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Evaluation of Agricultural Extension Service for Sustainable Agricultural Development Using a Hybrid Entropy and TOPSIS Method

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Abstract: Agricultural extension service is the foundation of sustainable agricultural development. The evaluation and analysis of the agricultural extension service for sustainable agricultural development can provide an effective analytical tool for sustainable agriculture. This paper analyzes the influence of agricultural extension service on sustainable agricultural development, and constructs an evaluation system for sustainable agricultural development from the four dimensions of agricultural environment, society, economy, and agricultural extension service. This work proposes a framework based on the combination of technique for order performance by similarity to ideal solution (TOPSIS) and entropy method to evaluate the performance of the evaluation system. Taking three national modern agriculture demonstration zones in Suzhou in Jiangsu Province as a case study, the method was verified. Moreover, the main factors affecting sustainable agricultural development are discussed, and the improvement measures and management suggestions are also put forward to reduce the obstacles to sustainable agricultural development and improve sustainable agriculture practice.

Keywords: agricultural extension service; sustainable agricultural development; multiple criteria decision-making

1. Introduction

The United Nations Sustainable Development Summit held in 2015 adopted 17 Sustainable Development Goals, and all countries in the world have been committed to working together to achieve sustainable development [1]. It is evident that there is a close relationship between agriculture and the environment, so the main challenge of agricultural development is to meet the growing population’s needs while mitigating the damage to the environment [2]. The use of natural resources in agricultural production has disturbed the natural environment [3], especially in terms of global warming, water resources pressure, soil degradation, and environmental damage, which pose a threat to the living environment of human beings. Therefore, new agricultural practices must be implemented [4]. Pretty [5] put forward the challenge of sustainability in agricultural development. Sustainable agricultural development refers to the sustainable development of agriculture, forestry, and fishery that is environmentally sound, technologically appropriate, economically feasible, and socially acceptable [6]. Additionally, Hansen [7] proposed that the goal of agricultural sustainability is to create a system that can meet current needs without compromising the interests of future generations.

The key to realizing sustainable agricultural development is to strengthen the construction of agricultural extension services (AES). Technological progress has become the main driving force for the growth of agricultural production in China [8,9]. AES is an important way to spread new technology, which also plays an increasingly significant role in the sustainable development of agriculture in China [10]. In China, AES is implemented through
a wide range of government agencies [11], including crop, animal husbandry, agricultural machinery, aquaculture management centers, as well as plant protection, horticulture, soil, and fertilizer technology centers [12].

Disseminating and promoting environmentally friendly agricultural technologies to increase agricultural economic benefits, to improve resource use efficiency, and to protect the natural environment is intended for developing the AES. Thus, AES can be viewed as an effective way to develop sustainable agriculture [13]. It is a form of knowledge dissemination supported by the public sector, which links agricultural technology with agricultural practice [10]. AES is expected to enhance the economic efficiency and protect the environment and natural resources through technology transfer [14], such as using pesticides to reduce the impact on water quality [15], applying integrated pest management to avoid the use of chemical pesticides and herbicides alone [10,16], implementing animal disease management to improve food safety [17], developing agrometeorological services to cope with climate change [18], using soil testing and fertilizer technology to conserve resources [19] and so on. Additionally, information technology can provide training and education tools for sustainable agricultural development because it can quickly benefit more and more people [20], thus improving the service efficiency of agricultural sustainable development [21].

The establishment of a scientific and rational evaluation system of AES for sustainable agricultural development is one effective way to realize sustainable agriculture. The evaluation system of AES can be used to analyze the main factors affecting the sustainable development of agriculture [22], to put forward improvement measures [23], and to improve the efficiency of AES [24]. The evaluation results of the evaluation system of AES can improve the decision-making of the agricultural sustainable system [25], reduce the obstacles to the sustainable development of agriculture [26], and provide support for the government to formulate agricultural policies [27]. In this study, sustainable agricultural development is analyzed from three dimensions of the environment, society, and the economy [28,29], as well as the dimension of AES, by constructing an evaluation index system of AES and adopting a multiple-criterion decision-making method [30]. It is believed that evaluating and analyzing AES in the sustainable development of agriculture is an effective analytical tool for sustainable agricultural development.

The motivation for the research is that the establishment of an evaluation system of AES for the sustainable development of agriculture can improve the efficiency of AES, reduce obstacles to the sustainable development of agriculture, and enhance the decision-making of agricultural sustainability through analyzing leading causes of affecting the sustainable development of agriculture; thus, it is one of the effective ways to achieve sustainable development of agriculture. In the Measures for the Management of Experimental Demonstration Zones for Sustainable Agricultural Development formulated by the Chinese government, the index system of sustainable agricultural development is proposed, including five dimensions of agricultural production, resources, environment, ecology, and farmers’ lives [31]. This paper considers the impact of AES on sustainable agricultural development and constructs a four-dimensional evaluation system, including the environment, society, the economy, and AES. Furthermore, the sustainable agricultural development in southern Jiangsu Province was investigated, and the evaluation system of AES was constructed to provide the tools for decision-makers to analyze sustainable agricultural development. Based on the current situation of sustainable agricultural development in southern Jiangsu Province, the evaluation index system and decision-making method of AES were also analyzed. To better understand the effectiveness of the evaluation system, the quantitative evaluation method and evaluation indexes were selected for empirical analysis. Three representative cases were selected, the evaluation system of AES was analyzed, and the management suggestions for sustainable agricultural development were put forward.

The rest of this paper is organized as follows. The evaluation index system of AES for sustainable agricultural development was put forward first. Then, the synthesized
multiple-criterion decision-making evaluation method based on information entropy is adopted to determine the index weight in Section 2, as well as the explanation of the evaluation model framework. Section 3 introduces the methods applied to verifying the evaluation model. Section 4 presents the results through case studies. Section 5 discusses the result, and finally, Section 6 provides a summary of the research.

2. Materials

2.1. Initial Index System

Sustainable development is a widely used concept [32], but it is not easy to measure sustainable agricultural development [33]. People worldwide are paying more and more attention to the social, ecological, and economic feasibility of agriculture [29,34]. It is necessary to promote the sustainable development of agriculture in terms of the environment, society, and economy [35]. Latruffe et al. [28] proposed that the index of sustainable agricultural development should be set from three dimensions of the sustainable concept, that is, environment, economy, and society. Additionally, Tomich et al. [36] also argued that the main dimensions of evaluating sustainable agricultural development are society, the economy, and the environment.

This paper takes the evaluation index system of AES for sustainable agricultural development as the research object. The impact of AES on sustainable agricultural development is analyzed from three aspects of environment, society, and economy. Therefore, an initial index system is constructed, including the environmental index, social index, economic index, and AES index, as shown in Figure 1.

![Figure 1. The evaluation system of agricultural extension service (AES) for sustainable agriculture.](image-url)
2.2. Environmental Criteria

China’s agricultural policy has gradually focused on reducing the impact of agriculture on the environment [37]. As a limited resource, water is an important environmental factor for promoting sustainable agricultural development. Water conservation is the foundation of sustainable development of agriculture [38]; thus, how to realize water conservation has become a primary problem for sustainable agricultural development in China [39]. Organic farming can improve water use efficiency [40], cut down greenhouse gas emissions, reduce energy demand and the harmful effects of chemicals in the agricultural production process [41,42]; it can also contribute to the sustainable development of agriculture [43].

The impacts on the environment are reduced through the effective disposal and recycling of crop residue, livestock manure, and agricultural film. Crop residue can be used as organic fertilizer [44] to control soil moisture and temperature, reduce weed growth [45], improve soil, and reduce energy consumption [46]. Livestock manure is the primary source of agricultural pollution. More than 90% of the total chemical oxygen demand in China’s agricultural pollution comes from livestock manure [47]. It will have a considerable impact on the environment in case of improper discharge of livestock manure [48]. In the face of challenges, it is necessary to adopt a sustainable livestock industry system for the effective management of livestock manure [49]. Due to the widespread use of agricultural film, the recovery rate is generally less than 60%, resulting in a large amount of agricultural film residue, which affects the soil structure and soil nutrients and leads to the problem of “white pollution” [47].

The agricultural environmental criteria are constructed by referring to the agricultural environmental index system mentioned in the “National Sustainable Agricultural Development Experimental Demonstration Zone Evaluation Index System” [31] issued by the Ministry of Agriculture and Rural Affairs of the People’s Republic of China in combination with the agricultural society system in the relevant literature. According to the analysis above, the agricultural environmental criteria include agricultural water consumption (I1), effective use coefficient of farmland irrigation water (I2), organic food yield (I3), synthesized use ratio of crop residue (I4), synthesized use ratio of livestock manure (I5), and agricultural film recovery rate (I6). The agricultural water consumption index (I1) belongs to the minimum type (i.e., the smaller, the better), and the other indexes belong to the maximum type (i.e., the larger, the better).

2.3. Social Criteria

Although social dimensions are increasingly being included in the sustainable development evaluation, there is no consensus on what should be included in the social dimensions and how to deal with them [50], and the indexes adopted in the social dimensions of sustainable development evaluation are also inconsistent [51,52]. Janker and Mann [50] pointed out that the aim of sustainable development is to make the earth habitable for humans today and in the future. Sustainability itself represents a human-centered concept. Therefore, quality of life is a sustainable influencing factor associated with social dimensions. Janker and Mann [50] also argued that training is one of the sustainability indexes in the social dimensions. Additionally, social welfare also represents an increase in local government revenue [53].

The agricultural social criteria are also constructed with reference to the agricultural social index system mentioned in the “National Sustainable Agricultural Development Experimental Demonstration Zone Evaluation Index System” [31] issued by the Ministry of Agriculture and Rural Affairs of the People’s Republic of China in combination with the agricultural society system in the relevant literature. Based on the analysis above, the social criteria include the per capita disposable income of farmers (I7), the number of the agricultural labor force with professional certificates (I8), the number of the labor force with a college education or above (I10), and local government income (I11). All the above indexes belong to the maximum type.
2.4. Economic Criteria

Sustainable agricultural development is the foundation of China’s economic development [54]. Sustainable agricultural development should include the sustainable development of agriculture, forestry, and fishery, which are economically feasible [6].

The agricultural economic criteria are constructed by referring to the China Statistical Yearbook. As can be observed from the China Statistical Yearbook issued by the National Bureau of Statistics of China, the total outputs of the agriculture, forestry, animal husbandry, and fishery are the main indexes for presenting the agricultural economy [55] in combination with the agricultural social system described in the relevant literature. Thus, the economic criteria constructed include agricultural output value (I12), forestry output value (I13), animal husbandry output value (I14), and fishery output value (I15). All the above indexes belong to the maximum type.

2.5. Agricultural Extension Service Criteria

AES is the key to realizing sustainable agricultural development, and it is supported by the public sector. The sustainable agricultural development technology is promoted by the agricultural technology service personnel, to improve the farmers’ ability through training and apply the technology to the agricultural practice [10]. China’s AES includes an animal epidemic prevention and control system, agricultural product quality supervision system, rural management system, and meteorological service system. The spread of animal diseases worldwide has brought new challenges to animal epidemic prevention and control systems [56]. With the improvement of animal epidemic prevention and control level, animal husbandry and the breeding industry have achieved sustainable development [17]. Additionally, Frame and Brown [57] emphasized that sustainable agricultural development can be realized through agricultural production management, and different irrigation and fertilizer management for different crops are also emphasized [58]. Moreover, a sound agrometeorological service system should be established to provide services for sustainable development of agriculture [18].

The AES uses the technology of integrated pest management and soil testing and fertilizer to serve sustainable agricultural development. The world is striving for sustainable agricultural practices, mainly through effective pest control [59]. Integrated pest management uses different methods to control pests [60] to avoid using only chemical pesticides and herbicides [16]. It can also avoid environmental damage and improve the agricultural system’s overall performance [61]. In addition, soil testing and fertilization are powerful measures for protecting resources and improving the environment [19].

With the development of information technology, the Internet provides a useful link between agricultural service organizations and farmers [10], benefiting more and more remote audiences, and providing training and education tools for sustainable agricultural development [20].

The AES criteria are constructed with reference to the function description [62] of the National Agricultural Technology Extension Center, which is subordinated to the Ministry of Agriculture and Rural Affairs of the People’s Republic of China with the number and coverage of agricultural extension services as sub-criteria in combination with the agricultural society system in the relevant literature. According to the analysis above, the AES criteria include the number of personnel for agricultural technology extension service (I16), the animal epidemic prevention and control system (I17), the quality supervision system of agricultural products (I18), the rural business management system (I19), the meteorological service system (I20), the green control coverage rate of crop diseases and insect pests (I21), the soil testing and fertilizer coverage rate (I22), the information service system (I23), and the number of broadband access (I24). All the above indexes belong to the maximum type.
3. Methods

To achieve the sustainable development of agriculture, an appropriate evaluation method is needed to provide information about the current state of the agricultural system and to put forward the intervention measures for the current state [29]. Synthesized evaluation is a powerful tool for sustainable agricultural development [63]. In this paper, the synthesized multi-criterion decision-making evaluation method combined with the entropy method is employed to determine the weights of the indexes (as shown in Figure 2).

![Figure 2. The flowchart of the entropy and TOPSIS method for the evaluation of sustainable agricultural development.](image)

3.1. Entropy Method

There are two methods of weighting determination: the subjective method and the objective method. The subjective weighting method is based on the experience of decision-makers and obtains the weight of indexes by analyzing their importance, such as the Delphi and Analytic Hierarchy Process [64]. Obviously, subjective weighting is subjective because it depends mostly on the preferences of the decision-maker.
The objective weighting method is a quantitative weighting method that is characterized by the existence of objective criteria for weighting. The weight coefficient for the evaluation index is calculated, rather than defined by people, which can effectively reflect the data and difference of the evaluation index.

The entropy method is a kind of objective weighting method. It uses entropy value to measure the degree of influence of various evaluation indicators on the pros and cons of schemes for the system, which avoids the influence of subjective factors from experts. The entropy method is used to determine the weight with good stability, and the result is relatively reasonable.

The main steps of the entropy method to determine weight are as follows [65].

1. Standardization of the decision matrix: Set up a decision matrix $y_{ij}$ with $n$ evaluation objects and $m$ evaluation indexes. Due to the differences in the dimension and the order of magnitudes of each index, each index should be standardized.

   $$P_{ij} = \frac{y_{ij}}{\sum_{i=1}^{n} y_{ij}} \quad (i = 1, 2, \ldots, n; j = 1, 2, \ldots, m)$$  

   where $P_{ij}$ is a standardized decision matrix, and $y_{ij}$ is the value $i = 1, 2, \ldots, n; j = 1, 2, \ldots, m$ of the $j$th evaluation index of the $i$th evaluation object.

2. Normalize the entropy value of the $j$th index among $n$ evaluation objects and $m$ evaluation indexes in the matrix:

   $$E_j = -K \sum_{i=1}^{n} P_{ij} \ln P_{ij} \quad (i = 1, 2, \ldots, n; j = 1, 2, \ldots, m)$$

   where $E_j$ is the entropy value of the $j$th index among the $m$ evaluation indexes. In the equation

   $$K = \frac{1}{\ln n}$$

3. Calculate the information utility value of the $j$th index:

   $$d_j = 1 - E_j \quad (j = 1, 2, \ldots, m)$$

4. Calculate the weight of the evaluation index:

   $$\omega_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \quad (j = 1, 2, \ldots, m)$$

where $\omega_j$ is the index weight of the $j$th index.

3.2. TOPSIS

Hwang and Yoon [66] proposed TOPSIS on the basis of constructing ideal solutions and negative ideal solutions for multi-index problems, as the foundation for evaluating feasible schemes approaching ideal solutions and the distance from negative ideal solutions. TOPSIS can be applied for ranking and calculating the alternatives [67]. Debnath et al. [68] pointed out that TOPSIS is an effective tool for multi-attribute decision-making. The main steps of TOPSIS are presented below:

1. Normalize the criteria value of the decision matrix.

   $$Z_{ij} = \frac{y_{ij}}{\sqrt{\sum_{j=1}^{m} (y_{ij})^2}} \quad (i = 1, 2, \ldots, n; j = 1, 2, \ldots, m)$$

where $Z_{ij}$ is a normalized decision matrix, and $y_{ij}$ is the value $i = 1, 2, \ldots, n; j = 1, 2, \ldots, m$ of the $j$th evaluation index of the $i$th evaluation object.
(2) Build a weighted and regulated matrix.
\[ x_{ij} = \omega_j \times z_{ij} \quad (i = 1, 2, \ldots, n; j = 1, 2, \ldots, m) \]  
where \( x_{ij} \) is a weighted decision matrix, and \( \omega_j \) refers to the index weight of the \( j \)th index.

(3) Determine the ideal solution \( X^+ \) and the negative ideal solution \( X^- \).
\[ X^+ = \{ \max x_{ij} \mid i = 1, 2, \ldots, n; j = 1, 2, \ldots, m \} = \{ x^+_1, x^+_2, \ldots, x^+_m \} \]  
\[ X^- = \{ \min x_{ij} \mid i = 1, 2, \ldots, n; j = 1, 2, \ldots, m \} = \{ x^-_1, x^-_2, \ldots, x^-_m \} \]  
where \( X^+ \) is the normalized and weighted target ideal solution, and \( X^- \) is the normalized and weighted target negative ideal solution.

(4) Calculate the distance between \( x^+_j \) and the ideal solution \( D^+_i \), and the distance between \( x^-_j \) and the negative ideal solution \( D^-_i \).
\[ D^+_i = \sqrt{\sum_{j=1}^{m} (x_{ij} - x^+_j)^2} \quad (i = 1, 2, \ldots, n) \]  
\[ D^-_i = \sqrt{\sum_{j=1}^{m} (x_{ij} - x^-_j)^2} \quad (i = 1, 2, \ldots, n) \]  
where \( D^+_i \) is the Euclidean distance between the actual value of each evaluation object and the ideal solution, and \( D^-_i \) is the Euclidean distance between the actual value of each evaluation object and the negative ideal solution.

(5) Calculate the queuing value of each alternative.
\[ C_i = \frac{D^-_i}{D^-_i + D^+_i} \quad (i = 1, 2, \ldots, n) \]  
where \( C_i \) is the relative approaching degree between the feasible solution and the ideal solution.

For the multi-level index evaluation model, it is necessary to generate the initial matrix of the upper level from the relative approaching degree \( C_i \) of the single level evaluation index, calculate the relative approaching degree of the upper-level indexes, and obtain the evaluation results of the upper level [69].

(6) Sort according to the queuing value of each alternative.
(7) Rank the preference order.

According to the mean and standard deviation of \( C_i \) [70], four classes are specified as follows:

Class I: \( C_i \geq \overline{C}_i + S_{C_i} \)

Class II: \( \overline{C}_i \leq C_i < \overline{C}_i + S_{C_i} \)

Class III: \( C_i - S_{C_i} \leq C_i < \overline{C}_i \)

Class IV: \( C_i < \overline{C}_i - S_{C_i} \)  
where \( \overline{C}_i \) is the mean of \( C_i \) and \( S_{C_i} \) is the standard deviation of \( C_i \).

The TOPSIS method used in this paper is to rank the distance from the evaluation object to the optimum solution and the worst solution [71]. To make better use of the original data, it has been extensively applied in multi-criterion evaluation [72] with no strict restriction on the sample content and the number of indexes of the data and good applicability. Moreover, TOPSIS can be used for evaluating different levels of the evaluation system to find out the problems existing in the evaluation object. The evaluation system of sustainable development of AES proposed in this paper is also applicable to the evaluation of sustainable development of agriculture.
4. Results

One of the objectives of this study is to provide a tool for decision-makers to analyze sustainable agricultural development for the sustainable development of agriculture. As an example, we consider a data set from China. China is an ideal setting, typifying an emerging market because of its population, fast-growing economy, and increased sustainability of most agricultural sectors. The data is collected from three national modern agriculture demonstration zones located in Suzhou, Jiangsu province in 2019, that is, Xiangcheng, Wujiang, and Kunshan. Those three modern national agriculture demonstration zones mainly produce grain and oil crops with abundant water resources and aquatic resources, ranking in the top 100 areas with the strongest comprehensive strength in China [73]. The gross outputs of the agriculture, forestry, animal husbandry, and fishery in Wujiang are 7.903 billion RMB [74], 2.863 billion RMB [75], and 5.131 billion RMB [76], respectively. A data matrix concerning synthesized evaluation was constructed using data of these three areas in 2018, according to the constructed agricultural extension services for the sustainable development of agriculture. The data are from the survey report conducted by the Suzhou Agriculture and Rural Bureau. Management comments on the sustainable development of agricultural development were discussed by analyzing the agricultural extension services evaluation system for the sustainable development of agriculture. Through the case study, we test the evaluation system of AES; moreover, some management suggestions for sustainable agricultural development are put forward.

4.1. Construction of a Sub-Criteria Decision Matrix

According to the evaluation index of the sustainable development of modern agricultural area and the evaluation index data in Figure 1, it is necessary to standardize each index to generate the standardized sub-criteria matrix \( P_{ij} \) because of the difference of the dimension and order of magnitude of each sub-criteria. By calculating the entropy value \( E_j \) and information utility value \( d_j \) of the sub-criteria, the weight of the sub-criteria \( \omega_j \), the standardized sub-criteria data matrix \( P_{ij} \) and the sub-criteria weight \( \omega_j \) are obtained, as shown in Table 1.

| Table 1. Standardized index data matrix and the sub-criteria weight. |
|---------------------------------------------------------------|
| **Initial Criteria** | **Sub-Criteria** | **Xiangcheng** | **Wujiang** | **Kunshan** | **Sub-Criteria Weight** | **Z** |
| Environment | Agricultural water consumption | 0.1351 | 0.5354 | 0.3295 | 0.1633 | + |
| | Effective use coefficient of farmland irrigation water | 0.3300 | 0.3251 | 0.3448 | 0.0004 | + |
| | Organic food yield | 0.1667 | 0.0000 | 0.8333 | 0.8277 | + |
| | Synthesized use ratio of crop residue | 0.3352 | 0.3312 | 0.3336 | 0.0000 | + |
| | Synthesized use ratio of livestock manure | 0.3307 | 0.3280 | 0.3413 | 0.0002 | + |
| | Agricultural film recovery rate | 0.3892 | 0.3059 | 0.3059 | 0.0894 | + |
| Society | Per capita disposable income of farmers | 0.4714 | 0.2614 | 0.2672 | 0.1067 | + |
| | Number of the agricultural labor force with professional certificates | 0.2035 | 0.4739 | 0.3226 | 0.1461 | + |
| | Number of the labor force with higher education level | 0.1945 | 0.5968 | 0.2487 | 0.2831 | + |
| | Number of the labor force with a college education or above | 0.1708 | 0.6135 | 0.2157 | 0.4353 | + |
| | Local government income | 0.2653 | 0.3602 | 0.3745 | 0.0287 | + |
| Economy | Agriculture output value | 0.0776 | 0.5918 | 0.3306 | 0.1982 | + |
| | Forestry output value | 0.1106 | 0.3176 | 0.5718 | 0.1515 | + |
| | Animal husbandry output value | 0.0520 | 0.8721 | 0.0959 | 0.5704 | + |
| | Fishery output value | 0.1470 | 0.4389 | 0.4140 | 0.0799 | + |
| Agricultural Extension Service | Number of personnel for agricultural technology extension service | 0.2948 | 0.3673 | 0.3379 | 0.0172 | + |
| | Animal disease prevention and control system | 0.4242 | 0.2424 | 0.3333 | 0.1075 | + |
| | Quality supervision system of agricultural products | 0.4242 | 0.2424 | 0.3333 | 0.1075 | + |
| | Rural business management system | 0.4242 | 0.2424 | 0.3333 | 0.1075 | + |
| | Meteorological service system | 0.4242 | 0.2424 | 0.3333 | 0.1075 | + |
| | Green control coverage rate of crop diseases and insect pests | 0.4297 | 0.3831 | 0.1872 | 0.2330 | + |
| | Soil testing and fertilizer coverage rate | 0.3190 | 0.3380 | 0.3430 | 0.0021 | + |
| | Information service system | 0.4242 | 0.2424 | 0.3333 | 0.1075 | + |
| | Number of broadband access | 0.2274 | 0.4784 | 0.2942 | 0.2104 | + |

Note: Numbers are rounded to the fourth decimal place.

Based on the normalized sub-criteria matrix \( Z_{ij} \) and the sub-criteria weight \( \omega_j \), the weighted decision matrix of the sub-criteria \( x_{ij} \) and the positive ideal solution \( D^+ \) and negative ideal solution \( D^- \) of the sub-criteria are generated, as shown in Table 2.
Table 2. Weighted decision matrix of the sub-criteria and the positive ideal solution and negative ideal solution.

| Initial Criteria | Sub-Criteria                                      | Xiangcheng | Wujiang | Kunshan | $D^-$ | $D^+$ |
|------------------|---------------------------------------------------|------------|---------|---------|-------|-------|
| **Environment**  |                                                   |            |         |         |       |       |
| Agriculture water consumption | 0.0343 | 0.1360 | 0.0837 | 0.1360 | 0.0343 |
| Effective use coefficient of farmland irrigation water | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 |
| Organic food yield | 0.0123 | 0.0000 | 0.8116 | 0.0000 | 0.8116 |
| Synthesized use ratio of crop residue | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Synthesized use ratio of livestock manure | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Agricultural film recovery rate | 0.0056 | 0.0044 | 0.0044 | 0.0044 | 0.0056 |
| **Society**      |                                                   |            |         |         |       |       |
| Per capita disposable income of farmers | 0.0836 | 0.0463 | 0.0474 | 0.0463 | 0.0836 |
| Number of the agricultural labor force with professional certificates | 0.0489 | 0.1139 | 0.0775 | 0.0489 | 0.1139 |
| Number of the labor force with a college education or above | 0.1106 | 0.3972 | 0.1397 | 0.1106 | 0.3972 |
| Local government income | 0.0131 | 0.0178 | 0.0185 | 0.0131 | 0.0185 |
| **Economy**      |                                                   |            |         |         |       |       |
| Agriculture output value | 0.0225 | 0.1719 | 0.0960 | 0.0225 | 0.1719 |
| Forestry output value | 0.0253 | 0.0726 | 0.1306 | 0.0253 | 0.1306 |
| Animal husbandry output value | 0.0208 | 0.5866 | 0.0623 | 0.0208 | 0.5866 |
| Fishery output value | 0.0189 | 0.0565 | 0.0533 | 0.0189 | 0.0565 |
| Number of personnel for agricultural technology extension service | 0.0088 | 0.0109 | 0.0100 | 0.0088 | 0.0109 |
| Animal disease prevention and control system | 0.0771 | 0.0440 | 0.0606 | 0.0440 | 0.0771 |
| Quality supervision system of agricultural products | 0.0771 | 0.0440 | 0.0606 | 0.0440 | 0.0771 |
| Rural business management system | 0.0771 | 0.0440 | 0.0606 | 0.0440 | 0.0771 |
| Meteorological service system | 0.0771 | 0.0440 | 0.0606 | 0.0440 | 0.0771 |
| Green control coverage rate of crop diseases and insect pests | 0.1654 | 0.1475 | 0.0720 | 0.0720 | 0.1654 |
| Soil testing and fertilizer coverage rate | 0.0011 | 0.0012 | 0.0012 | 0.0011 | 0.0012 |
| Information service system | 0.0771 | 0.0440 | 0.0606 | 0.0440 | 0.0771 |
| Number of broadband access | 0.0790 | 0.1662 | 0.1022 | 0.0790 | 0.1662 |

Note: Numbers are rounded to the fourth decimal place. The best value is marked in boldface.

4.2. Construction of a Criteria Decision Matrix

The criteria decision matrix is generated based on the initial data of the relative similarity $C_i$ calculated by the sub-criteria. The weight of the sub-criteria $\omega_j$, the criteria decision matrix and the criteria weight $\omega_j$ are obtained by the entropy method, as shown in Table 3.

Table 3. Criteria decision matrix and the criteria weight.

| Initial Criteria | Xiangcheng | Wujiang | Kunshan | Initial Criteria Weight |
|------------------|------------|---------|---------|------------------------|
| Environment      | 0.2278     | 0.0000  | 0.9428  | 0.2542                 |
| Society          | 0.1001     | 0.8999  | 0.1387  | 0.2984                 |
| Economy          | 0.0000     | 0.9074  | 0.2145  | 0.4118                 |
| AES              | 0.5771     | 0.6027  | 0.2682  | 0.0355                 |

Note: Numbers are rounded to the fourth decimal place.

Based on the normalized criteria matrix $Z_{ij}$ and the criteria weight $\omega_j$, the weighted decision matrix of the criteria $x_{ij}$ and the positive ideal solution $D^+$ and negative ideal solution $D^-$ of the criteria are generated, as shown in Table 4.

Table 4. Weighted decision matrix of the criteria and the positive ideal solution and negative ideal solution.

| Initial Criteria | Xiangcheng | Wujiang | Kunshan | $D^-$ | $D^+$ |
|------------------|------------|---------|---------|-------|-------|
| Environment      | 0.0830     | 0.0000  | 0.3436  | 0.0000 | 0.3436 |
| Society          | 0.0282     | 0.2537  | 0.0391  | 0.0282 | 0.2537 |
| Economy          | 0.0000     | 0.3468  | 0.0820  | 0.0000 | 0.3468 |
| AES              | 0.0211     | 0.0220  | 0.0098  | 0.0098 | 0.0220 |

Note: Numbers are rounded to the fourth decimal place. The best value is marked in boldface.

4.3. Evaluation Results

By calculating the positive ideal solution $D^+$ and negative ideal solution $D^-$ of the sub-criteria and criteria, the relative similarity $C_i$ of the sub-criteria and criteria are obtained and ordered to obtain the sustainable development level of the environment, society, the economy, and AES and the results of the synthesized evaluation, as shown in Table 5.
Table 5. Results of evaluation.

| Name     | Environment CI | Environment Rank | Society CI   | Society Rank | Economy CI | Economy Rank | AES CI     | AES Rank | Synthesis CI | Synthesis Rank |
|----------|----------------|------------------|--------------|--------------|------------|--------------|------------|----------|--------------|----------------|
| Xiangcheng | 0.2278         | 2                | 0.1001       | 3            | 0.0000     | 3            | 0.5771     | 2        | 0.1463       | 3              |
| Wujiang   | 0.0000         | 3                | 0.8999       | 1            | 0.9074     | 1            | 0.6027     | 1        | 0.5463       | 1              |
| Kunshan   | 0.9428         | 1                | 0.1387       | 2            | 0.2145     | 2            | 0.2682     | 3        | 0.5089       | 2              |

Note: Numbers are rounded to the fourth decimal place.

Based on the evaluation data in Table 5, a sustainable level of various criteria evaluation results and synthesized evaluation result of AES for a sustainable agricultural development map is drawn, illustrating the difference and fluctuation range of the evaluation results intuitively, as shown in Figure 3.

![Figure 3. Distribution map of the evaluation results of sustainable development level.](image)

As shown in Figure 3, the evaluation results of the environmental criteria of Kunshan are the highest, followed by Xiangcheng, with Wujiang having the lowest figure; the evaluation results of the social criteria are the highest in Wujiang, the second in Kunshan, and the lowest in Xiangcheng; the evaluation results of the economic criteria are the highest in Wujiang, followed by Kunshan, with the lowest results in Xiangcheng; the evaluation results of the AES criteria are the highest in Wujiang, followed by Xiangcheng and Kunshan.

According to the synthesized evaluation results for agricultural sustainability shown in Figure 3, Wujiang District receives the highest score; Kushan, which is very close to Wujiang, ranks second; and Xiangcheng District scores lowest.

5. Discussion
5.1. Criteria Evaluation

The environmental criteria emphasize improving the efficiency of resource recycling, reducing greenhouse gas emissions, reducing energy demand, reducing harmful impacts on the environment in agricultural production, and raising the level of sustainable agricultural development. As shown in Figure 3, the evaluation result of the environmental criteria is the highest in Kunshan, the second in Xiangcheng, and the lowest in Wujiang. It can be seen from Table 2 that the effective use coefficient of irrigation water, the yield of organic food, the use rate of residue, livestock manure, and agricultural film in Wujiang are all the lowest among the three regions. In particular, it is necessary to improve the yield of organic food and the recovery and use rate of agricultural film in Wujiang. Moreover, the yield of organic food in Xiangcheng is also low and needs to be improved.

The social criteria take into account indexes such as quality of life, education level, and local government income. The higher the result of social criteria evaluation is, the higher the level of sustainable development of agricultural society. As shown in Figure 3, the evaluation result of the social criteria is the highest in Wujiang, the second in Kunshan, and the lowest in Xiangcheng. It can be seen from Table 2 that the number of the agricultural labor force with a professional certificate, the number of the labor force with high school education level, and the number of the labor force with a college education or above in Xiangcheng and Kunshan are at a low level, several times lower than that of Wujiang, which needs to be improved.
Sustainable agriculture requires economic profitability. Sustainable agricultural development is an economical and feasible sustainable development of agriculture, forestry, fishery, etc. The economic criteria reflect the development level of the agricultural economy. The higher the evaluation result is, the greater the potential for sustainable agricultural development. As shown in Figure 3, the evaluation result of the economic criteria is the highest in Wujiang, the second in Kunshan, and the lowest in Xiangcheng. It can be seen from Table 2 that the output value of agriculture, forestry, and fishery in Xiangcheng and Kunshan is relatively low, far lower than that of Wujiang. Xiangcheng and Kunshan should vigorously develop agriculture, forestry, and fishery production.

The AES is an effective way to spread agricultural sustainable practice based on environmentally friendly agricultural technology, linking agricultural technology with agricultural practice to support sustainable agricultural development. The index system of AES includes agricultural production supervision, service system, and green technology coverage, reflecting the operation of the AES. The higher the evaluation result of this criterion is, the higher the efficiency of providing service for sustainable agricultural development. As shown in Figure 3, the evaluation result of the AES criterion is the highest in Wujiang, the second in Xiangcheng, and the lowest in Kunshan. It can be seen from Table 2 that the number of agricultural technology extension service personnel, the soil testing, and fertilizer technology coverage and broadband access are at a low level in Xiangcheng. The evaluation result of the sustainable development level of AES in Wujiang is the highest. However, its animal disease prevention and control system, agricultural product quality supervision system, rural management system, meteorological service system, and information service system are in the middle level among the three regions, which still needs to be improved.

5.2. Synthesized Evaluation

The sustainable agricultural development level in each region is described based on the synthesized evaluation result $C_i$ in Table 5, which is divided into four classes, as shown in Table 6.

| Classes | Synthesized Evaluation Result |
|---------|-------------------------------|
| Class I | $C_i \geq 0.62$              |
| Class II| $0.4 \leq C_i < 0.62$        |
| Class III| $0.18 \leq C_i < 0.4$       |
| Class IV| $C_i < 0.18$                 |

As shown in Table 7, the Class II sub-class includes Wujiang and Kunshan, which have a relatively high level of sustainable agricultural development. According to Figure 3, the criteria of Wujiang are higher than those of Xiangcheng and Kunshan, except for the environmental evaluation criteria; the criteria of Kunshan are higher than those of Xiangcheng, except for the AES evaluation criteria. Wujiang and Kunshan are in the same class. The sustainable development level of Wujiang is higher than that of Kunshan, but their sustainable development level is almost the same. Environmental sustainability in Wujiang should be improved, while the sustainability of society, economy, and AES in Kunshan should be improved.

| Name     | Value of $C_i$ | Class |
|----------|----------------|-------|
| Xiangcheng | 0.1463        | IV    |
| Wujiang   | 0.5463        | II    |
| Kunshan   | 0.5089        | II    |

Note: Numbers are rounded to the fourth decimal place.
As shown in Table 7, the Class IV sub-class includes Xiangcheng, which has the lowest sustainable agricultural development level among the three regions. The low sustainable development level of the agricultural environment, economy, and society in Xiangcheng have a negative effect on the evaluation of sustainable agricultural development level. All its criteria are lower than those in Kunshan and Wujiang, except for AES. Xiangcheng should take synthesized measures to focus on the sustainable development of the environment, economy, and society.

Based on the results of the criteria evaluation and the synthesized evaluation above, the evaluation system of AES for sustainable agricultural development is an effective way of realizing sustainable agricultural development. It is an effective tool to promote sustainable agricultural development by analyzing the main factors affecting sustainable agricultural development, putting forward improvement measures, improving the efficiency of AES, reducing the obstacles of sustainable agricultural development, and improving the decision-making of the agricultural sustainable system.

The analytic hierarchy process (AHP) is commonly used to evaluate sustainability [77,78]. The analytic network process (ANP) is another common method in sustainability evaluation, and is believed to solve a relatively complicated issue and select the best solution through pairwise comparison [79]. ANP and AHP were used to obtain the weight of each indicator through a questionnaire survey, while the questionnaire survey results showed subjective preference. As for the TOPSIS method used in this research, the entropy method was adopted to obtain the weight of each index, which can objectively reflect the importance of each index. This method improves the rationality of sustainability evaluation. Under TOPSIS, the evaluation objects are ranked based on the gap between the ideal solutions and the negative ideal solutions. It makes full use of the original data and has no strict limit on the number of data samples and the indexes. Therefore, TOPSIS has relatively good applicability. If the fuzzy evaluation method [80] is used to evaluate sustainability, a relatively large sample size is required. TOPSIS can also be used at different levels of the evaluation system in order to figure out the disadvantages of the evaluation object. The evaluation index system of sustainable development of agricultural extension service is complex and has many levels. To avoid subjectivity, the TOPSIS method was applied, and the entropy method was adopted to determine the weight of indicators in this study. Additionally, considering the influence of the lower indexes on the upper ones, computation is conducted across multiple levels of the index system while the complexity of computation is relatively low [81]. Moreover, the method can make the evaluation result of sustainable development more reasonable. However, to calculate quantified value of sustainability, methods such as data envelopment analysis are needed.

6. Conclusions

Sustainable agricultural development is the inevitable choice of agricultural development, and AES is the fundamental guarantee of the sustainable development of agriculture. Establishing a reasonable evaluation system of AES for sustainable agricultural development is the key to realizing sustainable agricultural development. In this paper, the role of AES in promoting sustainable agriculture and the relationship between the evaluation system of AES and the agricultural environment sustainability, social sustainability, and economic sustainability are analyzed. On this basis, an evaluation index system of AES for sustainable agricultural development was reasonably and comprehensively constructed, including the four initial criteria of environment, society, economy, and AES, corresponding to 24 sub-criteria, respectively. A synthesized evaluation index system was constructed to consider the indexes related to agricultural sustainable practice, such as water resources protection, circular agriculture, farmers’ income, agricultural output value, and agricultural science and technology.

Furthermore, scientific and rational evaluation methods play an essential role in supporting sustainable agricultural development practice. The evaluation of AES for sustainable agricultural development is a matter of multiple-criterion decision-making. Based on the status quo of sustainable agricultural development in southern Jiangsu Province,
this research selected three representative regions and used a TOPSIS-synthesized multiple-criterion decision-making evaluation method based on entropy weight to conduct empirical research, and finally obtained the results. On the basis of the evaluation results, the main factors affecting sustainable agricultural development were analyzed, and improvement measures and management suggestions were put forward for guaranteeing the sustainable development of agriculture.

From the perspective of the support of AES for agricultural environment, social and economic sustainability, this study constructed the evaluation index system of AES for sustainable agricultural development, and improved the evaluation system of sustainable agriculture. To verify the effectiveness of the evaluation system, three typical cases in southern Jiangsu Province were selected, and objective evaluation results were obtained by quantitative evaluation method. The validity and applicability of the research methods used in this study are limited by the background of the case. In future studies, more cases will be collected to enrich the agricultural sustainability indicator system. Furthermore, we will attempt to improve the agricultural sustainability index system from the perspective of agricultural resources, as well as the agricultural environment and social and economic sustainability, and continuous introduction of statistical and comprehensive evaluation methods will contribute to the sustainable development of agriculture.

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