frontiers | Frontiers in Sustainable Food Systems

TYPE Original Research
PUBLISHED 20 March 2025
DOI 10.3389/fsufs.2025.1491760

OPEN ACCESS

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RECEIVED 05 September 2024
ACCEPTED 28 February 2025
PUBLISHED 20 March 2025

CITATION
Ling S, Yin Z, Hu C and Dong J (2025) Research on livelihood strategy choices and influencing factors of farmers in the area of the Grain for Green Project in China. *Front. Sustain. Food Syst.* 9:1491760. doi: 10.3389/fsufs.2025.1491760

Research on livelihood strategy choices and influencing factors of farmers in the area of the Grain for Green Project in China

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Understanding the livelihood strategy choices and influencing factors of farmers in the area of GGP is conducive to improving the livelihood level of farmers in the area and promoting the quality and efficiency of the project. For this study, we combine the characteristics of farmers in the area of GGP, constructs a livelihood evaluation index system for farmers, and uses a binary logistic model to explore the influencing factors of farmers' livelihood strategy choices. The research found: (1) The livelihood capital of farmers is ranked from high to low as part-time agricultural type (0.183), non-agricultural type (0.174), and pure agricultural type (0.126). (2) The stability level of farmers' livelihoods is ranked from high to low as part-time agricultural type (0.607), non-agricultural type (0.519), and pure agricultural type (0.409). (3) The impact of livelihood capital on the livelihood strategy choices of different types of farmers varies significantly. The quality of economic forest site and the health status of the head of household is positively affecting the part-time agricultural type, negatively affecting pure agricultural type; Productive assets are positively affecting pure agricultural type, negatively acting on non-agricultural type, while labor is opposite. It is recommended that the government needs to pay attention to changes in farmers livelihoods after the expiration of the subsidy for GGP, and develop differentiated livelihood level improvement policies based on the characteristics of farmers' livelihood capital.

KEYWORDS

Grain for Green Project, livelihood capital, livelihood stability, livelihood strategy choices, influencing factors

1 Introduction

China launched the Grain for Green Project (GGP) in 1999. It aims to guide farmers to plant trees and forests through ecological subsidies and other methods, so as to effectively protecting and improving the ecological environment and increasing the incomes of farmers (Duan et al., 2021). Theoretically, the implementation of the project not only effectively protects the ecological environment, ensures the ecological safety of country, but also greatly changes the resource endowment structure of farmers and improves the level of livelihood of farmers (Lu and Yin, 2020; Zhao R. et al., 2023). In fact, whether the scholars' field surveys of the GGP or empirical research have strongly confirmed that the project has achieved huge comprehensive benefits, which greatly enhances the farmers' livelihood toughness (Gao et al., 2020; Li Z. et al., 2020). However, with the indepth implementation of the project, the livelihood of the farmers who participating in the project had a significant differentiation phenomenon. Currently, with the gradual expiration of subsidies for the GGP, how farmers choose livelihood strategies and ensure the sustainability of their livelihoods is a key issue in consolidating the achievements of the project.

Presently, academic research on the relationship between the GGP and farmers' livelihoods mainly focuses on the following aspects: firstly, analyzing the impact of the project on farmers' livelihoods. Some scholars believe that the project has a positive effect on the level of livelihood of farm households. Li L. et al. (2020) found that the Grain for Green Project has effectively adjusted the industrial structure of rural areas in Ningxia, promoting farmers to shift from traditional planting to grassland and animal husbandry. Song et al. (2014) found that the project significantly expanded the income sources of farmers, balanced the proportion of income, and effectively improved the livelihood diversity of farmers. Le and Leshan (2020) found that the GGP has effectively increased the income of farmers in Guizhou Province through direct economic compensation and non-agricultural employment, promoting the transformation of farmers' livelihoods. Some scholars have also found that the project has adverse effects on the livelihoods of farmers. The research results of Wu et al. (2021) on the Loess Plateau showed that due to the low compensation standards for the second round of the project, the fallow tree species have almost no economic benefits, coupled with the Government's strict management approach of closing the mountains to grazing, the net income of pure agricultural farm households has declined to some extent. Zhang J. et al. (2019) found that the development of follow-up industries for the GGP lags behind, supporting policies are not perfect, and the sustainable livelihoods of farmers are affected. Secondly, it focuses on measuring or describing the livelihood level of farm households in the area of the project. Shi et al. (2024) used the entropy right method to measure the livelihood capital of farmers in Qingyuan County of Liaoning Province, and concluded that it is necessary to enhance the livelihood level of farmers from the perspectives of strengthening labor technology training, increasing ecological compensation and credit support, and expanding their social network. Lulu and Fengrui (2020) calculated and compared the livelihood capital levels of different types of farmers in Huining County, Gansu, and found that compared with farmers with agricultural livelihood strategies, farmers with non-agricultural livelihood strategies have significantly higher human capital such as family labor force and education level. Wang et al. (2022a) and Wang et al. (2022b) measured the forestry wage income, production income, transfer income and property income of farmers in the rocky desertification areas of Southwest China from the perspective of income sources, and found that the poverty reduction effect of the policy of the GGP was remarkable, and the level of livelihoods was significantly improved. Thirdly, based on the classification of livelihood strategies for farmers, the relationship between livelihood capital and livelihood strategies was explored. Chen et al.'s (2022a) research shows that natural capital such as land and human capital such as labor are key factors affecting farmers' livelihood choices; Li et al. (2019) emphasize that the support of financial capital such as credit funds is an important factor in the choice of non-agricultural livelihood strategies of farmers; Zhao Y. et al. (2023), on the other hand, emphasized that physical, human and social capital contribute to the transformation of non- agricultural livelihoods by influencing the income levels of farm households.

Currently, China's second round of subsidies for the GGP is gradually expiring, and the follow-up policies are still unclear. Farmers who have participated in the project are facing multiple challenges such as reduced sources of livelihood and transitional adjustments to their livelihood strategies. Liu et al. (2018) found that the expiration of the first round of subsidies for the project would result in a greater shortage of funds for farmers to adjust their livelihood strategies, exacerbating their instability in facing the risks of job transfer or migrant work. Zhang et al. (2023) found that the expiration of the first round of the GGP would widen income inequality within farmers, making it difficult for low-income farmers to effectively adjust their livelihood strategies and achieve income growth. Chen et al. (2022b) found that the expiration of the first round of subsides for the GGP has to some extent promoted farmers to make non-agricultural employment decisions and increased non-agricultural income. It can be seen that the expiration of the subsidy for returning farmland has a dual impact on the livelihood strategies of farmers, and further research and exploration are needed for the implementation of related policies in the future.

In summary, scholars have made significant achievements in the study of the GPP and farmers' livelihoods. However, most of them focus on the impacts of the GGP or the expiration of the first round of the project subsidies on farmers' livelihoods during the subsidy period. There is relatively little research on the livelihood situation of farmers under the background of the expiration of the second round of the project subsidies and unclear follow-up policies. Moreover, most of the existing studies have focused on the changes in livelihood strategies of farmers who have returned farmland, and there are few studies that deeply explore the factors that affect farmers' livelihood strategy choices. In view of this, this article takes Yan 'an in Shaanxi Province and Bijie in Guizhou Province, which are key areas for the GGP in China, as the research areas, and farmers participating in the project as the research objects, the entropy power method was used to measure the livelihood level of different types of farmers, analyze the livelihood stability characteristics of farm households, and analyze the factors affecting the choice of livelihood strategies of farm households by using a binary logistic model, it has made up for the lack of research in related areas and provided suggestions for the government to further understand the livelihood level and stability of farmers after the expiration of the GGP subsidy, and to carry out differentiated continuing subsidy policies for farmers with different livelihood strategies, improve their livelihood capabilities, and promote the improvement of the quality and efficiency of the project.

2 Materials and methods

2.1 Study area

Since the first round of the GGP began in 1999 on a pilot basis in Sichuan, Gansu, and Shaanxi provinces (Shidong and Moucheng, 2022), a cumulative total of 447 million mu of fallow forest return has been implemented, of which 36.95 million mu of fallow forest return was implemented in Shaanxi Province, ranking second in the country, and Yan' an City in Shaanxi Province accounted for 36.95 million mu, ranking first in the country's prefectural-level municipalities (Ding et al., 2023) and it is the main battlefield of the first round of the project. Yan' an City is located in the north of Shaanxi Province and the middle stream of the Yellow River, dominated by hilly and gully landscapes with serious soil erosion, since the implementation of the GGP, the Loess Plateau, which used to be crisscrossed by ravines,

dusty, and covered in yellow sand, has turned into a green ocean. The livelihood strategy of farmers who have returned farmland has shifted from single planting agriculture to ecological agriculture, forest product processing and industrial manufacturing, non-agricultural industries such as mountain peaches, mountain apricots, and mountain apples, which are mainly economic tree species. The living standards of rural residents have been significantly improved (Hou et al., 2016; Figure 1). The area of the GGP within the national plan in Yan'an City accounts for 2.5% of the country's total and 27% of the province's total, involving 286,000 farmers and 1.248 million rural population, benefiting 80% of the city's rural population.

The second round of China's GGP began in 2014, and the cumulative area of the project was realized to be 75.5 million mu. Among them, Guizhou Province reached 17,053,300 mu, ranking first in the country; and Bijie City of Guizhou Province accounted for 4,894,900 mu, which ranked first in the country's prefectural-level cities (Wang et al., 2022a; Wang et al., 2022b) and it is a key area of the second round of the GGP. Bijie City is located in the western part of Guizhou Province, where the problem of rocky desertification is prominent, and since the implementation of the GGP, the forest coverage rate has increased significantly, and rocky desertification has been effectively managed (Delang, 2019; Figure 1). At the same time, it benefits 183,100 impoverished households and 688,300 impoverished people, allowing farmers not only to have reliable financial and cash subsidies, but also to free up surplus labor for various operations, sideline production, and migrant work. In 2019, the number of people exported through labor services in the city reached 1.5 million, with an annual income of about 4 billion yuan, becoming a new economic growth point in rural areas. In summary, the selection of these two regions as the research area is somewhat typical.

2.2 Data sources

The data used in this paper comes from field research conducted by the group in July–August 2023 for Yan'an City and Bijie City. Prior to the formal investigation, the research team conducted preliminary research in Yan'an and Bijie cities in May 2023, and conducted multiple in-depth interviews with some village cadres, township government staff, and farmers. Based on the preliminary research, a formal investigation questionnaire and interview outline were designed. In the survey, the principle of random sampling was strictly followed, and farmers participating in the GGP were numbered. Using random numbers, 40–50 households were selected from each village for one-on-one semi-structured interviews, and triangulation was conducted based on first-hand interview, and triangulation was conducted based on first-hand interview data and secondary data such as online reports. The questionnaire included basic information about the head of the household and family, the production and operation of agricultural and forestry, the status of the household's financial and social capital, as well as the situation of returning farmland to forests, and other basic information. A total of 258 questionnaires were distributed in this survey, and 250 valid

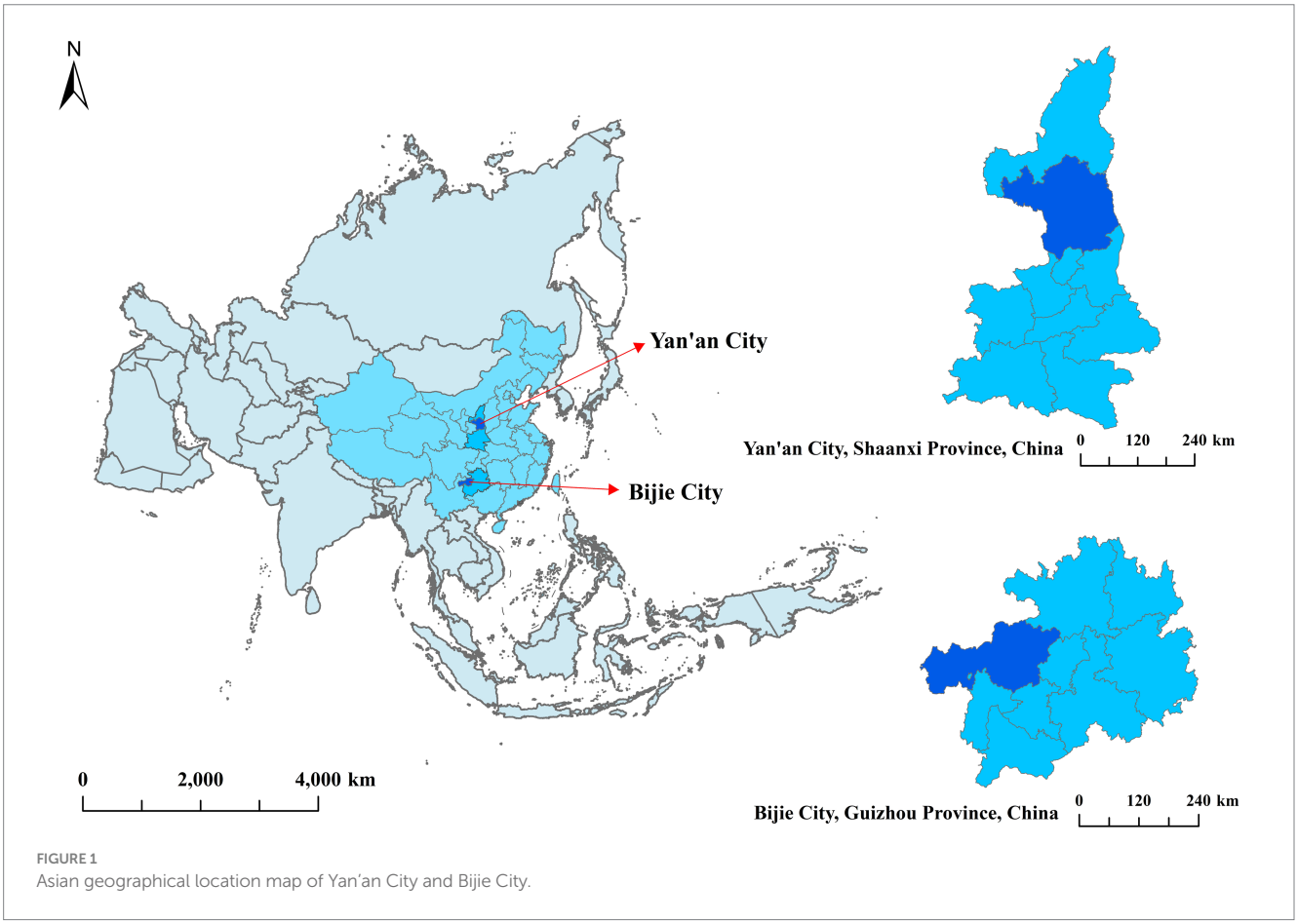

FIGURE 1
Asian geographical location map of Yan'an City and Bijie City.

questionnaires were collected, with a questionnaire validity rate of 96.90%.

The basic information of the surveyed sample household heads is shown in Table 1. From the perspective of household head gender, males are the main group, accounting for 89.2%; the heads of households are mainly young and elderly, with good physical health conditions; In terms of educational level, primary and junior high schools are the main ones, accounting for 91.6%. From the perspective of household head attributes, there are 35 party member households, accounting for 14%; there are 73 ethnic minority households, accounting for 29.2%, and 61 registered poverty-stricken households, accounting for 24.4%.

TABLE 1 Basic information on the heads of households in the survey sample.

Variables	Sub-item	Sample size/P	Proportions/%
Gender	Male	223	89.2
	Female	27	10.8
Age	0–14 years	0	0
	15–64 years	176	70.4
	65 years and above	74	29.6
Health	Poor	35	14
	General	60	24
	Good	155	62
Education	Primary and below	164	65.6
	Middle school	65	26
	Secondary or high school	18	7.2
	College and above	3	1.2
Party member	-	35	14
Ethnic minority	-	73	29.2
Registered poverty-stricken households	-	61	24.4

2.3 Research methodology

2.3.1 Evaluation system of farmers' livelihood capital indicators

Based on the research framework of DFID sustainable livelihoods, referring to scholars' related studies on livelihood capital and combining with the actual situation of production and life of farm households in China's GGP areas, we constructed a livelihood capital evaluation system covering 18 specific indicators from five dimensions, such as natural capital, social capital, etc., as shown in Table 2 (Wang et al., 2022a; Wang et al., 2022b).

(1) Natural Capital (N): Natural capital is the natural resources that farmers rely on for their livelihood, which mainly cultivated land and forest land. Since the study area is a region of China's GGP, part of farmers' cultivated land has been converted to forest land, and ecological forest species cannot directly bring economic benefits, the per capita area of economic forests and per capita area of cultivated land are used as indicators to measure the size of farmers' natural capital (Li et al., 2022). In addition, the quality of land site has a direct impact on land output performance and should also be taken into account (Wang M. et al., 2021; Wang et al., 2021a; Wang et al., 2021b).

(2) Human capital (H): Human capital refers to the labor capacity, health status, and acquired knowledge and skills of farmers, which are directly related to their choice of livelihood strategies. This study characterizes the human capital of farmers through four indicators: the education level of the household head, the health status of the household head, the number of household labor force, and the education level of family members. Specifically, householders with better health and higher education levels are usually more likely to master diverse livelihood skills, have stronger livelihood capabilities, and have more livelihood choices (Zhuo et al., 2023); farmers with a relatively large force and higher education levels among their family members are often more willing to choose diversified livelihood options to adapt to the complex and ever-changing external socio-economic environment (Deng et al., 2018; Wang M. et al., 2021; Wang et al., 2021a; Wang et al., 2021b).

(3) Physical capital (P): Physical capital is the infrastructure and production tools that ensure the basic livelihood needs of farmers (Yang et al., 2021). Due to the significant differences in housing conditions among farmers in the areas of the GGP, the ownership of productive assets directly reflects the productivity of farmers, while the ownership of consumer assets can better measure the quality of life of farmers. Therefore, four indicators are selected to measure the level of physical capital of farmers: type of family housing, per capita housing area, condition of consumer durables assets and status of productive assets (Ao et al., 2022; Quan and Doluschitz, 2021).

(4) Financial capital (F): Financial capital reflects the ability of farmers to obtain external funding. In this study, three indicators, per capita farm household income, time required to raise 100,000 yuan, and household loan amount, were selected to quantify. In general, the more stable the per capita household income, the shorter the time required to raise 100,000 yuan, and the stronger the ability of farmers to obtain external financial support (Zhang et al., 2018; Zhu et al., 2022), but the amount of household loans is one of the main sources of financial capital for farmers, directly reflecting the level of financial capital of farmers' households.

(5) Social capital (S): Social capital reflects farmers' access to and utilization of various social resources, which is characterized by three indicators selected in this study: family interpersonal expenses, neighborhood relationships, and how many tables of red and white celebrations are held at home. Specifically, the higher the household expenditure on human affairs, the more harmonious the relationship between farmers and neighbors, indicating the stronger the social network relationship of farmers, the easier it is to obtain support from various social resources (He and Ahmed, 2022; Li H. et al., 2020). The number of tables for happy events at home directly reflects the size of the social capital of farmers.

TABLE 2 Evaluation indexes and values of farmers' livelihood capital.

Livelihood capital	Definition and assignment	Unit	Statement	Index weight
Natural capital	Arable land per capita (N_1)	mu	Acres of operable arable land per capita	0.074
	Quality of arable land site (N_2)	-	1 = none;2 = poor; 3 = moderate; 4 = good; 5 = excellent	0.030
	Economic forests area per capita (N_3)	mu	Acres of economically viable forest per capita	0.127
	Quality of economic forest site (N_4)		1 = none; 2 = poor; 3 = moderate; 4 = good; 5 = excellent	0.044
	Quantity of labor force (H_1)	person	Number of household members aged 15–64	0.022
Human capital	Education level of the head of household (H_2)	-	1 = Primary and below; 2 = junior high school; 3 = secondary or high school; 4 = college and above	0.109
	Health status of the head of household (H_3)	-	1 = poor; 2 = general; 3 = good	0.018
	Higher education status of family members (H_4)	-	Number of family members who have attend or are attending university	0.145
Physical capital	Type of family housing (P_1)	-	1 = civil engineering structure; 2 = brick and concrete structure; 3 = reinforced concrete structure; 4 = other	0.008
	Housing area per capita (P_2)	m^2	Household per capita housing area	0.023
	Status of productive assets (P_3)	Type	Number of types of productive assets owned by households	0.039
	Condition of consumer durables assets (P_4)		Numbers of types of durable consumer goods assets owned by households	0.007
Financial capital	Household loan amount (F_1)	yuan	Total amount of household loans	0.148
	Household income per capita (F_2)	yuan	Household income per capita in 2022	0.046
	Time required to raise 100,000 yuan (F_3)	-	1 = More than half a mouth;2 = within half a mouth; 3 = in one week;4 = in three days; 5 = in one day	0.076
Social capital	How many tables are usually set up for red and white weddings at your home (S_1)	table	Number of tables for red and white weddings	0.021
	How is your neighborhood relationship (S_2)	-	1 = extremely poor; 2 = relatively poor; 3 = general; 4 = relatively good; 5 = extremely good	0.007
	Family interpersonal expenses (S_3)	yuan	Cost of family in 2022	0.056

2.3.2 Farmers' livelihood capital evaluation model

In this paper, the entropy weight method is used to calculate the weights of evaluation indicators (Huang et al., 2023; Alary et al., 2022), which not only effectively avoids the interference of subjective factors in traditional methods and objectively reflects the situation, but also identifies key influencing factors through weight comparison, laying the foundation for further exploration of farmers' livelihood strategies. The main process is as follows:

Step 1: Standardize the raw data of livelihood capital, and the calculation formulas for positive and negative indicators are Equations 1, 2, respectively.

$$X'_{ij} = \frac{x_{ij} - x_{\min}}{x_{\max} - x_{\min}} \left(i = 1,2,3\ldots n; j = 1,2,3,\ldots m\right) \quad (1)$$

$$X'_{ij} = \frac{x_{\max} - x_{ij}}{x_{\max} - x_{\min}} \left(i = 1,2,3\ldots n; j = 1,2,3,\ldots m\right) \quad (2)$$

Among them, X_{ij} represents the raw data of the j-th indicator of the i-th farmer, $x_{\max}$ is its maximum value, $x_{\min}$ is its minimum value, and X'_{ij} is the standardized value of the raw data.

Step 2: Calculate the information entropy e_j and redundancy d_j of the j-th indicator for the i-th farmer according to Equations 3–5.

$$p_{ij} = \frac{X'_{ij}}{\sum_{i=1}^{n} X'_{ij}} \left(j = 1,2,3,\ldots m\right) \quad (3)$$

$$e_j = -\frac{1}{lnm} \sum_{i=1}^{m} p_{ij} \ln p_{ij} \quad (4)$$

$$d_j = 1 - e_j \quad (5)$$

Step 3: Calculate the weight of j_{th} according to Equation 6.

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \quad (6)$$

Step 4: Calculate the livelihood capital index for each dimension of the farm household.

$$C_p = \sum_{i=1}^{n} w_j X_{ij}^{'} \quad (7)$$

Step 5: The five types of livelihood capital calculated in Equation 7 are averaged separately and finally summed to obtain the farm household livelihood capital index, as shown in Equation 8:

$$LCI = \sum_{p=1}^{5} \overline{C_p} \quad (8)$$

2.3.3 Measurement of livelihood stability of farm households

Livelihood stability is the ability of a farm household to withstand risk in response to external or household changes (Xu and Hu, 2018). Combining existing studies, this paper measures the livelihood stability of farmers from two aspects: diversity and dependence (Yang et al., 2022). Among them, the diversity index includes livelihood diversity index and income diversity index, and the dependence index includes income dependence and natural resource dependence index.

2.3.3.1 Diversity index

The Farm Household Livelihood Diversity Index indicates the richness of livelihood activities undertaken by farm households. In terms of sources of income, there are two main categories: agricultural and non-agricultural activities. Non-agricultural livelihood activities mainly include transfer income (e.g., government subsidies, low-income insurance subsidies, pension insurance income), land rent, rent, borrowing, household self-employment, and wage income, etc. Agricultural livelihood activities mainly include livestock breeding, crop cultivation on arable land, and forestry cultivation on forest land, etc., and the specific measurement formulas are as follows:

$$M_{act} = I_i / I \quad (9)$$

In the formula: I_i which refers to the number of livelihood activity types owned by each farmer, and I refers to the number of all livelihood activity types participated by farmers.

The income diversity index of farmers represents the number of different types of income sources owned by farmers and the balance of the proportion of various types of income in the total household income. The larger the income diversity index, the more diverse the sources of income for farmers, and the stronger their ability to withstand unknown risk shocks.

$$M_{inc} = -\sum R_n \ln R_n \quad (10)$$

Among them, M_{int} represents the income diversity index, which R_n refers to the ratio of farmers' income to total income under the nth income source.

2.3.3.2 Dependency index

The income dependence index refers to the degree of dependence of a farm household on a particular income. The higher the income dependency index, the greater the loss and the difficulty of self-recovery for the farmer household when a particular income is significantly reduced by an external shock and the farmer household needs to transfer other incomes to compensate for the loss caused by the external shock. The formula is as follows:

$$D_{inc} = \sum \frac{E_n\left(E_n - 1\right)}{E\left(E - 1\right)} \quad (11)$$

In the formula, D_{inc} refers to the income dependency index, E_n refers to the household income under the nth income source of farmers, and E represents the total household income.

The natural resource dependency index is the extent to which a farming household relies on natural resources to form industrial income for development. In this paper, the income from agricultural livelihood activities mainly includes income from livestock farming, income from forest land and fruit tree cultivation, income from cash crop cultivation, and so on. The calculation formula is:

$$D_{sou} = E_N / E \quad (12)$$

Among them, D_{sou} is the natural resource dependence index, which E_N refers to the income of farmers engaged in livelihood activities under natural resources, and E is the total household income.

According to the above formula, each index is measured and the total livelihood stability index, LSI, is obtained after summing using the entropy weighting method of assignment and the comprehensive weighting model.

2.3.4 Analysis of factors influencing the choice of farmers' livelihood strategies

Unlike general models that need to consider issues such as normal distribution of variables and homogeneity of variance, binary logistic regression can analyze the influencing factors of different categories of a categorical variable, which can well meet the modeling requirements of categorical data. Therefore, this paper analyzes the factors influencing the choice of livelihood strategies of different types of farm households by constructing a binary logistic regression model. In the model, three types of livelihood strategies of farmers are used as dependent variables and five types of livelihood capital are used as independent variables. For specific empirical evidence, a certain type of livelihood strategy is assigned a value of 1 and the remaining two types are assigned a value of 0, so as to analyze the influencing factors under each strategy. The regression model is as follows:

$$Y = \ln\left(\frac{P_i}{1 - P_i}\right) = \alpha + \sum_{k=1}^{k} \beta_k X_{ki} \quad (13)$$

In the formula, Y represents the dependent variable, $P_i = \{1 / x_1, x_2 \ldots x_k\}$ represents the probability of a certain farmer's livelihood strategy choice occurring, X_{ki} represents a series of influencing factors that affect the farmer's livelihood strategy choice, and β_k represents the corresponding coefficient to be estimated. Thus, the methodological framework diagram of this paper is obtained, as shown in Figure 2.

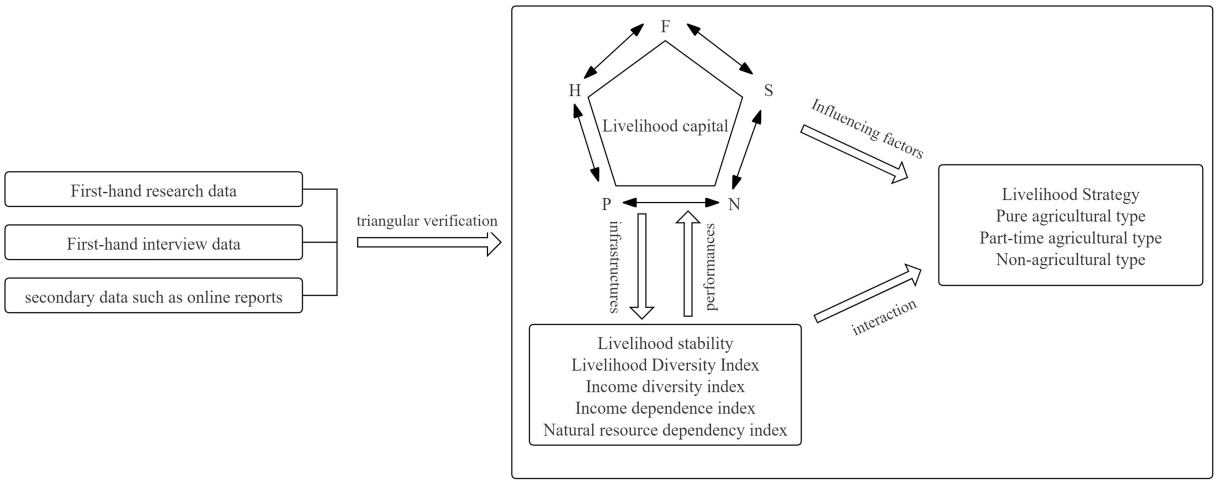

FIGURE 2
Methodological framework diagram.

3 Results

3.1 Analysis of livelihood capital characteristics of different types of farmers

Drawing on scholars' studies on livelihood strategies (Chen and Gan, 2024; Huang et al., 2022), this paper categorizes the livelihood types of farm households into pure agricultural, part-time agricultural and non-agricultural types based on the share of agricultural income in household income (He and Ahmed, 2022). In the sample, there are 47 households of pure agricultural type, accounting for 18.8%, 79 households of part-time agricultural accounting for 31.6%, and 124 households of non-agricultural type, accounting for 49.6%.

The livelihood characteristics of the farming households were analyzed using one-way ANOVA as shown in Table 3 and Figure 3. For pure agricultural farmers, the ranking of their five livelihood capital scores is: natural capital (0.051) > human capital (0.025) > physical capital (0.023) > financial capital (0.017) > social capital (0.011). High natural capital is the most prominent characteristic of pure agricultural farmers, and it significantly higher than non-agricultural type farmers. The per capita arable land area of pure agricultural farmers is 5.21 mu, which is five times that of non-agricultural farmers. The site quality of arable land is also relatively the best, reaching 3.13. Abundant natural capital is a solid foundation for agricultural development. Secondly, the shortage of human capital is the biggest obstacle to the livelihood transformation of pure agricultural farmers, which has a significant difference compared to the other two types of farmers. The average number of laborers in farm households is only 0.85 per household, which is low overall. The proportion of family members who have received higher education is 0.06, which is significantly lower than that of part-time and non-agricultural farmers. On this basis, farmers have a single way of utilizing their outstanding natural capital, and the effect of creating economic benefits and driving the development of other livelihood capital through traditional agricultural production is slow. The per capita income of households is only 13447.11 yuan, and their ability to resist livelihood risks is weak, and their livelihood level cannot be effectively improved, financial capital and social capital are also significantly lower than other types of farmers.

For part-time agricultural farmers, the livelihood capital index reaches 0.183, significantly higher than that of pure farmers. Research has found that the human capital index of part-time farmers is the highest, at 0.059. Excellent human capital supports their expansion of livelihood activities and their transition from traditional agricultural production to other livelihood methods, during which other livelihood capital is also effectively developed. At the same time, benefiting from the government's efforts to increase the construction of economic forests in the GGP, providing support for farmers in agricultural and forestry machinery, forest planting training, etc., the per capita economic forest area of part-time farmers is the highest, reaching 2.98 mu, which is 2.04 times that of non-agricultural farmers, greatly enriching natural and physical capital. However, the current economic benefits of forest production in areas of the project are not high, and supporting industries need to be improved, which restricts the transformation of natural capital into financial capital. At the same time, this type of farmers has diverse sources of income and relatively low demand for loans, so the financial capital is significantly lower than that of non-agricultural farmers.

Compared to the previous two livelihood strategies, non-agricultural farmers face a scarcity of natural resources such as arable land and economic forests. Most of the arable land is converted into ecological forests with low economic benefits, and the natural capital index is only 0.038, which form significant differences. However, non-agricultural livelihood strategy farmers have relatively abundant financial capital, with a comprehensive evaluation value of 0.042, which is 2.47 times and 1.27 times higher than the financial capital of pure agricultural type and part-time agricultural type, respectively. The survey found that non-agricultural farmers took advantage of the opportunity of returning farmland to forests, a large number of labor force created income through non-agricultural employment, and realized the livelihood transformation. The per capita household income reached the highest, 25,614.93 yuan, it is 1.91 times the per capita income of pure agricultural type, which is 13447.11 yuan and the ability to obtain loans was relatively

TABLE 3 Analysis of livelihood capital characteristics of farmers of different types.

Norm	Pure agricultural type	Part-time agricultural type	Non-agricultural type
N_1	5.21	2.93	0.98
N_2	3.13	3.03	2.65
N_3	2.84	2.98	1.46
N_4	1.85	2.78	2.69
H_1	0.85	2.91	3.65
H_2	2.15	2.62	2.52
H_3	1.26	1.57	1.43
H_4	0.06	0.34	0.40
P_1	2.21	2.18	2.42
P_2	56.50	37.51	33.02
P_3	2.17	2.51	1.73
P_4	5.53	6.48	6.65
F_1	1.70	2.29	2.39
F_2	15255.32	41949.37	103778.23
F_3	13447.11	22250.06	25614.93
S_1	18.26	23.38	24.06
S_2	4.19	4.19	3.92
S_3	2338.30	6238.61	8919.35
Observed value	47	79	124

strong and thus supporting their engagement in non-agricultural production or migrant employment.

3.2 Analysis of livelihood stability of different types of farmers

According to Equations 9–12, calculate the livelihood stability of farmers and conduct one-way ANOVA. The results are shown in Table 4 and Figure 4, the livelihood stability index, from high to low, is as follows: part-time agricultural type (0.607), non-agricultural type (0.519), and pure agricultural type (0.409), there is a significant difference among the three. In terms of subindices, the livelihood diversity index (0.189) and income diversity index (0.997) of part-time agricultural type is the highest and significantly higher than pure agricultural and non-agricultural farmers. The reason is that part-time agricultural type farmers can engage in agricultural production activities during busy farming seasons and obtain income through work during slack farming seasons. Adequate human capital in families can engage in diverse ways of livelihood. They have diverse livelihood types and relatively strong ability to resist livelihood risks. The income dependence of non-agricultural farmers is the highest (0.683), the lowest dependence on natural resources (0.016) and most farmers choose to work outside and obtain income by selling their labor, the source of income is relatively single. Due to the impact of the economic situation, labor market prices have fallen, job positions have been reduced, and the livelihoods of non-agricultural farmers are vulnerable to impact. Pure agricultural farmers have the highest dependence on natural resources, at 0.733 and significantly higher than the other two types of farmers. Pure agricultural farmers mainly maintain their basic livelihood needs through agricultural production, which is greatly affected by natural factors such as precipitation and temperature, so the income of pure agricultural farmers is relatively more unstable in comparison. For example, some pure agricultural farmers in the research area experienced a sudden decrease in income that year due to natural disasters such as hail, pests and diseases (Figure 4).

4 Analysis of factors influencing the livelihood strategy choices of farmers

Based on the above analysis, for different types of livelihood strategies, according to Equation 13, using SPSS 27.0 for analysis, the factor influencing the livelihood strategies of returning farmland farmers were evaluated based on the magnitude of the regression coefficient (B value) and the significance reflected by the Wald value in the regression results. The results are shown in Table 5.

(1) Pure agricultural type: The status of household productive assets has a significant positive impact on the choice of pure agricultural livelihood strategies, while indicators such as the quality of economic forest site, quantity of labor force, the health of the head of the household, and family interpersonal expenses have a significant negative effect, the number of labor force is the most critical factor, with a Wald value of 24.417. For pure agricultural farmers, natural resources are more abundant, their livelihood activities are mainly based on agricultural production, and they use production machinery on a large scale, productive assets such as rotary tillers and tractors can effectively replace labor and improve the efficiency of agricultural production. However, compared with part-time agricultural and non-agricultural households, the labor force of pure agricultural households is relatively small, with an average of only 0.85 people per household. The head of the household is relatively old and has poor health conditions. Due to their own limitations, pure agricultural farmers find it difficult to obtain income through employment outside the home, the livelihood stability of pure agricultural households is challenged, which restricts the development of livelihood diversity. However, the economic benefits of current economic forests are relatively low, and the planted fruits are prone to natural disasters. In addition, the supporting industries such as storage and sales are not yet perfect, resulting in a mismatch between input and output and the sustainability of the livelihoods of pure agricultural farmers is not guaranteed. The relatively low income level of agricultural production also makes it difficult to maintain high personal expenses, which restricts the development of social capital and the transformation of farmers' livelihoods.

(2) Part-time agricultural type: The quality of economic forest site, the education level and health status of household heads, and neighborhood relationships have a significant positive effect on choosing a mixed farming livelihood strategy, the type of

TABLE 4 Livelihood stability index of different types of farmers.

Norm	Pure agricultural type	Part-time agricultural type	Non-agricultural type	Average
M_{act}	0.157	0.189	0.153	0.165
M_{inc}	0.836	0.997	0.568	0.754
D_{inc}	0.553	0.470	0.683	0.591
D_{sou}	0.733	0.256	0.016	0.227
LSI	0.409	0.607	0.519	0.526
Observed value	47	79	124	250

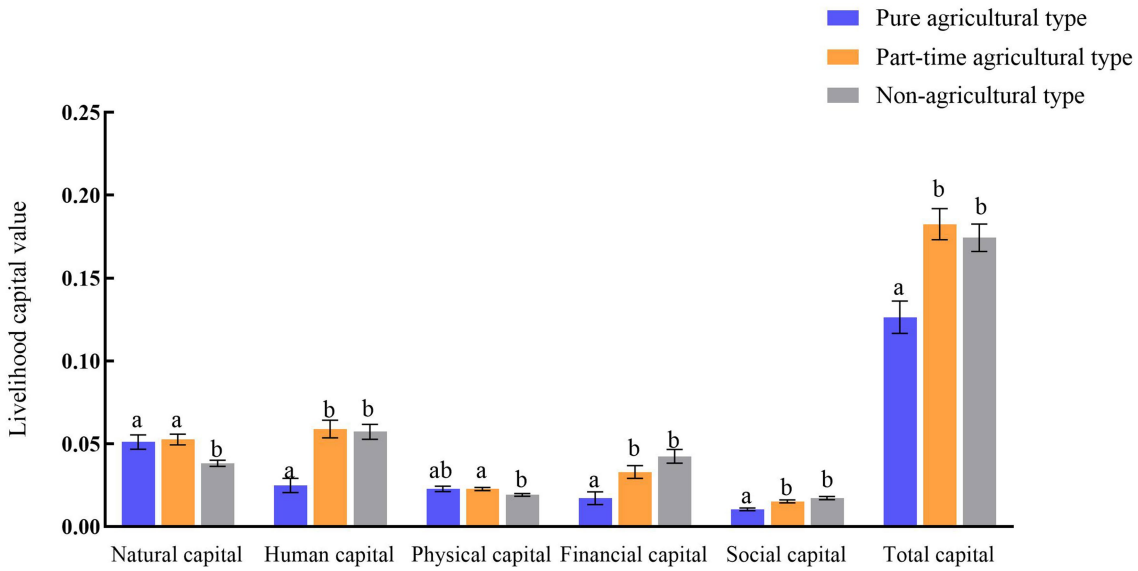

FIGURE 3
Significance analysis of livelihood capital of different types of farmers. Data without labeled letters and data with the same letters indicate no significant difference between the two at the 0.05 significance level, while data without the same letters indicate a significant difference between the two.

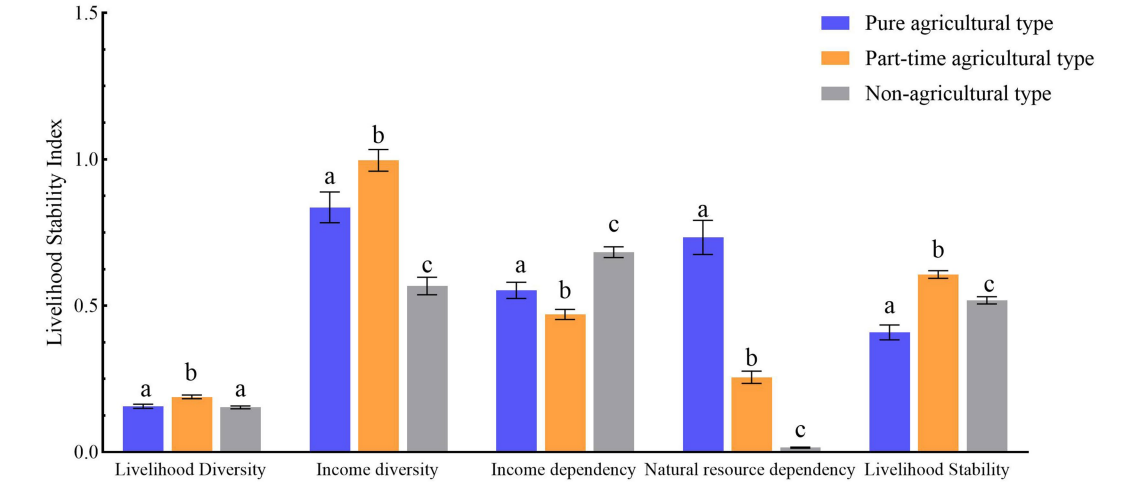

FIGURE 4
Significance analysis of livelihood stability of different types of farmers. Data without labeled letters and data with the same letters indicate no significant difference between the two at the 0.05 significance level, while data without the same letters indicate a significant difference between the two.

family housing is the most critical factor, with a Wald value of 8.202. Part-time agricultural farmers have relatively high levels of human and natural capital, and are able to engage in agricultural and forestry production as well as work outside, with diverse livelihood types. Research has found that this type farmers have a high level of education, good health conditions, and a strong ability to receive training in new technologies such as economic forest planting, and they are willing to try new ecological agriculture such as mountain peaches and apricots. At the same time, good relationships also provide various assistance to farmers, making the income sources of part-time agricultural farmers diversified and their livelihood stable. The amount of household loans shows a negative effect, indicating that the part-time agricultural farmers have a variety of income sources and have less need for loans. However, research on the types of family housing has found that households living in rural areas for a long time in the survey area generally have brick and concrete structures for their family housing, while those living in cities for a long time have reinforced concrete structures for their family housing. This highly overlaps with the distribution of permanent residences for both part-time and non-agricultural farmers, thus showing a reverse relationship of change.

(3) Non-agricultural type: The number of labor force and loan amount have a significant positive impact on non-agricultural type, while per capita arable land area, productive asset status, number of red and white wedding tables, and neighborhood relationships have a significance negative impact, the most critical factor is the per capita arable land area, with a Wald value of 10.25. For non-agricultural farmers, abundant human capital and financial capital are important factors affecting their livelihood level. Researched has found that households of farmers who choose non-agricultural livelihood strategies have sufficient labor force, strong ability to obtain loans, are more receptive to new ideas, learn new technologies, and engage in non-agricultural employment. Non-agricultural farmers take advantage of the opportunity of returning farmland to forests to transform idle farmland into forest land, achieving effective resource utilization while also gaining some income, successfully achieving livelihood transformation, with low dependence on natural capital such as arable land and material capital such as means of production, and per capita arable land for part-time farmers is only 0.98 mu, which mainly meets their own production and living needs. Meanwhile, non-agricultural farmers mainly in non-agricultural industries outside, and their social relationships within the village are relatively simple.

5 Discussion

On the basis of existing research, this study focuses on exploring the livelihood situation of farmers and the factors that affect their livelihood strategy choices under the background of the gradual expiration of the GGP subsidy and unclear continuation policies, in order to provide decision-making references for improving farmers' livelihood levels and consolidating the achievements of the project. The research results of this article also provide corresponding

TABLE 5 Analysis of factors influencing livelihood strategy choices of different types of farmers.

Index	Pure agricultural type		Part-time agricultural type		Non-agricultural type	
	B	Wald	B	Wald	B	Wald
N_1	13.449	0.324	11.608	0.555	−100.045***	10.250
N_2	39.676	1.517	11.623	0.441	−1.093	0.003
N_3	−7.451	0.089	2.630	0.046	2.828	0.019
N_4	−65.288***	7.972	21.619*	3.065	5.800	0.188
H_1	−568.281***	24.417	63.284	1.748	129.738**	5.459
H_2	−9.924	0.547	11.213*	2.730	−11.427	2.062
H_3	−72.084*	3.081	52.854**	4.095	−7.304	0.074
H_4	7.270	0.247	−3.202	0.304	−0.195	0.001
P_1	208.235	0.865	−391.925***	8.202	197.015	2.312
P_2	71.766	0.773	1.716	0.001	−108.881	2.430
P_3	88.299**	5.741	29.137	2.396	−63.393***	7.965
P_4	219.107	0.345	40.714	0.047	−4.712	0.001
F_1	−36.390	0.821	−27.852**	4.617	25.066*	3.232
F_2	133.784	1.281	44.101	0.768	−5.563	0.010
F_3	−18.756	2.206	−3.463	0.299	9.523	1.691
S_1	82.695	0.473	63.262	1.197	−119.907*	3.507
S_2	2.596	0.000	195.980**	3.896	−231.521**	4.191
S_3	−170.773*	2.746	−31.852	1.258	62.150	3.499

***, ** and *, respectively, in 1, 5, and 10% level of statistical significant.

references for other regions implementing similar land policies. Based on the above analysis, the following insights can be drawn:

(1) After the implementation of the GGP, the livelihood of farm households is clearly differentiated, and there is a difference in the impact of economic forest development and family loans on the livelihood strategies of farm households. The two categories of compatible and non-agricultural farmers accounted for more than 80% of the research sample, indicating that most of the farmers realized their livelihood transformation after participating in the GGP. This is consistent with the findings of Yin et al. (2018) and Wei et al. (2021), and others, which concluded that the GGP improves the livelihood level and livelihood stability of farm households by guiding them to adjust their industrial structure to improve productivity and participate in non-agricultural employment to increase economic benefits. Unlike previous studies that mostly studied the policy impacts of the GGP from the perspective of retired farm households as a whole (Li et al., 2021), this paper analyzes retired farm households differently by dividing them into three categories, and the results show that different factors have opposite effects on the livelihoods of farm households; for example, using economic forests instead of the traditional forest land indicator to measure natural capital, it is found that the stand quality of economic forests has an opposite effects, suggesting that the current development of economic forests in fallow fields has differential impacts on farm households; financial capital, such as household loans, also has different impacts on farm households, which differs from Wang et al.'s (2021) study in which financial capital was able to fully contribute to the transformation of livelihoods of farm households. In addition, based on the research background of the expiration of the second round of fallow subsidy and the uncertainty of the subsequent succession policy, this paper puts forward corresponding countermeasures suggestions, which need to consider whether the subsequent policy change affects the livelihood status of the farm households, as compared with the previous studies on fallow subsidy (Zhang B. et al., 2019; Chen et al., 2024). Meanwhile, previous studies have focused on the impacts of the GGP on livelihoods (Wang et al., 2022a; Wang et al., 2022b) and income (Fanbinl et al., 2024), but have paid little attention to the stability of the livelihoods of retired farm households. This paper shows that livelihood stability is also one of the main considerations for the government to formulate the policy of the GGP.

(2) There are certain deviations in the livelihood capital, livelihood stability, and livelihood strategies of various types of farmers, which urgently need to be effectively addressed. For pure agricultural farmers, excessive reliance on natural capital makes them vulnerable to environmental risks and market fluctuations, leading to fluctuations in their livelihoods. On the one hand, farmers themselves need to pay real-time attention to changes in the external environment and make corresponding adjustments in a timely manner. On the other hand, the government needs to pay attention to the needs of farmers and reduce economic losses caused by unpredictable factors such as natural disasters and market fluctuations by establishing and improving agricultural insurance systems, setting up ecological compensation funds, and creating public welfare positions. The livelihood capital and livelihood stability of part-time farmers are well matched. For non-agricultural farmers, they have the highest financial capital, but their livelihood stability is relatively low. The main reason is that most of their income relies on working, and their income fluctuates greatly due to fluctuations in the job market and weak social networks. Firstly, the government needs to increase subsidies for returning farmland to forests, strengthen communication and cooperation between farmers and enterprises, and provide various employment opportunities for enterprises to broaden farmers' livelihood channels. Secondly, combined with its good financial capital, targeted vocational skills training should be carried out to drive the diversified development of other capital through financial capital.

(3) At the practical level, the government first needs to improve the subsidy policy for the GGP, including extending the subsidy period and raising the subsidy standards. Secondly, it needs to base on the differences in livelihood characteristics of farmers and formulate differentiated livelihood level improvement policies. For pure agricultural farmers, the government should first strengthen basic education in areas where farmland is returned to forests, provide skill training and employment opportunities for farmers, in order to enhance their human and financial capital. For example, establishing forest product processing enterprises such as peaches and apples, and hiring local farmers to participate in the deep processing and transportation of forest products; Secondly, the government needs to promote the concentration of forest land and farmland toward large-scale planters, encourage farmers to engage in large-scale operations, and improve their income levels; Thirdly, the government needs to encourage insurance companies to develop characteristic agricultural product insurance for economic forests, in order to enhance the livelihood stability of pure agricultural farmers, for part-time agricultural farmers, the government needs to increase forestry subsidies and loan support, encourage farmers to utilize the advantages of natural and human capital, and focus on developing advantages livelihood activities on the basis of exploring diversified livelihoods. For example, by providing low interest agricultural loans to encourage part-time farmers to develop local characteristic economic forest industries, and improving supporting measures for forest product processing and sales, a complete industrial chain can be formed. For non-agricultural farmers, on the one hand, the government needs to encourage farmers to turn out their forest land to obtain transfer income and avoid idle and wasteful use of forest resources. On the other hand, the government needs to increase targeted non-agricultural technical training efforts to improve farmers' non-agricultural employment capabilities. For example, by concentrating on absorbing non-agricultural farmers to transfer their forest land, working together with large-scale growers, financial institutions, agricultural and forestry enterprises, etc. to create a local characteristic agricultural industry chain, conducting specialized skills training courses, and absorbing idle labor to participate in improving the supply chain.

6 Conclusion and prospect

Based on DFID sustainable livelihood theoretical framework and livelihood stability theory, the study takes farmers who participating in the GGP in Yan'an City and Bijie City as the research objects, constructs livelihood capital and livelihood stability evaluation index system, and empirically studying the factors that affect the livelihood strategy choices of the farmers. The main conclusions drawn from this paper are as follows:

(1) There are significant differences in the livelihood characteristics of different types of farmers, ranked from high to low as part-time agricultural farmers (0.183), non-agricultural farmers (0.174), and pure agricultural farmers (0.126). The natural capital of pure agricultural farmers is relatively high, while their human capital and financial capital are at a lower level. The development of livelihood capital in various dimensions is relatively balanced among part-time agricultural farmers, and they have the highest human capital. Non-agricultural farmers have the highest financial and social capital, while their natural capital is relatively the lowest.

(2) There are significant differences in the livelihood stability types of farmers, ranked from high to low as part-time agricultural farmers (0.607), non-agricultural farmers (0.519), and pure agricultural farmers (0.409). Pure agricultural farmers have the highest natural resource dependency index and are susceptible to external risks such as natural disasters and market fluctuations. The livelihood diversity and income diversity index of part-time agricultural farmers are the highest, and their dependence on a single income and natural resources is weak, with the strongest ability to resist external risks. Non-agricultural farmers have the highest income dependency index and the lowest income diversity index, indicating that they are overly dependent on a single income from labor and are vulnerable to the economic and other factors.

(3) The impact of livelihood capital on the livelihood strategy choices of different farmers varies significantly. The quality of economic forest site and the health status of household heads have a positive impact on part-time agricultural type and a negative impact on pure agricultural type; productive assets and other physical capital are important foundations for farmers to engage in agricultural production, positively affecting pure agricultural type and negatively affecting non-agricultural type. Labor is an important human capital for families and the basis for participating in non-agricultural employment, so its impact is opposite to that of productive assets; financial capital such as family loan is an important driving force of farmers' livelihood transformation, which has a negative effect on part-time agricultural type and a positive effect on non-agricultural type, while neighborhood relationship has the opposite effect.

Based on this, the research in this article provides strong reference for local governments' decision-making. Local governments need to formulate differentiated policies according to the characteristics of different types of farmers, expand financial subsidies, provide vocational skills training, and improve the economic forest insurance system, which will effectively improve the livelihood level of farmers and help consolidate the achievements of returning farmland to forests. At the same time, although this study focuses on analyzing the livelihood strategy choices and influencing factors of farmers in the area of returning farmland to forests, there are still areas worthy of expansion. At the data level, the sample size is relatively small and mainly relies on primary data. In the future, we plan to conduct supplementary research in Anhui, Fujian and other places to expand the research scope to cover the eastern, central and western parts of China, and combine online reports, literature and other second-hand materials to verify the data; at the temporal level, the empirical secondary is only based on cross-sectional data, and in the future, the study needs to conduct empirical analysis of longitudinal time-series data such as retiring farm subsidies by supplementing the preliminary investigation and the future tracking surveys, longitudinal time-series data such as farmland return subsidies are empirically analyzed to explore the dynamic change process of farmers' livelihood capital and the influencing factors of livelihood strategy transformation. In terms of content, external data such as price indices of agricultural market and labor market, climate, cultural perceptions and local governance were collected before and after the implementation of the GGP policy, and the DID model and Probit models, etc. were used to explore the influence of external factors on the livelihood capital and livelihood strategy choices of farm households.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the [patients/participants OR patients/participants legal guardian/next of kin] was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

SL: Data curation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing. ZY: Data curation, Investigation, Writing – review & editing. CH: Data curation, Investigation, Writing – review & editing. JD: Conceptualization, Funding acquisition, Investigation, Supervision, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research and/or publication of this article. This research was supported by the Jiangsu Provincial Social Science Fund (24ZZB002), China, and National Natural Science Foundation of China (72473067), China.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2025.1491760/full#supplementary-material

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