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Research on Improving the Financial Capacity of Farmers Based on Fuzzy Analytic Hierarchy Process

Yongyi Gu[1], Kaijun Xu[1,*], Xinyue Hu[1], Mengting Chen[1]

[1] Department of Statistics and Mathematics, Guangdong University of Finance and Economics, Guangzhou 510320, China; gdguyongyi@163.com; xu18124366896@163.com; moonstarhh@163.com; Cmengting2023@163.com.

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Abstract

This study uses the Fuzzy Analytic Hierarchy Process (FAHP) to analyze the key factors that profoundly enhance the financial capabilities of farmers. The research results show that personal economic status is the dominant factor, with personal income, consumption, and savings becoming the core elements for enhancing financial capabilities. The importance of economic factors for farmers' financial literacy is highlighted, providing a foundation for formulating targeted policies. Financial training and digital technology are also emphasized. The diversity of financial institutions is also seen as a key factor driving financial capabilities. Social factors have a relatively small impact on the research. Based on the comprehensive research results, it is proposed that the government should strengthen agricultural modernization, promote financial training and digital development, increase internet coverage, support diversified services of financial institutions, and encourage social capital investment to build a comprehensive policy framework to enhance the financial capabilities of farmers.

Keywords: Fuzzy analytic hierarchy process, Financial capabilities, Farmers.

1 | Introduction

The Scholars and practitioners in the UK and Canada first proposed the term financial capability. The UK government defines it as people's knowledge and skills to understand their financial situation and motivation to take action. Previously, people found that financial literacy, as a way to help people make reasonable financial decisions, cannot effectively promote financial behaviour when hindered by a lack of skills or a decision-making environment. Based on this, financial capability was introduced to broaden the concept. Sherranden [1] pointed out that financial ability to promote financial decision-making needs to include not only the ability (knowledge, skills, confidence, and motivation) of individual actions but also the opportunities for individual actions (environment for obtaining financial products and services).

Corresponding Author: xu18124366896@163.com

Digital inclusive finance is a new type of business in which the traditional financial industry relies on continuously upgrading various digital technologies and plays an essential role in reducing social income inequality [2]. However, digital inclusive finance development requires digital infrastructure and consumer awareness. Compared with high-income countries, the role of digital inclusive finance in reducing income inequality is relatively weak for low-income countries [3]. Low-income households face the problem of lack of financial knowledge and quality financial services, especially in rural areas of developing countries. According to the relevant data in the consumer financial literacy survey and analysis report, the financial literacy level of consumers in rural areas of China is significantly lower than that in urban areas. Rural residents, older people, and other vulnerable groups lack the ability and freedom to access and enjoy basic financial knowledge. The lack of financial knowledge and single financial skills are prominent problems which make it challenging to adapt to the rapid development of financial services supported by inclusive finance policies. Therefore, it is of great practical significance to deeply study the factors that influence the improvement of rural residents' financial ability, help low-income families accumulate wealth, and reduce their vulnerability to the changing economy.

Therefore, the motivation for this study comes from the deep understanding of the current situation in the rural finance field and the sense of mission to build a comprehensive, well-off society. With the development of socialism in our country, realizing the farmers' all-round well-off life has become an important goal of national development. Improving farmers' financial ability is directly related to the farmers' economic situation and living standards. Improving farmers' financial ability becomes an indispensable part of realizing this goal, which aligns with the core concept of socialism with Chinese characteristics to pursue people's happy lives. Through an in-depth study of the critical factors of financial capacity, we can better formulate financial policies in line with China's national conditions to ensure farmers can steadily improve economically.

In terms of definition and measurement, financial ability is measured by three groups of variables: perceived financial ability, financial knowledge, and financial behavior [4]. Lusardi [5] found that Financial capabilities are classified as the ability to break even, plan, select and manage financial products, and have the skills and knowledge to make financial decisions. Atkinson et al. [6]. used factor analysis to measure the financial ability of residents.

In terms of direct influencing factors, Taylor [7] studied the influencing factors of financial ability from the perspectives of personal characteristics and social status. Lusardi and Mitchel [8] use the life-cycle savings model to point out that consumers who have received financial education have more prominent financial ability than consumers who have not. This view is verified in the research [4]. It is also believed that both general financial education and financial education from specific sources positively correlate with the financial ability index. Gina et al. [9], according to the study's findings, the existence of saving in the environment will affect the saving behaviour of the residents in the community. The stronger the community's saving standard, the stronger people's saving habits will be. In addition, social workers should consider adopting an intervention model to provide training and assistance to low-income families so that they can eventually start financial behaviour.

In terms of indirect influencing factors, it is proposed that the development of digital inclusive finance can significantly reduce the financial vulnerability of farmers' households. Farmers' financial literacy significantly mediates and regulates [10]. It is believed that the digital divide may reduce household income by weakening social networks, curbing self-employment and entrepreneurship and reducing credit availability. The negative impact is even greater in rural areas, third-, fourth- and fifth-tier cities, and older people [11]. Through heterogeneity analysis, Chen and Gong [12] pointed out that digital financial inclusion can alleviate the financial vulnerability of farmers by reducing credit constraints and improving their financial literacy. Moreover, it has a greater role in alleviating the financial vulnerability of households with low assets and education levels.

To sum up, although the existing research studies the establishment of a financial capability assessment system from various aspects, no research has been conducted to explore further the specific factors affecting farmers'

financial capability improvement. In measuring financial capability, most researchers adopt questionnaires, answering questions and other methods without examining the impact of the financial environment on farmers' financial capability. How to scientifically and objectively measure and evaluate the financial ability of farmers and construct a reasonable index system. Differentiated promotion strategies must be formulated to ensure the accurate implementation of the policies according to the differences between different regions and different types of farmers.

Finding an appropriate decision analysis method is necessary to study the main factors affecting farmers' financial ability. In selecting suppliers for the research company, Shafi [13] used the FAHP method to consider four types of components, evaluated and analyzed the suppliers of manufacturing enterprises, and obtained reasonable results in the end. Boonmee et al. [14]. To study the site selection of temporary safety areas during haze pollution, use the comprehensive method of FAHP and FTOPSIS to assign weights to each standard through FAHP and then evaluate candidate positions through FTOPSIS standard to generate scores for each site. The study results show that the model can generate the optimal solution. Yuliani et al. [15] supplement the evaluation criteria of religious funds; their research put forward six factors respectively: regulation (three factors), institutions (two factors), process (four factors), system (three factors), results (two factors) and influence (four factors), and based on the FAHP method to build the national religious fund index. Shi et al. [16] selected 50 sub-factors from individual, organizational, and environmental dimensions to evaluate the incentive factors for high-tech talent gathering and used the FAHP method for comparison. The results show that individual incentives are more important than environmental factors, and environmental incentives are more influential than organizational ones. Job satisfaction, the welfare system, and geographic location were the highest-ranked factors. Abusaeed et al. [17], on the agile software development cost of priority factors, based on personnel, project, process, and products, through the agile project manager, agile practitioners and senior developers questionnaire survey, extracted 16 influencing factors, finally using the FAHP method got them influence size and sorting. Chandna et al. [18] evaluated the performance of the online learning course delivery platform and determined the importance of each factor by providing questionnaires to experts. The FAHP method was used to compare the performance of different online learning platforms and get the final results. Shwetank et al. [19] on the selection of metal composites because there are many factors affecting the choice of metal composites, including tensile strength, hardness, melting point, density and cost; their research using FAHP and FTOPSIS methods to compare different composite materials, and in the end got the most suitable matrix material. In addition, fuzzy sets, multi-attribute decision-making, multi-criteria decision-making, and multi-objective decision-making methods [20]–[24] have been widely used to solve significant decision-making problems.

Based on various scholars' research methods of multi-level decision analysis, fuzzy-level analysis has a strong practical application in this kind of research, so this paper will use fuzzy-level analysis to analyze the key factors for improving farmers' financial ability.

The research of this paper provides targeted theoretical support for policymaking in the field of rural finance. This paper comprehensively analyzes the factors affecting the farmers' financial ability from multiple dimensions. This comprehensive analysis provides a theoretical basis for formulating targeted, scientific, and effective rural financial policies. It contributes substantial insights to realizing the goal of comprehensive, well-off farmers and promoting sustainable growth of the rural economy.

The rest of the paper is arranged as follows the second part introduces the selection of the second, third, and fourth indexes and makes a theoretical analysis of their principles. In the third part, the framework is constructed based on the introduction of fuzzy chromatography analysis. The fourth part is the empirical process and results; the last part is the conclusion and enlightenment.

2 | Factors Affecting the Improvement of Financial Capabilities

2.1 | The Selection of Secondary and Tertiary Indicators

Financial capability is a complex and comprehensive concept that is influenced by multiple levels of factors. Therefore, discussing the factors affecting farmers' financial capability improvement requires a multiple-level layer-by-layer analysis.

At the individual level, improving farmers' financial ability is closely related to their education situation, economic status, financial behaviour and habits, financial goals and planning. The individual's educational level is directly related to farmers' understanding and mastery of financial knowledge. Farmers who have received good education are more likely to understand the operational mechanisms of financial markets, various financial products, and investment tools and thus implement financial decisions more wisely. Farmers who have received good education often have higher financial literacy. In terms of financial management, they can better plan funds, avoid risks, and create more investment opportunities. The personal economic situation directly impacts the improvement of farmers' financial ability, directly affecting their activities, choices, and decisions in the financial field. Farmers with better economic conditions may also be more susceptible to certain levels of risk and better able to cope with larger financial risks, which is closely related to risk awareness and management in improving financial capabilities. Improving farmers' financial ability is related to their financial behaviour and habits, as their financial behaviour and habits directly reflect their understanding of financial knowledge, ability to plan finances, and level of risk awareness. Improving farmers' financial capabilities is also related to their personal financial goals and plans, as clear goals help farmers make more targeted financial planning and decisions, such as saving, investing, or purchasing a house. Setting financial goals requires carefully considering individual values, life stages, and future plans, directly affecting the direction and intensity of financial capability improvement. At the social level, improving farmers' financial capabilities is closely related to community support, social digitization, and the socio-cultural environment.

Improving farmers' financial capabilities is related to community support, mainly reflected in the community's support for financial education, financial services, etc. The increase in the number of communities and the abundance of activities usually means more platforms are used to carry out financial activities, including training courses, seminars, etc. Farmers can have a more comprehensive understanding of financial knowledge through these financial activities, thereby improving their financial literacy and decision-making level. Improving farmers' financial capabilities is related to community digitization because the widespread application of digital technology in the financial field provides farmers with more convenient, efficient, and inclusive financial services, thereby promoting their better participation in financial activities. Through mobile banking, electronic payments, and other digital platforms, farmers can more easily transfer funds, make payments, and check account balances, reducing time and geographical limitations in traditional financial services and improving the accessibility of financial services. Improving farmers' financial capabilities inevitably relates to the social and cultural environment. To a certain extent, the social and cultural environment even determines an individual's values and beliefs, especially for farmers. Due to the development of urban informatization and digitization, personal values and beliefs are also influenced by the online world, and the influence of the social and cultural environment is not significant. However, in underdeveloped areas such as rural areas with information and digitization, an individual's values and beliefs are almost determined by the current social and cultural environment. Their values directly shape their attitude, behaviour, and decision-making in the financial field, thereby affecting the acquisition of financial knowledge, the setting of financial goals, and the execution of financial planning, which greatly impacts the improvement of financial capabilities.

At the government level, the improvement of farmers' financial capabilities is related to the financial regulations and policies implemented by the government, financial education and training conducted, and support from financial institutions.

The improvement of farmers' financial capabilities is related to the financial regulations and policies implemented by the government. This is because the government's regulations and policies directly shape the financial market's operating environment and profoundly impact the financial services, accessibility of financial products, and financial behaviour norms of farmers. The government has formulated relevant regulations to promote financial institutions to provide more financial products and services to rural areas, promoting the improvement of financial capabilities. By formulating incentive policies, the government can encourage financial institutions to provide preferential measures such as low-interest loans and financial subsidies to farmers, thereby reducing the cost of obtaining financial products for farmers and improving their financial capabilities. In addition, the financial regulations and policies formulated by the government also have a guiding role in regulating the financial behaviour of farmers, helping to prevent financial risks and protect the rights and interests of farmers. The financial education and training carried out by the government can also significantly enhance the financial capabilities of farmers. Farmers can gain specific financial knowledge and enhance their financial capabilities through financial education and training. The support of financial institutions can also significantly enhance the financial capabilities of farmers. The existence and services of financial institutions directly affect farmers' participation and development in the financial field. By providing services such as funding, savings, financial management, training, and insurance, farmers can better participate in and respond to various activities in the financial market.

In summary, the factors affecting farmers' financial capability improvement can be approached by individuals, society, and government. These three levels also constitute the secondary indicators that affect the improvement of farmers' financial capabilities. These three levels can be subdivided into several three-level indicators, namely education situation, economic situation, financial behaviour and habits, financial goals and planning; Community support, social digitization, and socio-cultural environment; Financial regulations and policies implemented by the government, financial education and training conducted, and support from financial institutions; Summarized in *Table 1*.

Table 1. Indicator selection.

Primary Indicators	Secondary Indicators	Third Level Indicators
Improving the financial capabilities of farmers	Individual level	Education situation
		Economic situation
		Financial behavior and habits
		Financial goals and planning
	Social level	Community support
		Social digitization
		Social and cultural environment
	Government level	Financial regulations and policies
		Financial education and training
		Financial institution support

2.2|The Selection of Quaternary Indicators

2.2.1 | Individual level

From the analysis above, it can be concluded that the individual level includes their education situation, economic situation, financial behaviour and habits, as well as financial goals and plans.

Education situation indicators: education indicators can include multiple aspects, among which the length of education is directly related to farmers' knowledge level and cognitive ability, including financial knowledge. The duration of financial training reflects the degree to which farmers receive training in specialized financial fields. Receiving systematic financial training can cultivate financial literacy and improve financial abilities. The investment in education refers to the individual's investment in education, such as purchasing books, paying tuition fees, etc. This reflects the importance that farmers attach to education, and good education is accompanied by higher financial literacy and abilities.

Economic status indicators: personal income is a fundamental parameter for evaluating an individual's economic situation, reflecting their relative achievements in production and labour markets. It is crucial for improving financial capabilities. Personal consumption refers to an individual's level of expenditure in daily life, which reflects not only their economic situation but also their level of rationality and consumption habits in financial decision-making. The employment situation reflects the individual's participation in the labour market, and a stable employment situation usually helps to stabilize the individual's economic situation, allowing farmers to have more resources to participate in financial activities and enhance their financial capabilities. Personal residential area is an indicator that examines an individual's living standards, closely related to their economic situation and reflects their expectations for future economic conditions.

Financial behavior and habit indicators: personal savings are an important component of individual financial planning, and higher personal savings often mean better financial planning and management, which is beneficial for improving the financial stability of farmers and providing financial support for future investments. The amount of personal investment directly reflects farmers' participation level in the financial market. Both of these reflect farmers' concerns about financial planning and the future. Payment methods reveal the payment habits of farmers as an indicator of daily financial habits. Farmers who frequently use mobile payments often participate more actively in financial activities, providing convenience for their financial activities.

Financial goals and planning indicators: short-term investment goals reflect farmers' attention to the current economic situation and short-term financial needs. In contrast, long-term investment goals reflect their long-term planning for future financial conditions. Savings goals are the foundation of financial planning, providing short-term and long-term investment goals by accumulating funds. These three focus on setting financial goals at different time scales.

2.2.2 | Social level

The social level includes community support, social digitization, and socio-cultural environment.

Community support indicators: the number of communities and the number of activities carried out in the community directly reflect the degree of social support in terms of quantity, and social capital investment reflects the degree of social support from a qualitative perspective.

Social digitalization indicators: the number of mobile phones/computers and the proportion of internet users reflect the level of social digitization from the perspectives of individuals and households, directly related to whether farmers can participate in digital financial activities. The degree of digitalization of enterprises reflects the widespread application of digital technology in society, which profoundly impacts the development of social digitization. These three indicators can comprehensively reflect society's digitalization and thus reflect social digitalization's impact on improving farmers' financial capabilities.

Social and cultural environment indicators: the number of public service facilities directly affects the support and services that farmers receive in society. Financial values reflect the motivation of farmers to participate in financial planning and activities, and establishing a positive financial attitude is a prerequisite for improving financial capabilities. Social traditions and customs reflect the environment in which farmers live; for example, more rigid social traditions will be detrimental to improving their financial capabilities.

2.2.3 | Government level

The government level includes financial regulations and policies, financial education and training, and support from financial institutions.

Financial regulations and policy indicators: various security regulations have a direct effect on individual farmers. This article selects three key indicators: personal financial information protection regulations, farmer rights protection regulations, and financial risk prevention measures. These three indicators reflect the financial security regulations set by the government for farmers. Based on these regulations, farmers can enhance their financial capabilities. In addition, this article also selected policy indicators for agricultural credit

issuance. Compared to urban residents, farmers lack a personal economic level, and the government needs certain credit issuance policies to help farmers implement financial activities.

Financial education and training indicators: the financial training program implemented by the government includes specialized training for individual farmers and training for financial practitioners. The former is the most intuitive way to enhance the financial capabilities of farmers. Therefore, this article selects financial training programs for farmers and digital financial training indicators. The latter is a supplement to the former, providing professional training for financial practitioners and indirectly affecting the improvement of individual financial capabilities of farmers to a certain extent.

Financial institution support indicators: financial institution support includes the number of various financial institutions and the financial products provided by financial institutions. This article selects the number of important banks, the number of credit cooperatives, and the types of financial products as the four-level indicators supported by financial institutions.

In summary, this article has selected a total of 32 four-level indicators, corresponding to 10 third-level indicators and 3 second-level indicators. The comprehensive selection of indicators has laid the foundation for the empirical analysis in the following text. Add 32 fourth-level indicators to *Table 1* and summarize them in *Table 2*.

Table 2. Indicator selection.

Primary Indicators	Secondary Indicators	Third Level Indicators	Fourth Level Indicators
Improving the financial capabilities of farmers	Individual level	Education situation	Years of education Financial training time Education investment situation
		Economic situation	Personal income Personal consumption Employment situation Personal residential area
		Financial behavior and habits	Personal savings amount Personal investment amount Payment method
		Financial goals and planning	Short-term investment goals Long-term investment goals Savings target
	Social level	Community support	Number of communities Number of community activities carried out Social capital investment
		Social digitization	Number of mobile phones/computers owned Internet user proportion Enterprise digital technology level
		Social and cultural environment	Number of public service facilities Financial values Social traditions and customs
	Government level	Financial regulations and policies	Personal financial information protection regulations Agricultural credit disbursement policy Regulations on the protection of farmers' rights and interests Financial risk prevention measures
		Financial education and training	Financial education program for farmers Professional training for rural financial practitioners Digital finance training
		Financial institution support	Number of banks Number of credit cooperatives Types of financial products

3 | Research Method

3.1 | Method Introduction

Drawing on Bhyan et al. [25] idea of developing a comprehensive sustainability assessment system in the whole building life cycle stage of group housing in India, this paper uses a FAHP to say so. The FAHP handles fuzzy information and uncertainty in multi-criteria decision-making. It is developed based on the traditional Analytic Hierarchy Process (AHP), and compared to AHP, FAHP aims to better deal with the fuzziness of expert judgments and the uncertainty in real-world decision-making problems. It overcomes the limitations of the traditional AHP. The most significant difference is that AHP requires experts to provide accurate ratings, clear comparisons and rankings. It assumes that all elements of the judgment matrix are definite and accurate values. At the same time, FAHP introduces the concept of fuzzy mathematics, allowing for fuzziness and uncertainty in the judgment matrix. It is more suitable for dealing with fuzzy information in decision problems. In real life, the info experts judge is often fuzzy, such as equally important, strongly important, etc. FAHP needs to convert these fuzzy evaluations into numerical values, while AHP bypasses fuzzy evaluations and directly provides specific numerical values. Therefore, FAHP is more flexible in dealing with real-life decision-making problems.

Before conducting FAHP, indicators must be divided into target, standard, substandard, and decision layers. A fuzzy judgment matrix can be constructed by converting the fuzzy evaluations given by experts on the indicators of the standard, substandard, and decision layers into numerical values. The elements in the judgment matrix represent the importance of row indicators relative to column indicators, and the elements on the diagonal are all 1. The comparison between indicators is not transitive. Therefore, a fuzzy judgment matrix can be constructed for each set of indicators. The number of fuzzy judgment matrices that need to be constructed is the sum of first-level, second-level, and third-level indicators. This article consists of 14 fuzzy judgment matrices. A fuzzy judgment matrix cannot be constructed arbitrarily and needs to meet consistency testing. Due to the subjectivity of expert fuzzy evaluation, consistency testing is precisely to ensure the objectivity of the fuzzy judgment matrix. Only through consistency testing can the expert's fuzzy evaluation have credibility. Consistency testing requires calculating the Consistency Index (CI) and ratio and determining whether they have passed the consistency test based on size. The specific operating steps are as follows:

Specific mathematical formulas must be used to calculate the CI and Consistency Ratio (CR) through the judgment matrix. The specific Python code can be found in *Algorithm A1*. Firstly, calculate the maximum eigenvalue of the judgment matrix:

$$\lambda_{max} = \frac{1}{n}\sum_{i=1}^{n}\frac{\sum_{j=1}^{n} a_{ij}\omega_j}{\omega_i}. \tag{1}$$

Among them a_{ij} is the element in the judgment matrix, ω_{ij} is the element of the normalized judgment matrix, and n is the number of elements. Calculate the CI based on the calculated maximum eigenvalue

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

The consistency ratio can be calculated using the CI, which is the ratio of the CI to the average Random Consistency Index (RCI). There is a certain correspondence between the average RCI and the order of the judgment matrix, as shown in *Table 3*.

Table 3. Average RCI.

Matrix Order	1	2	3	4	...
RI	0.00	0.00	0.58	0.90	...

By consulting relevant literature, it can be seen that the consistency of the fuzzy judgment matrix can be accepted when the CI and consistency ratio are less than 0.1. After passing the consistency check, the fuzzy weight can be calculated.

To calculate fuzzy weights through a fuzzy judgment matrix, it is necessary first to normalize the judgment matrix, which is to divide the original matrix by the sum of each column, then calculate the mean of each row of the normalized matrix, and finally obtain 3×1 matrix refers to fuzzy weights, and the specific Python code can be found in *Algorithm A2*.

3.2|Construction of Fuzzy Analytic Hierarchy Process Framework

Based on the indicator selection mentioned above, construct the framework of FAHP. The target layer is to enhance the financial capabilities of farmers. The standard layer includes the individual, social, and government levels. The substandard and decision layers are the corresponding third and fourth-level indicators in indicator selection. Based on consistency testing, 14 judgment matrices are established based on the fuzzy scores given by experts. The weights of 3 secondary indicators, 10 tertiary indicators, and 32 fourth-level indicators are calculated based on the judgment matrices. Finally, the weights of each decision-making level are obtained by multiplying them. Based on this weight, effective decisions for improving the financial capacity of farmers are obtained.

4|Application of Fuzzy Analytic Hierarchy Process

4.1|Building a Fuzzy Judgment Matrix

To construct a fuzzy judgment matrix, it is necessary first to compare the indicators individually. Given that expert fuzzy evaluation is more objective, this study consulted experts who have conducted extensive research on farmer finance to conduct a fuzzy evaluation. The experts provided five criteria for the same, slightly important, obviously important, strongly important, and extremely important between two indicators, and then converted these fuzzy evaluations into scores corresponding to 1, 3, 5, 7, and 9, respectively. The size of the score only represents the important differences between indicators in the same category, and its scale is summarized in *Table 4*.

Table 4. Fuzzy judgment evaluation scale.

Evaluation Scale	Meaning
1	Indicates that two factors have the same importance compared to each other
3	Compared to two factors, the former is slightly more important than the latter
5	Compared to two factors, the former is significantly more important than the latter
7	Indicates that compared to the latter, the former is more strongly important than the latter
9	Compared to the two factors, the former is extremely important compared to the latter
The reciprocal of the above scale	If the ratio of importance between factor A and factor B is a, then the ratio of importance between factor B and factor A is 1/a

Based on expert fuzzy evaluation, this article uses rating scales to convert specific values and constructs 14 judgment matrices. This article only lists the fuzzy judgment matrices constructed by the standard layer to avoid excessive length. The results are shown in *Table 5*.

Table 5. Standard layer fuzzy judgment matrix.

Judgment Matrix	Individual Level	Social Level	At the Government Level
Individual level	1	9	3
Social level	1/9	1	1/5
At the government level	1/3	5	1

According to the meaning of fuzzy evaluation, to improve the financial capabilities of farmers, the individual level is extremely important compared to the social level. The individual level is slightly more critical. Compared to the social level, the government level is important. According to the research of Liu and Zhanmin [26] the main responsibility for improving the financial capabilities of farmers lies with individuals and the government, and it gradually shifts from the government to the individual . This is consistent with constructing the fuzzy judgment matrix, proving the credibility of expert fuzzy evaluation.

4.2|Consistency Testing of Fuzzy Judgment Matrices

The fuzzy judgment matrix needs to pass consistency testing to have credibility. The steps of consistency testing have been mentioned earlier, and CR and CI need to be calculated. Generally, when both CR and CI are less than 0.1, constructing the fuzzy judgment matrix is considered more reasonable.

The consistency test results of the fuzzy judgment matrix constructed by the target, standard, and sub-standard layers are shown in *Table 6*.

Table 6. Consistency test results.

Indicator Categories	Indicator Name	CI value	CR value
Target layer	Improving the financial capabilities of farmers	0.01453	0.02505
	Individual level	0.05688	0.06321
Standard layer	Social level	0.03244	0.05498
	At the government level	0.00002	0.00001
	Education situation	0.03244	0.05498
	Economic situation	0.07238	0.08042
	Financial behavior and habits	0.04015	0.06805
	Financial goals and planning	0.03244	0.05498
Sub standard layer	Community support	0.04015	0.06922
	Social digitization	0.04015	0.06922
	Social and cultural environment	0.00276	0.00477
	Financial regulations and policies	0.03899	0.04333
	Financial education and training	0.01926	0.03320
	Financial institution support	0.00351	0.00605

From this, it can be seen that the construction of the 14 fuzzy judgment matrices meets the consistency test; that is, both CI and CR meet the threshold of less than 0.1. Fuzzy evaluation by experts has a certain degree of credibility.

4.3|Consistency Testing of Fuzzy Judgment Matrices

Based on expert fuzzy evaluation, the fuzzy judgment matrix can be used to calculate the corresponding weights of each indicator in the matrix. For example, the fuzzy judgment matrix constructed by the target layer can calculate the weights of individual, social, and government levels, respectively. The calculation method of weights has been explained in the research method introduction above, and the calculated results are shown in the *Tabel A1*.

The sum of weights obtained for each fuzzy matrix is 1. The results indicate that to enhance the financial capacity of farmers, more attention should be paid to starting from the individual level, and the government and society levels should not be ignored. It is necessary to deepen together at the individual level. At the individual level, it is important to pay primary attention to the economic situation of farmers, as having a good economic situation is the most important foundation for enhancing financial capabilities. At the social level, more attention should be paid to the development of social digitization, and the improvement of social digitization has a strong positive effect on the financial capacity of farmers. The government should pay more attention to the support of financial institutions; in other words, it is necessary to ensure a certain number of rural banks and credit cooperatives and actively enrich the types of financial products they provide. To better start from the decision-making level and provide effective decision-making suggestions so that the weights of each decision-making level indicator are clearly visible, the weights calculated from the fuzzy judgment matrix

constructed by the target layer, standard layer, and substandard layer are multiplied accordingly to obtain the final weights of the decision-making level, as shown in *Table 7*.

Table 7. Weight calculation.

Name of Decision-Maker Indicators	Weight	Name of Decision-Maker Indicators	Weight
Years of Education	0.03908	Number of mobile phones/computers owned	0.01309
Financial training time	0.08890	Internet user proportion	0.02882
Education investment situation	0.01019	Enterprise digital technology level	0.00252
Personal income	0.26448	Number of public service facilities	0.00120
Personal consumption	0.10474	Financial values	0.01412
Employment situation	0.04820	Social traditions and customs	0.00421
Personal residential area	0.01981	Personal financial information protection regulations	0.00285
Personal savings amount	0.00962	Agricultural credit disbursement policy	0.00611
Personal investment amount	0.02118	Regulations on the protection of farmers' rights and interests	0.02796
Payment method	0.00185	Financial risk prevention measures	0.01320
Short-term investment goals	0.04423	Financial education program for farmers	0.03174
Long-term investment goals	0.01944	Professional training for rural financial practitioners	0.00532
Savings target	0.00507	Digital finance training	0.01306
Number of communities	0.00034	Number of banks	0.10054
Number of community activities carried out	0.00079	Number of credit cooperatives	0.03655

The above is the weight of all indicators for the decision-making level, and the following is an analysis of the weight results for the decision-making level:

I. Economic factors dominate. The weight of personal income is the highest, reaching 26.45%, indicating the significant impact of personal economic status on improving the financial capacity of farmers. Personal consumption and savings are also around 10%, further emphasizing the dominant position of economic factors.

II. The key role of personal financial training time. Financial training time accounts for 8.89% of the overall weight, emphasizing the key role of financial training in improving financial literacy. This indicates that improving the training of farmers on financial knowledge and skills is crucial.

III. The importance of financial institutions. The number of banks, the number of credit cooperatives, and the types of financial products account for 10.05%, 3.66%, and 1.33% of the overall weight, respectively, indicating the importance of financial institutions in enhancing the financial capabilities of farmers. The diversity and increase in the number of financial institutions are crucial for expanding financial service channels.

IV. Digital finance and internet applications. The proportion of internet users and digital financial training accounts for 2.88% and 1.31%, respectively, highlighting the potential value of digital technology and internet applications in improving financial literacy.

V. Social factors are relatively low. Social traditions, customs, and social capital investment account for 0.42% and 0.40% of the overall weight, respectively, relatively low. This indicates that social and cultural factors have a relatively small impact on rural financial development.

VI. The regulatory factors, such as regulations on protecting the rights and interests of farmers and agricultural credit issuance policies, have relatively low weights. However, they still occupy a place in overall decision-making, accounting for 2.80% and 0.61%, respectively.

In summary, when formulating policies and plans, special attention should be paid to improving personal economic level, promoting practical financial training, developing diversified financial institutions, and promoting the application of digital financial technology.

5 | Conclusion

In this study, we conducted an in-depth analysis of the critical factors that enhance the financial capabilities of farmers by using the FAHP. The research results clearly indicate that personal economic status dominates the overall factors, with personal income, consumption, and savings becoming the core elements for enhancing financial capabilities. This highlights the importance of economic factors in shaping farmers' financial literacy, providing an essential basis for formulating targeted policies. The study also emphasizes the crucial role of financial training and digital financial technology. Indicators such as financial training time and the proportion of internet users demonstrate the importance of enhancing financial capabilities. Providing comprehensive financial knowledge training for farmers and promoting the widespread application of digital technology have become effective ways to improve financial literacy. The diversity of financial institutions is also a key factor in promoting the financial capabilities of farmers. The number of banks and types of financial products account for a significant proportion of the overall weight, emphasizing the crucial importance of financial institutions in providing diversified financial services. This provides a clear direction for expanding financial service channels and meeting the diverse financial needs of farmers. On the contrary, social factors have a relatively small impact in this study. Factors such as social traditions and customs and social capital investment have a relatively low proportion of the overall weight, indicating that social and cultural factors have a relatively small impact on improving farmers' financial capacity.

Based on in-depth research on enhancing the financial capabilities of farmers, this article proposes the following comprehensive policy recommendations. Firstly, the government should promote agricultural modernization and increase the income level of farmers by implementing rural industrial development plans. Secondly, strengthen the design and promotion of financial training programs, covering basic financial knowledge, wealth management skills, and digital financial applications to improve farmers' financial literacy. At the same time, the government needs to invest heavily in digital infrastructure in rural areas, increase internet coverage, promote the popularization of digital payment tools, and enable farmers to participate in financial activities more conveniently. In addition, we support financial institutions in establishing more branches in rural areas and encourage innovative financial products to meet the diversified financial needs of farmers. Finally, by encouraging social capital to invest in the rural financial field, establishing social organizations and enterprises to participate in farmer financial training projects, forming a joint effort between the government, financial institutions, social organizations, and farmers, comprehensively enhancing rural financial capabilities. These policy recommendations aim to build a comprehensive framework involving multiple parties, promote the comprehensive development of farmers in finance, and support sustainable rural economic growth.

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Author Contribution

Conceptualization, Yongyi Gu and Xinyue Hu; methodology, Kaijun Xu and Yongyi Gu; validation, Mengting Chen; formal analysis, Kaijun Xu; resources, Xinyue Hu and Kaijun Xu; writing-original draft preparation, Kaijun Xu and Xinyue Hu; writing—review and editing, Yongyi Gu and Mengting Chen; supervision, Yongyi Gu. All authors have read and agreed to the published version of the manuscript.

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Data Availability

The data used to support the findings of this study are included in the article.

Conflicts of Interest

The authors declare no conflict of interest.

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Appendix A

Algorithm A1. Consistency check.

```
import numpy as np
def calculate_ci(matrix):
    n = len(matrix)
    eigenvalues, _ = np.linalg.eig(matrix)
    max_eigenvalue = max(eigenvalues)
    ci = (max_eigenvalue - n) / (n - 1)
    return ci
def calculate_cr(ci, ri):
    cr = ci / ri
    return cr
judgment_matrix = np.array([ [1,3, 7 ],
    [1/3, 1, 3],
    [1/7, 1/3, 1]])
ri_table = {3: 0.58}
ci_value = calculate_ci(judgment_matrix)
print("The CI of the judgment matrix:", ci_value)
ri_value = ri_table[len(judgment_matrix)]
cr_value = calculate_cr(ci_value, ri_value)
print("The consistency ratio of the judgment matrix:", cr_value)
```

Algorithm A2. Weight calculation.

```
import numpy as np
def fahp(matrix):
    normalized_matrix = matrix/matrix.sum(axis=0)
    fuzzy_weights = normalized_matrix.mean(axis=1)
    final_weights = fuzzy_weights / fuzzy_weights.sum()
    return final_weights
fuzzy_matrix = np.array([ [1,3, 7 ],
    [1/3, 1, 3],
    [1/7, 1/3, 1]
])
weights = fahp(fuzzy_matrix)
print("The calculated weight is:", weights)
```

Table A1. (Weight result).

Indicator Categories	Indicator Name	Subordinate Indicators	Weight
Target layer	Improving the financial capabilities of farmers	Individual level	0.68035
		Social level	0.06906
		At the government level	0.25059
Standard layer	Individual level	Education situation	0.20828
		Economic situation	0.64268
		Financial behavior and habits	0.04800
		Financial goals and planning	0.10104
	Social level	community support	0.07377
		Social digitization	0.64339
		Social and cultural environment	0.28284
	At the government level	Financial regulations and policies	0.20000
		Financial education and training	0.20000
		Financial institution support	0.60000
Sub standard layer	Education situation	Years of Education	0.28284
		Financial training time	0.64339
		Education investment situation	0.07377
	Economic situation	personal income	0.60488
		personal consumption	0.23955
		Employment situation	0.11024
		Personal residential area	0.04533
	Financial behavior and habits	Personal savings amount	0.29464
		Personal investment amount	0.64862
		Payment method	0.05674
	Financial goals and planning	Short term investment goals	0.64339
		Long term investment goals	0.28284
		Savings target	0.07377
	community support	Number of communities	0.06851
		Number of community activities carried out	0.15490
		Social capital investment	0.77660
	Social digitization	Number of mobile phones/computers owned	0.29464
		Internet user proportion	0.64862
		Enterprise digital technology level	0.05674
	Social and cultural environment	Number of public service facilities	0.06122
		Financial values	0.72305
		Social traditions and customs	0.21572
	Financial regulations and policies	Personal Financial Information Protection Regulations	0.05689
		Agricultural credit disbursement policy	0.12187
		Regulations on the Protection of Farmers' Rights and Interests	0.55789
		Financial risk prevention measures	0.26335
	Financial education and training	Financial Education Program for Farmers	0.63335
		Professional training for rural financial practitioners	0.10616
		Digital finance training	0.26050
	Financial institution support	Number of Banks	0.66870
		Number of credit cooperatives	0.24310
		Types of financial products	0.08820