Preliminary Construction of Evaluation Index System and Method of Regional Suitability of Straw Storage and Transportation Mode

Jing Du,[a,b] Yingpeng Zhang,[a] Yonglan Xi,[a] Xiangping Kong,[a] Zhizhou Chang,[a] and Xiaomei Ye [a,*]

The industrial utilization of straw from the field is an important way to achieve its comprehensive utilization. Construction of an efficient collection system is the premise and foundation for the efficient utilization of straw resources. It has become an urgent problem to reduce the cost of storage and transportation of straw from the field. In order to construct an indexing system and method of regional suitability evaluation of straw storage and transportation technology model, a model based on regional suitability criteria for straw storage and transportation technology has been constructed by using literature analysis. The evaluation method of the straw storage and transportation technology model is briefly discussed. This method provides a quantifiable basis for screening, evaluation, integration, and popularization of the straw storage and transportation technology model.

Keywords: Crop straw; Storage and transportation mode; Hierarchical analysis; Index system; Evaluation

Contact information: a: Institute of Agricultural Resources and Environment, Jiangsu Academy of Agricultural Sciences; Key Laboratory of Crop and Livestock Integration, Ministry of Agriculture and Rural Affairs; East China Scientific Observing and Experimental Station of Development and Utilization of Rural Renewable Energy, Ministry of Agriculture and Rural Affairs; Jiangsu Collaborative Innovation Center for Solid Organic Waste Resource Utilization, Nanjing 210014, China; b: Institute of Agricultural Engineering, Jiangsu University, Zhengjiang 212013, China;
**Corresponding author: yexiaomei610@126.com*

INTRODUCTION

The industrial utilization of straw alleviates the environmental pollution caused by straw burning and aids the development of livestock and poultry breeding, clean energy supply, and edible fungus planting (Bi *et al.* 2010; Sheng 2015). Due to the characteristics of seasonality, small density, large volume, loose distribution, and inconvenient storage and transportation, straw collection costs are too high, and the operational benefit of straw utilization enterprises is low. This reality has become one of the key factors hindering the utilization of industrial straw in China (Sun *et al.* 2018). Therefore, the construction of viable collection systems is necessary to realize the efficient utilization of straw resources. Choosing the appropriate storage and transportation mode of straw is an urgent problem to reduce the cost of storage and transportation of straw from the field (Xi *et al.* 2019; Zhang *et al.* 2019). Therefore, it is necessary to carry out comprehensive and quantitative research on the storage and transportation mode of straw and to construct a regional suitability evaluation index system and its evaluation method. These steps can identify the indicators and methods that should be adopted to evaluate the advantages and disadvantages of single technology and the comprehensive benefits of integrated technology in production practice

(Wang and Wang 2009; Song *et al.* 2011). This has important reference value for scientifically evaluating the advantages of single or comprehensive technology and integrating multiple single technologies efficiently.

Construction of Regional Suitability Evaluation Index System for Storage and Transportation of Straw

Building ideas

Regional suitability evaluation refers to the comprehensive evaluation from the perspective of straw storage and transportation technology, storage capacity, investment, storage capacity, investment and output accounting, and social environmental impact. According to the characteristics of straw collection area, the straw demand and straw supply capacity need to match under different storage and transportation modes. In order to determine the suitability and limitation of different straw storage and transportation modes to straw supply potential, the suitability grade is obtained. The evaluation determines whether 1.) the functional and applicability are benefits (including economic benefit, environmental benefit and social benefit) of various technical models and whether 2.) they are suitable for the development of straw storage and transportation industry in local areas through qualitative and quantitative methods (Bi 2010; Yang *et al.* 2013). Taken together, there is a need to consider the comprehensive impact of the model on the natural-economic-social composite system. The evaluation goal depends on the evaluator's understanding of the value composition and comprehensive value of straw storage and transportation technology. The evaluation index system is the standard (Bi *et al.* 2008). The selection of indicators should follow the principles of comprehensiveness, hierarchy, relevance, independence, maneuverability, and sensitivity. The objective of establishing a regional suitability evaluation index system of straw storage and transportation mode is not to simply copy, add, and accumulate the traditional statistical indexes in the fields of technology, society, economy, and environment, but rather to select, combine, refine, and integrate a large number of individual indexes on the basis of certain principles. Therefore, it is actually an organic collection of comprehensive indicators that have strong organization and innovation, which can reflect the state of the overall goal and also reflect the variation of single factors. Furthermore, the evaluation of straw storage and transportation mode not only contains the characteristics of the technology itself, but also has an important impact on nature, economy, and society (Ittersum *et al.* 2008). Therefore, this assessment contains three evaluation aspects: technical, economic, and social environment.

Construction principles

Because there are many influencing factors and subjectivity in the selection of indicators, different people may choose different indicators for the same problem and draw different conclusions. For the evaluation conclusion to be objective, the selection of evaluation indicators must follow certain principles (Sun 2017):

(1) Principle of consistency. The indicator must be consistent with the goal, and the goal must be a guide to people's action. The information that all of programmes can reach the goal is the main information that the decision maker is concerned about when evaluating, and it is also a main criterion to measure the good or bad action. Therefore, the selected indicators must be able to reflect the level of information that can be achieved.

(2) Principle of feasibility. The selected index should be clear and easy to understand. The qualitative index should be able to define the scoring standard, the data needed for the

quantitative index should be easy to collect, and the existing method or model can be used to solve the problem.

Table 1. Framework of Regional Suitability Evaluation Index System for Storage and Storage of Straw

Target layer (A)	Constrained layer (B)	Criteria layer (C)	Indicator layer (D)
Evaluation indicator system	Technical Indicators (B1)	Characteristics of Straw Collection Area (C1)	The extent to which straw can be collected (D1)
			Road status of straw collection (D2)
			Seasonal differences in straw collection (D3)
		Material, energy and human consumption (C2)	Purchase cost of straw raw materials (D4)
			Cost of Straw Storage and Transportation (D5)
			Maintenance and site management cost of straw storage and transportation equipment (D6)
		Straw Storage Capacity (C3)	Collection and storage scale (D7)
		Straw Storage and Transportation Technology (C4)	Technology Mode of Storage and Transportation of Straw (D8)
			Acceptance of Straw Storage Subject (D9)
			Regional straw storage rate (D10)
			Technical suitability (D11)
	Economic Indicators (B2)	Investment - returns (C5)	Total investment on the same straw storage scale (D12)
			Straw Raw Material Investment (D13)
			Infrastructure investment (D14)
			Equipment investment (D15)
			Annual total income (D16)
			Investment payback (D17)
		Regional share of storage and transportation mode (C6)	Share of Straw Storage and Transportation Area (D18)
		Increased profit effect of the same investment (C7)	Increased profit effect of the same investment (D19)
	Social & environment indicators (B3)	Increased employment effectiveness (C8)	Increased number of jobs (D20)
		Reduction of security risks (C9)	Reduction of security risks (D21)
		Environmental improvement (C10)	Reduction in land tenure (D22)

(3) Principle of practicality. The selection of indicators should be comprehensive and refined, and the number of indicators should not only reflect the evaluation scheme, but

also realize the simplicity and practicality of calculation, while avoiding the omission of important sensitivity indicators. So one should also pay attention not to select irrelevant secondary indicators to make the whole index system too complex and insensitive.

(4) The principle of independence. The index system should be hierarchical, structure clear, indicators should be as independent as possible, avoiding the correlation caused by redundancy.

Build framework

The regional suitability evaluation index system of straw storage and transportation mode is a comprehensive and comprehensive concept, which is composed of different side and different levels of indicators. According to the content requirements of regional suitability evaluation of straw storage and transportation mode, the comprehensive evaluation index system is divided into four levels according to the concentration degree, namely, the target layer, the constraint layer, the criterion layer and the index layer, corresponding to the corresponding four-level index (Table 1). Finally, a four-level analytical structure model is constructed.

Target layer (A)

The first level index belongs to the highest level, that is, the overall goal of comprehensive evaluation, that is "ranking the comprehensive benefits of technology". The analysis and comparison of this level index can comprehensively evaluate the comprehensive benefits of "single technology", "technology combination", or "integration mode", thus providing the most direct reference for the selection and assembly of straw storage and transportation technology model.

Constraint layer (B)

The secondary index, set up under the primary index, belongs to the middle layer, that is, the sub-goal of each individual evaluation system that constitutes the comprehensive evaluation content. In order to achieve the overall goal, according to the benefit structure of the technical model of straw harvesting and storage, it is confined to three kinds of parameters, such as technical, economic and social environment.

Criterion layer (C)

In the three-level index, under the secondary index, belongs to the middle layer, which can represent the constraint layer. This can represent the key information of the whole characteristic and behavior of the single evaluation subsystem, and is also the standard to measure whether the overall goal can be achieved. It has spatiotemporal dynamics. The criterion layer can be divided into 11 kinds of parameters, such as the characteristics of straw collection area, storage capacity, investment-income situation, and the improvement of living / production environment.

Indicator layer (D)

The fourth grade index belongs to the lowest level. It consists of the concrete variable data within the system, represents the concrete meaning of the evaluation index, is the foundation of the comprehensive evaluation, and is also the data that needs to be obtained in practice when establishing the index system. As can be seen from Table 1, the index system includes descriptive indicators and quantitative indicators, the former focuses on description, interpretation functions, while the latter focuses on evaluation, monitoring

and early warning functions, and the two types of indicators are interdependent and independent each other (Song *et al.* 2011).

Indicator screening

The regional suitability evaluation of straw storage and transportation technology model has the commonness of general comprehensive evaluation and its own evaluation characteristics. The research team collected the evaluation indexes of agricultural sustainable development (Wang *et al.* 2003; Qiu *et al.* 2005), ecological cycle (Wang and Li 1990; Ma *et al.* 2005), modern agricultural (Zhao 2008), and agricultural waste resources (Song *et al.* 2011), and selected some indexes that have been used frequently in recent years. Then, a hierarchical index database was established as the reference sample of the regional suitability evaluation index system of straw storage and transportation technology model. These results are related to the evaluation of straw storage and transportation mode, the technical and economic evaluation of agricultural waste resource utilization, and the of complex ecosystem (Hong and Xue 2006; Ittersum *et al.* 2008). The indices closely related to the regional suitability evaluation target of straw storage and transportation mode are selected from the above index database.

Evaluation Method

The regional suitability evaluation method of straw storage and transportation mode is restricted by many factors such as straw species and resource density, development level of straw storage and transportation, and local social and economic development level.

Evaluation indicator system

According to the ideas and methods of the above index system, this study follows the principles of consistency, science, maneuverability, completeness, hierarchy, comparability, guidance, qualitative and quantitative combination, and macro-micro combination (Wang and Xu 2005; Zhang *et al.* 2005). The regional suitability evaluation index system of straw storage and transportation model is detailed in Table 1.

Quantification of evaluation indicators

Each evaluation index is a variable of comprehensive evaluation, and the calculation of variables is the basic work of comprehensive evaluation. Table 1 shows that the index of regional suitability evaluation of straw storage and transportation mode can be divided into a quantitative index and a qualitative index. The quantitative index is expressed in numerical form, such as straw raw material purchase cost, equipment investment, total investment, *etc*. The different nature of indicators leads to a lack of comparability between data. To eliminate the influence of index type, it is necessary to quantify the original data. It is usually necessary to establish the corresponding grading standard and obtain the quantitative value of qualitative index by hierarchical assignment (Song *et al.* 2011). In Table 1, the units and dimensions of each index are not exactly the same, which will also lead to a lack of comparability between the data. To make each index comparable, it is necessary to standardize the raw data; that is, the index data of different dimensions, levels and units are classified into dimensionless data in the range of zero to one [0,1]. Furthermore, to ensure the comparability of indicators, both quantitative indicators and qualitative indicators after assignment, and whether the original values of quantitative indicators are within the range [0,1] or not, must be standardized.

Evaluation indicator weight determination

The regional suitability evaluation of straw storage and transportation mode belongs to multi-attribute evaluation. The determination of evaluation index weight plays an important role in evaluating the suitability of straw storage and transportation mode in different regions. Index weight refers to the importance of each index under the same goal constraint. It represents the importance of indicators in the evaluation process and is a quantitative index. In the comprehensive evaluation of multiple indicators, the weight coefficient plays an important role, and it will make the comprehensive evaluation results more objective and more realistic.

The purpose of weight calculation is to determine the importance of each evaluation index in the comprehensive evaluation. After the index system is determined, it is necessary to give different weight coefficients to each index. Among the methods of weight determination, there are two kinds of mathematical weighting (quantitative weighting) and empirical weighting (qualitative weighting). The former is scientific with the help of mathematical principles, including principal component analysis, analytic hierarchy process, fuzzy weighting, rank-sum ratio, moisture content, relational number, *etc*. The latter is mainly evaluated directly by experts, mainly including expert scoring method, pairwise comparison method and other (Liu and Ding 2010).

Selection of evaluation methods

Experience shows that the evaluation method that can be used to deal with open complex systems effectively is a comprehensive integrated method combining qualitative and quantitative methods (Liu *et al.* 2006). Because Analytic Hierarchy Process (AHP) can deal with the qualitative and quantitative factors in decision-making, it is widely used in multi-objective decision-making system and belongs to an effective, qualitative, and quantitative comprehensive treatment method. It decomposes the complex system into multiple constituent factors according to the nature and requirements of the total evaluation goal, classifies and arranges the factors and indexes contained, forms an orderly hierarchical structure, determines the weight relative to the target of the previous level by pairwise comparison method, and analyzes it from the lowest level to the highest level. Because the optimal selection of straw storage and transportation technology mode involves three factors, such as technology, economy and social environment, it is a multi-objective decision-making problem. At the same time, the overall goal of this decision can be divided into four levels: target layer, constraint layer, criterion layer, and index layer under the overall goal of selecting the best technology. Therefore, AHP is an objective, simple, and effective method to solve the optimal selection of straw storage and transportation technology model (Liu *et al.* 2006; Li *et al.* 2020).

Discussion

Based on the research results of comprehensive evaluation index system and evaluation method of agricultural sustainable development, ecological circulation, modern agriculture, and agricultural waste resource utilization, a set of regional suitability evaluation index system of straw storage and transportation technology model is preliminarily constructed based on literature research.

CONCLUSIONS

1. The results of the research on the comprehensive evaluation index system and evaluation methods, such as sustainable agricultural development, ecological cycle, modern agriculture and recycling of agricultural wastes, are referenced.
2. A set of regional suitability evaluation index systems of straw storage and transportation technology model is systematically constructed by using a literature analysis method.

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