Study on Site Selection Factors of Feed Additive Factories

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Abstract: Feed mill site selection has always been one of the important issues in the development of agricultural industry. In this study, Analytic Hierarchy Process (AHP) is adopted to solve this problem. Feed mill site selection is a complex decision-making problem, involving supply chain management, environmental impact, transportation convenience and other key factors. This paper uses AHP as a decision-making tool to determine the optimal feed plant location scheme. AHP helps decision makers to weigh and make decisions among several interrelated evaluation criteria effectively through hierarchical structure and allocation of expert opinion weights. First, this paper introduces the basic principle and application steps of AHP method, and then shows how to use AHP method to quantitatively evaluate and compare different site selection schemes through concrete cases. Finally, it summarizes the practicability and effectiveness of AHP in the problem of feed mill location, and its wide application potential in complex decision-making problems. This study provides a new idea and method for the decision of feed mill location, which is of great significance for promoting the sustainable development of agricultural industry.

1 INTRODUCTION

In China, the feed industry has developed rapidly since the 1980s, becoming one of the largest feed producers and consumers in the world. With the development of economy and the acceleration of urbanization, people's demand for high-quality meat and dairy products has increased, and the feed industry is facing multiple challenges such as environmental protection and food safety while providing high-quality animal protein. In 2024, the total output value of the national feed industry was 140.83 billion yuan, an increase of 6.5% over the previous year. Its total revenue was 1.330.44 billion yuan, up by 5.4% (Asad et al., 2024). The rapid development of the feed industry has made more enterprises focus on the method of reducing cost and increasing efficiency, of which the feed plant site construction is a larger plate. Feed additives play an important role in the livestock and poultry industry, which can improve the production performance of animals and also affect the production efficiency and product quality of the livestock industry (Gu et al., 2015). Therefore, choosing the right plant location is crucial to ensure production efficiency, reduce costs, meet market demands, and reduce environmental impact (Li et al., 2017).

When deciding on the location of a feed additive plant, a number of factors need to be considered, including but not limited to geographical location, supply chain convenience, raw material supply, transportation costs, human resources, environmental regulations, community response, etc. There is a complex interrelationship between these factors, and the rationality of the decision directly affects the operation efficiency of the plant, the market competitiveness, and the impact on the surrounding environment and community (John and Saeid, 2024).

Choosing the right plant location can optimize the production layout and reduce the distance between production lines thereby improving production efficiency and reducing waste in the production process (Liu, 2005). Reasonable location can reduce the transportation distance and time of raw materials and finished products, reduce logistics transportation costs, and improve the profitability of enterprises. Reasonable plant location can optimize production layout, reduce transportation costs, improve supply chain efficiency, so as to achieve the long-term development goals of enterprises (Li et al., 2024).

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When making a feed plant location decision, a number of factors need to be considered, including but not limited to location, land availability, environmental impact, supply chain convenience, community response, and laws and regulations. In addition, with the increasing global concern for sustainable development, the site selection of feed factories also needs to take into account the protection of the environment, the commitment of social responsibility and the standardization of corporate governance (Li, 2017). The problem of feed plant location needs to be considered from a multi-dimensional direction, such as the policy problem of plant location, production line layout, labor market and other aspects. At the same time, in the context of the development of global green industry, this paper also needs to consider the solution of pollution problems. In China, there are strict laws related to pollutant treatment and strict health management for feed enterprises. In the preliminary preparation, Kamran et al. (2024) conducted in-depth discussion on a series of issues such as whether the general plan is reasonable, whether the detailed design of the single building is applicable, and the automation level, labor intensity, production efficiency, product quality, production cost and corporate image of the subsequent feed plant production management. The multi-mode raw material reception and plant model are introduced. In terms of supply chain and personnel management, Iunderstand and analyze. For example, optimize and adjust the soundness of supply chain and procurement process management, and train employees to increase their cost awareness. Finally, this paper draws more views, and makes comprehensive consideration from market capacity, transportation network, sales radius, local laws and regulations.

2 METHODS

In this study, multidimensional and three-dimensional analysis of feed mill site selection was conducted through analytic hierarchy process, and comprehensive analysis was conducted through expert scoring.

2.1 Numerical Source

To determine the influencing factors of feed mill site selection, this paper selects the methods of literature review and expert scoring. The analytical hierarchy Process (AHP) is used to analyze the influencing factors (Nandi et al., 2024). This method can make up for the shortcomings of many quality management analysis methods, such as only qualitative analysis and unable to judge the influence degree of each factor. Through the combination of qualitative and quantitative analysis, the analysis results are more scientific and intuitive, and provide more favorable and reliable basis for management decision-making.

2.2 Method Introduction

Hierachy Process was founded by American professor Satty. The principle is to divide the problem to be solved into different levels according to the target layer, criterion layer and index layer. Experts compare the importance of each index according to the actual situation and experience (Liang et al., 2008). The eigenvectors of the judgment matrix and the priority weights of indicators at each level relative to the indicators at the previous level are calculated. Finally, weighted average method is used to summarize the weight coefficient of each indicator relative to the overall target. The largest factor is the most important influencing factor. The calculation steps are as follows:

First, establish hierarchical structure model. Analyze the problem deeply, divide the influence factors of the problem into different levels, and draw the hierarchical structure. Second, construct the judgment matrix. For the influence weight of n indicators of X_n on the superior target Y, X_i and X_j, are selected each time for pairwise comparison, a_{ij} represents the ratio of the influence degree of the two indicators on the target Y, and the judgment matrix A $= (a_{ij})_{n\times n}$ represents the comparison results of n influential factors. $a_{ij} > 0$, $a_{ij} = 1/a_{ij}$, $a_{ij} = 1$ $(\mathrm{i}, \mathrm{j} = 1, 2, \ldots, \mathrm{n})$. In order to quantify the comparison judgment, the 1-9 scale method is used, that is, a_{ij} takes 1-9 or reciprocal 1 (See Table 1).

Third, sort hierarchically and perform consistency checks. For the judgment matrix A, the eigenvector W of the largest eigenroot λ_{max} of A can be obtained by formula (1).

$$\lambda_{max} = \sum_{i=1}^{n} \frac{(AW)_i}{nW_i} \quad (1)$$

where W_i is the weight value of the single ordering of the corresponding index. Check the consistency of judgment matrix A. The formula (2) is used to calculate the average value of the consistency index CI, and the average random consistency index RI is obtained from the known consistency index. If the consistency ratio CR = CI /RI < 0.1, the consistency of the judgment matrix is acceptable. Otherwise, adjust the judgment matrix.

$$CI = \frac{\lambda_{max} - n}{n-1} \tag{2}$$

In accordance with the code for feed mill construction and site selection, China has a complete specification system mainly SBJ05-1993 "Feed mill engineering design Code", GB50187-2012 "Industrial enterprise graphic design code", GB12348-2008 "Industrial enterprise factory boundary noise standard", GB8978-2002 "comprehensive sewage discharge standard" and so on. The above specification requirements are taken into comprehensive consideration as the design bottom line principles and design restrictions of this paper. Through literature review and expert questionnaire survey, combined with the principles of systemization, independence and comparability of influencing factors, the influencing factors for the design quality management of construction drawings of waste disposal projects are preliminarily determined, as shown in Table 2.

Table 1: AHP Scale evaluation sheet.

Scale	Scale mean
1	i factor is as important as j factor
3	i factor is slightly important than j factor
5	I factor is more important than factor j
7	i factor is much more important than j factor
9	i factor is absolutely more important than j factor
2,4,6,8	The importance of the two factors i and j lies between the above two adjacent judgment scales
count backwards	The comparison value between factor ai and factor aj is aji=1/aij

Table 2: Influencing factors of feed mill site selection.

Destination layer	Index level	Index Level	Descr
Feed mill location method	Employee factor	Labor market price	Local labor price level
		Quality of the local labor force	Local average educational background and social environment
		Commuting distance	Average commuting time for employees
	Supply chain factors	Market capacity	Place on feed gap size
		Raw material origin distance	Transportation time and cost of raw materials
		Traffic environment	Road levels and traffic jams
		Logistics service level	Logistics speed and service quality
		Land price	Local land lease or purchase price
		Surrounding facilities	Airports, ports, railway hubs, and living facilities
		Energy costs	Electricity, water and other energy-consuming materials prices
	Pollution factor	Pollutant treatment	The distance from the pollution treatment plant and the local discharge conditions
		Impact on the surrounding community	Odour and the impact of noise pollution on nearby residential areas
	Follow-up development and policy factors	Reserved space for subsequent development	Reserve land for subsequent expansion of production scale
		Local policy support	Local policy support for the feed industry and management of pollution or plant construction policies

3 RESULTS AND DISCUSSION

The decision of plant location is decided by many factors, and the influence of these factors is not the same. Therefore, in determining the factors that affect the location decision, it is necessary to consider from multiple perspectives and multiple levels. The previous interviews with experts have statistically analyzed the most important 14 factors affecting location decision, and now the analytic hierarchy process is used to analyze and study them.

3.1 Structural Model Building

Through the interviews with the interviewees, the relationships between each main factor and each sub-factor have been thoroughly mastered, and the AHP analysis method has been used to establish the hierarchical analysis structure model for the research objects.

3.2 Construct Judgment Matrix

The general hierarchical analysis method will divide the goal of the decision, the factors to be considered (decision criteria) and the object of the decision into the highest, middle and lowest levels according to their mutual relations, and draw a hierarchical structure. The system only shows the goal of the decision, the factors considered (decision criteria) and the corresponding weight value of each factor. Through the data sorting and analysis on the SPSSPO platform, it can be seen in the table 3.

3.3 Check Consistency

The following table shows the CR value of the judgment matrix constructed by each expert. The second-order matrix does not need to judge the consistency, and the third-order and above need to judge the consistency. Consistency test results require CR value less than 0.1, which is used to judge whether there are logical errors in the construction of judgment matrix. For example, there are three indicators ABC, this paper judges that A is more important than B, and B is more important than C, so logically A is definitely more important than C, but if C is more important than A when constructing judgment A is more important than C, then this paper has made a logical error. Failed the conformance test. According to the table4, it can be judged that the CR value of all experts is less than 0.01, so all the weights can be used (table 4).

Table 3: Judgment Matrix.

Primary index	First-order Index weight	Secondary index	Secondary index weigh
Employee factor	8.919%	Labor market price	4.210%
		Quality of the local labor force	2.991%
		Commuting distance	1.717%
Supply chain factors	53.747%	Market capacity	17.34%
		Raw material origin distance	5.956%
		Traffic environment	5.975%
		Logistics service level	4.619%
		Land price	7.631%
		Surrounding facilities	5.014%
		Energy costs	7.207%
Pollution factor	18.336%	Pollutant treatment	8.998%
		Impact on the surrounding community	9.338%
Follow-up development and policy factors	18.995%	Reserved space for subsequent development	4.473%
		Local policy support	14.522%

3.4 Factor Weight Analysis

The matrix results of all experts are retained based on parameters, and the criterion layer indexes of each expert are weighted respectively. Finally, the criterion layer weights of these experts are averaged. The data components in Table 5 show that the 4 main factors of layer B and the 14 sub-factors of layer C have a significant impact on the feed mill location decision, but the importance of the impact is different. Among the four main factors in layer B, the intensity of their influence is ranked from strong to weak as follows: The weight ratios of supply chain factors, pollution factors, subsequent development and policy factors, and staff factors are 53.74759%, 18.3366%, 18.99592%, and 8.91989%, respectively, indicating that the feed mill pays great attention to the factors affecting its supply chain in the location decision. Pollution and subsequent development and policy factors also have a greater impact on feed plant location decisions, while staff factors have a lesser impact (see table 5).

4 CONCLUSION

In the study of feed plant location, AHP is an effective method, which can help decision makers to weigh and make decisions among many influencing factors. According to the results of the study, the main site selection factors in order from strong to weak are supply chain factors, pollution factors, subsequent development and policy factors, and staff factors.

Table 4: Summary table of CR values.

Specialist	Level 1 index matrix	Level 2 indicator matrix: employee factor	Level 2 index matrix: Supply chain factors	Level 2 index matrix: pollution factor	Level 2 indicator matrix: Follow-up development and policy factors
Specialist 1	0.086	0.011	0.018	-	-
Specialist 2	0.020	0.093	0.012	-	-
Specialist 3	0.010	0.004	0.056	-	-
Specialist 4	0.092	0.093	0.071	-	-
Specialist 5	0.010	0.080	0.045	-	-
Specialist 6	0.048	0.098	0.033	-	-
Specialist 7	0.068	0.004	0.052	-	-
Specialist 8	0.007	0.004	0.017	-	-
Specialist 9	0.007	0.091	0.041	-	-
Specialist 10	0.023	0.049	0.015	-	-

Table 5: Summary of factor weight values.

Specialist number	Staff factor	Supply chain factor	Pollution factor	Follow-up development and policy factors
Specialist 1	10.103%	33.78429%	50.00634%	6.10551%
Specialist 2	9.907%	64.5359%	3.40134%	22.15482%
Specialist 3	10.849%	65.689%	10.492%	12.968%
Specialist 4	11.041%	66.852%	9.886%	12.219%
Specialist 5	6.507%	57.616%	13.986%	21.889%
Specialist 6	3.825%	64.670%	7.935%	23.567%
Specialist 7	19.966%	15.466%	43.044%	21.522%
Specialist 8	7.652%	62.231%	9.372%	20.743%
Specialist 9	4.794%	49.827%	16.609%	28.768%
Specialist 10	4.549%	56.800%	18.630%	20.019%
Average value	8.919%	53.747%	18.336%	18.995%

Supply chain factors are considered to be one of the most important influencing factors. The location of feed mills needs to take into account the availability of raw materials and the distribution channels of products. A stable feedstock supply chain and efficient product distribution are critical to feed mill operations. In AHP analysis, this factor may include a comprehensive consideration of supplier reliability, supply distance, transportation cost and other factors. Secondly, pollution is listed as the second most important factor. The production of feed mills may involve environmental pollution issues, such as wastewater treatment, noise, air quality, etc.

Choosing the right location and environmental assessment is crucial to reducing potential environmental impacts, which is also closely related to the local government's environmental regulations. And the subsequent development and policy factors are considered to be the third influential factors. These factors include expectations for future development, local government development plans and possible policies for new feed mills. The stable policy environment and good development prospects will provide favorable conditions for the long-term operation of the feed mill. Finally, the employee factor is listed as one of the least influential factors. This factor involves the recruitment, training and performance management of feed mill employees.

Although less influential in the AHP analysis, a qualified staff team is equally critical to the proper operation of the feed mill, especially in highly automated and technology-intensive production environments. In summary, the study of feed mill location problem through AHP can effectively help decision makers to clarify the priority and tradeoff relationship of various influencing factors. In the actual decision-making process, it is necessary to comprehensively consider the specific situation of the above factors, and flexibly adjust and weigh according to the specific project characteristics and local actual conditions. This method not only improves the scientific and accurate decision-making, but also lays a solid foundation for the long-term successful operation of the feed mill. In the study of feed plant location, AHP is an effective method, which can help decision makers to weigh and make decisions among many influencing factors. According to the results of the study, the main site selection factors in order from strong to weak are supply chain factors, pollution factors, subsequent development and policy factors, and staff factors.

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