and establish a diversified, regional and efficient industrial chain of straw resources utilization.

3.2. Current Situation of Straw Utilization in Shouxian

3.2.1. Straw Collection and Storage

Straw collection generally refers to the manual or mechanical collection of straw, straw binding, compression, packaging and other steps. Straw storage refers to the storage of straw in the processing plant or storage point. Straw transportation is to transport straw to the processing plant.The technical mode of straw collection, storage and transportation in China is mainly decentralized and centralized. The main body of decentralization is farmers, professional cooperative economy or straw broker, who collect straw first and then provide it to enterprises.

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However, the defect of this mode is that the principle of system management is poor and is restricted by individuals.The main body of centralized collection, storage and transportation mode is professional straw collection, storage and transportation company or farm. After the overall collection, processing and transportation of straw, it will be classified and sold. This model solves the random risk of straw supply, but the disadvantage is that the capital cost of early investment is large.In response to the government's call for comprehensive utilization of straw, Shouxian has established about 600 collection and storage points in the whole county, and actively established systematic and regional straw collection and storage network, and achieved good demonstration effect. At the same time, the introduction of straw based enterprises as industrial raw materials to achieve efficient utilization of straw. For example, Anhui Geyi circular economy Industrial Park Co., Ltd., as an Anhui Provincial technology enterprise, consumes 180000 tons of crop straw every year.

3.2.2. Straw Returning

The economy of Shouxian is underdeveloped. As the main way of straw utilization, straw returning is low cost and easy to operate, accounting for 80% of the total straw utilization.Good experimental results have been achieved in covering, crushing and organic returning. However, straw returning also faces some challenges.Straw returning directly to the field is easy to rot, and the microorganisms decomposed may destroy the balance of carbon and nitrogen ratio in soil layer, thus affecting crop sowing and development.On the current market, although the automatic integrated sowing harvester is simple in operation and efficient in efficiency, the cost of agricultural machinery is slightly higher, and the operator is required to have professional technology and rich experience. In view of this problem, Shouxain government introduced and implemented the agricultural machinery subsidy policy. As of 2018, the county has 1000 tractors above 66.15 kW, 1360 straw returning machines, 7000 rotary tillers, 150 reverse stubble cutters and 100 balers.

3.2.3. Straw Organic Fertilizer

Shouxian is short of chemical fertilizer resources. Since 2017, Shouxian county has vigorously promoted the work of straw organic fertilizer, and established two demonstration sites for integrated rice and fertilizer agricultural planting. There are about 12 organic fertilizer processing enterprises and demonstration sites in the county. About 50% of them can produce more than 20000 tons of organic fertilizer annually. For example, CITIC Geyi recycling economy Co., Ltd. is committed to the production of straw organic fertilizer, with an annual output of 26000 tons of organic fertilizer and an annual consumption of 28500 tons of straw raw materials.However, the research and development of strains on the biological bacteria decomposition process is relatively slow, and the requirements for temperature control are relatively high, and some nitrogen and phosphorus elements will be lost in the processing process. Therefore, the processing point should improve the level of professional technology, control the strain and temperature, and balance the fertilizer yield and nutrition.

3.2.4. Straw Energy

The fossil energy in Shouxia is mainly coal consumption, and excessive coal mine energy consumption will make it face the dilemma of lack of disposable energy and uncoordinated development.However, reasonable utilization of straw resources and improvement of energy structure can well adjust the current situation of unreasonable energy distribution. At present, the straw energy industry chain in Shouxian is not perfect. As one of the first batch of renewable energy projects for biomass power generation in China, Guoneng bio Power Generation Co., Ltd. is the first straw power generation project in Shouxian county with energy conservation and emission reduction as the center. The financial support of the county government is 1.473 million yuan. According to statistics, it can generate 100 million kwh per year, of which the average annual consumption of crop straw is about 170000 tons ,and the company adds 6000

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to 8000 extra per capita for local farmers per year Income.However, the tar produced in the gasification process of straw greatly reduces the efficiency of straw utilization, and the black carbon particles produced during the combustion of straw also cause serious loss to power generation equipment, which also greatly increases the cost.

4. Comprehensive Benefit Analysis based on AHP

4.1. Related Theories and Applications of AHP

The analytic hierarchy process is to decompose specific problems into goals,criteria and indicators, on this basis, perform quantitative analysis to obtain the optimal decision. Petrini (2016) [18] believes that the analytic hierarchy process can divide complex issues into multiple levels, then compare the advantages and disadvantages, and finally rank the importance of various influencing factors. This method can combine qualitative and quantitative analysis with subjective judgment to achieve the purpose of problem-solving. Yu Jusheng (2014) [19] believes that the analytic hierarchy process can generally be divided into four processes: constructing a hierarchical system, constructing a matrix, calculating a weight vector and performing a consistency check.

The analytic hierarchy process has been used in many aspects abroad, such as agricultural public policy evaluation, resource management, etc. The basic research methods are to decompose the target hierarchically into a hierarchical structure, then construct a matrix of related indicators, and finally calculate the results and sort the indicators. Yavuz (2013) [20] carried out a hierarchical analysis study on the rationality of Brazilian government policies, so as to understand the living conditions of farmers in sugarcane growing areas, and find out the factors that influence the policies. Oddershede (2007) [21] evaluated the water management strategy of the largest lake basin in Turkey, combined the SWOT method with the analytic hierarchy process, and finally found the best way to solve the problem.

4.2. AHP Analysis

4.2.1. Establish an Indicator System

As a major agricultural county in Anhui, Shouxian mainly produces rice,wheat and soybeans, with an annual output of about 1.6 million tons of straws. Therefore, scientific recycling and utilization of straw resources is of great significance in economic, social and environmental aspects. Improving the efficiency of comprehensive utilization of straw can help the local government build "Green Shouxian" and "Ecological Shouxian", what's more, it realizes the recycling of agricultural and sideline products resources while increasing employment for residents and driving the development of the county's ecological economy. Therefore, this article analyzes the comprehensive utilization of local straw from the perspectives of straw returning to the field, organic fertilizer and energisation. The indicator system constructed includes three parts, namely the target layer, the criterion layer and the indicator layer. The specific index system diagram is shown in Table 2:

Table 2. comprehensive benefit evaluation index system of straw utilization mode

Target layer	Criterion layer	Index layer
Comprehensive benefits of straw utilization A	Economic benefits B1	Input output ratio C1
		Return on investment C2
		Enterprise development capability C3
	Social benefits B2	Average annual income increase of farmers C4
		New posts C5
	Environmental benefits B3	Carbon dioxide emission reduction C6
		Energy conversion rate C7
		Resource recycling rate C8

4.2.2. Scale Definition and Construction of Judgment Matrix

The construction of reasonable judgment matrix affects the accuracy of the final decision. Experts with rich experience in straw related fields were invited to give evaluation scores for each index according to the evaluation criteria. The number 1-9 and its reciprocal are used as the scale. Table 3 for details, and the judgment matrix is determined by expert scoring.

Table 3. Definition of judgment matrix scale

Scale	Definition
1	Index i and index j have the same importance
3	Index i is slightly more important than indicator j
5	Index i is more important than index j
7	Index i hightly important than index j
9	Index i extremly important than index j
2,4,6,8	The intermediate value of the above adjacent judgments
reciprocal	If the ratio of importance of index i and j is a, the ratio of importance of index j and i is 1 / A

4.2.3. Calculate the Weight and Consistency Test of Each Index in the Criterion Layer

The judgment matrix of the criterion layer relative to the target layer obtained by expert scoring is shown in Table 4.

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Table 4. Judgment matrix of criterion layer relative to target layer

A	B1	B2	B3
B1	1	2	3
B2	1/2	1	1
B3	1/3	1	1

Calculate weight vector

The weight vector of the judgment matrix is obtained by the sum product method. In the first step, the judgment matrix is normalized according to the column, and the standard judgment matrix is obtained.

$$\bar{b}_{ij} = \frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}}$$

The second step is to sum the standard judgment matrix by row.

$$\bar{W}_i = \sum_{j=1}^{n} \bar{b}_{ij}$$

The results are as follows

Table 5. The results

A	B1	B2	B3	Sum
B1	0.5455	0.5000	0.6000	1.6455
B2	0.2727	0.2500	0.2000	0.7227
B3	0.1818	0.2500	0.2000	0.6318

The third step is to normalize the sum and get the weight of each index

$$W_i = \frac{\bar{W}_i}{\sum_{j=1}^{n} \bar{W}_i}$$

The results are as follows

Table 6. The results (2)

Index	Weight vector
B1	0.5485
B2	0.2409
B3	0.2106

Consistency test

After calculating the weight of each index, the consistency test should be carried out.

The first step is to calculate the consistency index CI:

$$CI = \frac{\lambda_{max} - m}{m - 1}$$

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The maximum eigenvalue λmax is calculated as follows

$$\lambda_{max} = \sum_{i=1}^{n} \frac{\sum_{j=1}^{n} a_{ij} W_i}{nW_i}$$

Get λmax=3.0183
Since M = 3,CI = 0.0092 is obtained
The second step is to find the random consistency index RI:

Table 7. Standard value of random consistency index RI

m	1	2	3	4	5	6	7	8	9
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46

Because the judgment matrix is a third-order matrix, M = 3, RI = 0.52
In the third step, the consistency ratio Cr is calculated:

$$CR = \frac{CI}{RI}$$

If the CR value is less than 0.1, it means that the consistency test has been passed, otherwise, it means that the consistency test has not been passed.
And CR = 0.0176, less than 0.1, so it passed the consistency test.

4.2.4. Calculate the Weight and Consistency Test of Each Index Layer

Repeat the above process, calculate the relative weight of each index in the index layer and conduct consistency test. The results are as follows:

Table 8. Judgment matrix, weight and consistency test results of "economic benefit" index

B1	C1	C2	C3	Wi	CR
C1	1	2	3	0.5390	
C2	1/2	1	2	0.2973	0.0089
C3	1/3	1/2	1	0.1638	

Table 9. Judgment matrix, weight and consistency test results of "social benefit" index

B2	C4	C5	Wi	CR
C4	1	2	0.6667	0
C5	1/2	1	0.3333	

Table 10. Judgment matrix, weight and consistency test results of "environmental benefit" index

B3	C6	C7	C8	Wi	CR
C6	1	1/2	1	0.2341	
C7	2	1	4	0.5794	0.0518
C8	1	1/4	1	0.1865	

To sum up, the weight results obtained by AHP are as follows:

Table 11. The weight results obtained by AHP

Target layer	Criterion layer	Index layer	0.5390
Comprehensive benefits of straw utilization A	Economic benefits B1	Input output ratio C1	0.5390
		Return on investment C2	0.2973
		Enterprise development capability C3	0.1638
	Social benefits B2	Average annual income increase of farmers C4	0.6667
		New posts C5	0.3333
	Environmental benefits B3	Carbon dioxide emission reduction C6	0.2341
		Energy conversion rate C7	0.5794
		Resource recycling rate C8	0.1865

From the table ,it can be seen that in the economic benefits, the weight of input-output rate is the largest. In the social benefits, the weight of farmers' annual income increase is the largest. Among the environmental benefits, the weight of energy conversion rate is the largest.

4.3. Fuzzy Comprehensive Benefit Evaluation

4.3.1. Determine the Evaluation Factor Set, Weight Set, Comment Set and Value Set

(1) Evaluation factor set

According to the comprehensive benefit evaluation index system of straw utilization, the evaluation factor set has two layers.

The first floor is A=(B1,B2,B3);

The second floor is B1=(C1,C2,C3),B2=(C4,C5),B3=(C6,C7,C8)

(2)Weight set

According to the weight obtained by analytic hierarchy process, the weight set of target assignment can be obtained as follows:

W=(W1,W2,W3)=(0.5485,0.2409,0.2106)

W1= (0.5390,0.2973,0.1638)

W2= (0.6667,0.3333)

W3= (0.2341,0.5794,0.1865)

(3) Comment set and value set:

Comment set V=(V1,V2,V3,V4)=(very good, good, average, poor)

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The value set corresponds to the comment set, specifically as N=（N1,N2,N3,N4）=（4, 3, 2, 1）

4.3.2. Determination of Membership Degree

According to the comprehensive benefit evaluation index system of straw utilization, a questionnaire was designed and 36 valid questionnaires were distributed and recovered. The content of the questionnaire is to evaluate the indicators of the index layer, and the evaluation content is "very good, good, general, poor". The filling amount of each index evaluation grade of returning farmland, fertilizer and energy is as follows.

Table 12. The filling amount of each index evaluation grade of straw returning farmland

Index	Very good	Good	Average	Poor
C1	16	12	6	2
C2	14	19	2	1
C3	17	14	2	3
C4	15	16	5	0
C5	13	12	6	5
C6	19	13	2	2
C7	13	15	6	2
C8	15	11	9	1

Table 13. Filling amount of each index evaluation grade of straw organic fertilizer

Index	Very good	Good	Average	Poor
C1	7	15	10	4
C2	11	18	6	1
C3	9	14	7	6
C4	12	17	5	2
C5	11	16	9	0
C6	10	14	8	4
C7	8	19	6	3
C8	13	15	5	3

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Table 14. Filling amount of each index evaluation grade of straw energy utilization

Index	Very good	Good	Average	Poor
C1	3	13	16	4
C2	5	15	9	7
C3	5	12	13	6
C4	6	13	15	2
C5	8	15	11	2
C6	5	17	13	1
C7	3	12	14	7
C8	6	16	9	5

According to the filling quantity of each evaluation grade, the membership degree of each index can be obtained. If the filling quantity of "good" in "returning farmland" is 16, then 16 / 36 = 0.4444. By analogy, a general table of membership degrees can be obtained, as shown below.

Table 15. Membership table of straw returning

Index	Very good	Good	Average	Poor
C1	0.4444	0.3333	0.1667	0.0556
C2	0.3889	0.5278	0.0556	0.0278
C3	0.4722	0.3889	0.0556	0.0833
C4	0.4167	0.4444	0.1389	0.0000
C5	0.3611	0.3333	0.1667	0.1389
C6	0.5278	0.3611	0.0556	0.0556
C7	0.3611	0.4167	0.1667	0.0556
C8	0.4167	0.3056	0.2500	0.0278

Table 16. Membership table of straw organic fertilizer

Index	Very goood	Good	Average	Poor
C1	0.1944	0.4167	0.2778	0.1111
C2	0.3056	0.5000	0.1667	0.0278
C3	0.2500	0.3889	0.1944	0.1667
C4	0.3333	0.4722	0.1389	0.0556
C5	0.3056	0.4444	0.2500	0.0000
C6	0.2778	0.3889	0.2222	0.1111
C7	0.2222	0.5278	0.1667	0.0833
C8	0.3611	0.4167	0.1389	0.0833

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Table 17. Membership table of straw energy utilization

Index	Very good	Good	Average	Poor
C1	0.0833	0.3611	0.4444	0.1111
C2	0.1389	0.4167	0.2500	0.1944
C3	0.1389	0.3333	0.3611	0.1667
C4	0.1667	0.3611	0.4167	0.0556
C5	0.2222	0.4167	0.3056	0.0556
C6	0.1389	0.4722	0.3611	0.0278
C7	0.0833	0.3333	0.3889	0.1944
C8	0.1667	0.4444	0.2500	0.1389

4.3.3. First Level Fuzzy Evaluation

According to the membership degree of each evaluation factor, the fuzzy relation matrix corresponding to the index of the criterion layer can be obtained and expressed by RI. For example, the fuzzy relation matrix R1, R2 and R3 corresponding to the economic benefit, social benefit and environmental benefit of the criterion layer are as follows.

$$R_1 = \begin{bmatrix} 0.4444 & 0.3333 & 0.1667 & 0.0556 \\ 0.3889 & 0.5278 & 0.0556 & 0.0278 \\ 0.4722 & 0.3889 & 0.0556 & 0.0833 \end{bmatrix}$$

$$R_2 = \begin{bmatrix} 0.4167 & 0.4444 & 0.1389 & 0 \\ 0.3611 & 0.3333 & 0.1667 & 0.1389 \end{bmatrix}$$

$$R_3 = \begin{bmatrix} 0.5278 & 0.3611 & 0.0556 & 0.0556 \\ 0.3611 & 0.4167 & 0.1667 & 0.0556 \\ 0.4167 & 0.3056 & 0.2500 & 0.0278 \end{bmatrix}$$

Similarly, the fuzzy relation matrix corresponding to each criterion layer index of fertilizer conversion and energy conversion can be obtained. Due to the space relationship, it is not listed here one by one. After calculating the fuzzy relation matrix of each criterion layer over the years, the corresponding evaluation matrix can be obtained by the formula Ei=Wi×Ri. For example, the evaluation matrix of each criterion layer index is as follows.

$$E1=W1\times R1=(0.5390,0.2973,0.1638)\times \begin{bmatrix} 0.4444 & 0.3333 & 0.1667 & 0.0556 \\ 0.3889 & 0.5278 & 0.0556 & 0.0278 \\ 0.4722 & 0.3889 & 0.0556 & 0.0833 \end{bmatrix}$$

= (0.4325,0.4003,0.1155,0.0519)

E2=W2×R2= (0.3982,0.4074,0.1481,0.0463)

E3=W3×R3= (0.4105,0.3829,0.1562,0.0504)

After calculating the evaluation matrix corresponding to each criterion layer index over the years, it is necessary to score it. Similarly, taking returning farmland as an example, the P_i of each index in the criterion layer is as follows.

P1=E1× NT = (0.4325,0.4003,0.1155,0.0519)×(4,3,2,1) T =3.2137

P2=E2× NT = (0.3982,0.4074,0.1481,0.0463)×(4,3,2,1) T =3.1574

P3=E3× NT = (0.4105,0.3829,0.1562,0.0504)×(4,3,2,1) T =3.1535

In the same way, the evaluation matrix, and corresponding scores of each index in the criterion layer of fertilizer and energy conversion can be obtained. The specific results are as follows.

Table 18. The specific results

Straw utilization	Index	Very good	Good	Average	Poor	Score
Straw returning	Economic benefits B1	0.4325	0.4003	0.1155	0.0519	3.2137
	Social benefits B2	0.3982	0.4074	0.1481	0.0463	3.1574
	Environmental benefits B3	0.4105	0.3829	0.1562	0.0504	3.1535
Straw organic fertilizer	Economic benefits B1	0.2366	0.4369	0.2311	0.0954	2.8149
	Social benefits B2	0.3241	0.4630	0.1759	0.0370	3.0741
	Environmental benefits B3	0.2611	0.4745	0.1745	0.0898	2.9070
Straw energy utilization	Economic benefits B1	0.1090	0.3731	0.3730	0.1450	2.4462
	Social benefits B2	0.1852	0.3796	0.3796	0.0556	2.6944
	Environmental benefits B3	0.1119	0.3866	0.3565	0.1451	2.4653

4.3.4. Secondary Fuzzy Evaluation

Konwn W = (W1, W2, W3) = (0.5485, 0.2409, 0.2106). In the first level fuzzy evaluation part, the comprehensive fuzzy relation matrix R of returning farmland, fertilizer and energy is obtained. Taking returning farmland as an example, the comprehensive fuzzy relation matrix R is as follows.

$$R(\text{Straw returning}) = \begin{bmatrix} 0.4235 & 0.4003 & 0.1155 & 0.0519 \\ 0.3982 & 0.4074 & 0.1481 & 0.0463 \\ 0.4105 & 0.3829 & 0.1562 & 0.0504 \end{bmatrix}$$

The comprehensive evaluation matrix can be obtained by multiplying the weight of each index in the criterion layer and the comprehensive fuzzy relation matrix, E=W×R,and then the comprehensive score can be obtained by P= E× NT. Finally, the comprehensive evaluation matrix and score of returning farmland, fertilizer and energy are obtained as follows.

Table 19. fertilizer and energy access

Straw utilization	Very good	Good	Average	Poor	Score
Straw returning	0.4196	0.3983	0.1319	0.0502	3.1875
Straw organic fertilizer	0.2628	0.4511	0.2059	0.0802	2.8967
Straw energy utilization	0.1279	0.3775	0.3711	0.1235	2.5100

Therefore, it can be concluded that the comprehensive benefit score of straw returning is higher than that of the other two methods, which is worthy of being widely used in this area. The cost of straw returning to the field is low, and after implementation, it can also improve the land fertility, which is conducive to increasing crop yield and increasing farmers' income. Straw organic fertilizer also has advantages in social and environmental benefits. Due to the high implementation cost and tedious operation of straw energy, the score of economic and social benefits is low.

5. Analysis Conclusion

This article takes the Shouxian of Anhui Province as an example, combines the local economic level and regional characteristics, uses the analytic hierarchy process and the fuzzy evaluation method, and obtains the most suitable straw utilization method for the local area through comprehensive benefit analysis. Therefore, the selection of straw utilization methods should be suitable for local conditions. In regions with rich resources and high economic and technological levels, priority should be given to the development of the straw energy industry, such as establishing relevant industrial bases and introducing technical talents. In areas with a low level of economic and technological development, the government should improve the policy subsidy system and increase the awareness of local farmers about the use of straw. Simple and easy use is the best choice. Secondly, because the straw recycling and storage system in some rural areas has not been established and perfected, the straw utilization rate is low, which is not conducive to the long-term development of the ecological economy. The local government should vigorously support and encourage the development of local purchasing and storage enterprises, help them improve the regional collection system as soon as possible according to the cost, time, transportation and other related factors of straw collection to ensure the efficient use of straw resources. In establishing the straw industry chain, the local government and relevant departments should optimize the comprehensive use of straw utilization methods based on the actual utilization of straw resources and technology, effectively and scientifically improve the comprehensive utilization of local straw by adopting the straw multivariate recycling method. In addition, the government should maintain close communication with relevant enterprises and research institutes, cooperate in the development of new technologies used in the straw field, explore new market models, actively transform research results to jointly promote industrial economic development and improve social benefits.

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