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Research on the influence of ecological specialty industry vine tea on farmers' livelihoods in Laifeng County, China

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The development of ecological specialty industries has emerged as a research priority in recent years. Nevertheless, there is a paucity of research that has examined the impact of the interconnection between ecological specialty industries and farmers' livelihoods. To investigate the causal relationship between the local vine tea industry and farmers' livelihoods, a case study incorporating field surveys was conducted in Laifeng County, Hubei Province. This study developed a farm household livelihood indicator system based on a sustainable livelihood analysis framework and employed a binary logit model. The findings indicate that (i) with the booming development of the vine tea industry, farmers' income has increased significantly, and the growth rate of participants is considerably higher than that of non-participants, with the highest growth rate reaching 46%; (ii) the farmers with higher incomes exhibit a greater level of livelihood capital; (iii) farmers' livelihood capitals have an impact on their willingness to participate in the vine tea industry, with varying degrees of influence observed among farmers with different income levels. This research puts forward constructive suggestions for promoting the development of vine tea specialty industry, improving farmers' livelihoods and rural revitalization.

KEYWORDS

vine tea industry, rural revitalization, livelihood capital, livelihood strategy, Laifeng

1 Introduction

In China, the development of ecological specialty industries has become increasingly significant in the country's ongoing efforts to promote the building of an ecological civilization. The ecological industry, which focuses on ecological revitalization and environmental protection, has emerged as a significant approach to fostering green and low-carbon development. By capitalizing on unique regional resources, this industry transforms these assets into distinctive goods and renowned products (Liu et al., 2012). Recent studies highlight the growing focus on ecological industries in ecologically fragile areas. For example, a systematic review of 319 studies reveals that village ecological industries are increasingly linked to rural revitalization, particularly through strategies addressing index systems, driving factors, and mechanism design (Yu et al., 2025). This underscores the importance of integrating ecological industries with localized livelihood strategies, as exemplified in Laifeng County' vine tea industry. Currently, China's ecological specialty industry is predominantly concentrated in under-developed regions such as Gansu, Shaanxi, and Guizhou (Party, 2019, 2023, 2021). For example, subsidies for seedling

cultivation operators have significantly promoted the green and low-carbon development of the seedling industry in Qingyang, Gansu Province. Similarly, by optimizing and improving the industry chain of ginger ecological specialty, southern Shaanxi has achieved substantial advancements in developing its ginger specialty industry (Mu, 2021). In Jinxi County in Jiangxi Province, distinctive industries such as oil tea, high-quality rice, and greenhouse vegetables, as well as chili pepper, pepper, and other ecological specialty food industries that have played a significant role in promoting rural revitalization in Guizhou (Liu, 2018). In addition, distinctive industries such as pecans and dried stalagmites in Yaoshan Township of Hangzhou and wild horehound wild horehound cultivation in Yongde County of Yunnan are also experiencing rapid growth. From large provinces and cities to little towns and villages, the ecological specialty industry is thriving throughout China.

At present, the research related to the ecological specialty industries in China is an emerging field, with an average of over six articles per year on ecological industries and products, primarily focusing on five areas: theoretical research, technology research and development, model construction, demonstration and promotion, and benefits analysis (Li et al., 2021). However, there is still relatively paucity of research on the market model of ecological industry and product value realization including aspects of model construction and monitoring and evaluation (Li et al., 2020a). Notably, environmental regulations, including command-and-control and market-based tools, have demonstrated spatial spillover effects on ecological industrialization, particularly through green technological innovation (Xie et al., 2025). This spatial interdependence implies that localized initiatives like Laifeng's vine tea policies could amplify farmers' income growth and ecological outcomes through cross-regional policy synergies. Ren et al. (2022) examined the case of Bashan village, a typical karst rocky desertification area in Guizhou Province, to study the development of the yellow essence industry and propose a revitalization mechanism based on the actor network theory. Bahers et al. (2019) proposed "design for disassembling and recycling," which was a study on the technical aspects of ecological product design. Besides, additional scholars have explored the establishment of a market-based value realization mechanism for ecological products and the establishment of an orderly market environment for modern resource and environmental transactions (Yao, 2015; Qu et al., 2022; Chen et al., 2025). This focus on institutional innovation aligns with recent findings from Malaysia's palm oil industry, where corporate environmental responsibility (CER) practices such as waste recycling and agroecological certification were shown to reduce ecological footprints while enhancing livelihood sustainability (Shen et al., 2018). Such evidence suggests that incentivizing CER adoption among vine tea enterprises in Laifeng, through mechanisms like organic certification subsidies, could strengthen farmers' trust and participation in ecological industrialization. Most studies focus on market dynamics and industrial growth, few analyze their role in rural prosperity and farmers' livelihoods.

The concept of "livelihood" has been widely used in current research on rural development and poverty alleviation. From the perspectives of different statements of livelihoods, multiple analytical frameworks on sustainable livelihood have been developed (Adato and Meinzen-Dick, 2002; Guo et al., 2019; Pandey et al., 2017; Scoones, 1998). The Sustainable Livelihoods Analysis Framework (SLA) proposed by the UK Department for International Development (DFID) is the most extensively utilized (Su and Yin, 2020; Yi et al., 2022; Liu et al., 2022). As a comprehensive, people-centered approach to sustainable development, the framework comprises five interrelated components: vulnerability content, livelihood capital, institutions and policies, livelihood strategies, and livelihood outcomes, which are both independent and interconnected and provide an effective tool for depicting and analyzing the livelihood challenges faced by individuals residing in impoverished regions (Bilu et al., 2024). The livelihood capital, which is the core of the framework, encompasses various assets essential for the survival and development of farmers, including natural capital, physical capital, human capital, financial capital, and social capital. Adaptability models, such as the entropy-weighted TOPSIS method, have been employed to assess the harmony between ecological industries and local environments (Liu and Xu, 2016). This approach aligns with our use of the SLA framework to evaluate livelihood capitals, emphasizing the need for tailored strategies in Laifeng based on income-level disparities. However, these five capitals primarily focus on the residents themselves and objective factors, with limited attention given to the environmental conditions surrounding the farmers and their psychological subjective factors (Guo et al., 2022). For instance, in the traditional SLA framework, natural capital mainly refers to the natural resources that farmers can directly access and utilize for production, such as land and water resources, while human capital is largely defined by education and skills. This narrow focus may overlook the broader environmental context that influences the availability and quality of these resources, as well as the psychological wellbeing of farmers, which can significantly affect their decision-making and resilience. Therefore, in consideration of the actual situation of farmers in the research area, environmental capital and mental capital were introduced in this study to enhance the scientific and comprehensiveness of the framework. Environmental capital refers to the broader ecological conditions that affect agricultural productivity and sustainability, such as soil quality, climate change impacts, and biodiversity. Mental capital encompasses the psychological and emotional wellbeing of farmers, including their stress levels, mental health, and overall motivation, which are crucial for effective livelihood strategies. By incorporating these additional dimensions, the livelihood pentagon is expanded into a livelihood heptagon to construct a more comprehensive livelihood capital index system for farmers.

The Vine tea, a wild plant rich in flavonoids (Zhang et al., 2021), was first utilized by humans in the late 1950s and was cultivated and marketed on a large scale in the 1990s, particularly in regions like Laifeng. According to records in *the Chinese Materia*, vine tea possesses various properties including heat-clearing, detoxifying, diuretic, and blood-activating effects (Zhang et al., 2018a). Scientific research has demonstrated that the primary active component, dihydromyricetin, exhibits cardioprotective, hepatoprotective, antidiabetic, and neuroprotective properties (Zeng et al., 2019; Li et al., 2020b). Chen et al. (2020) demonstrated

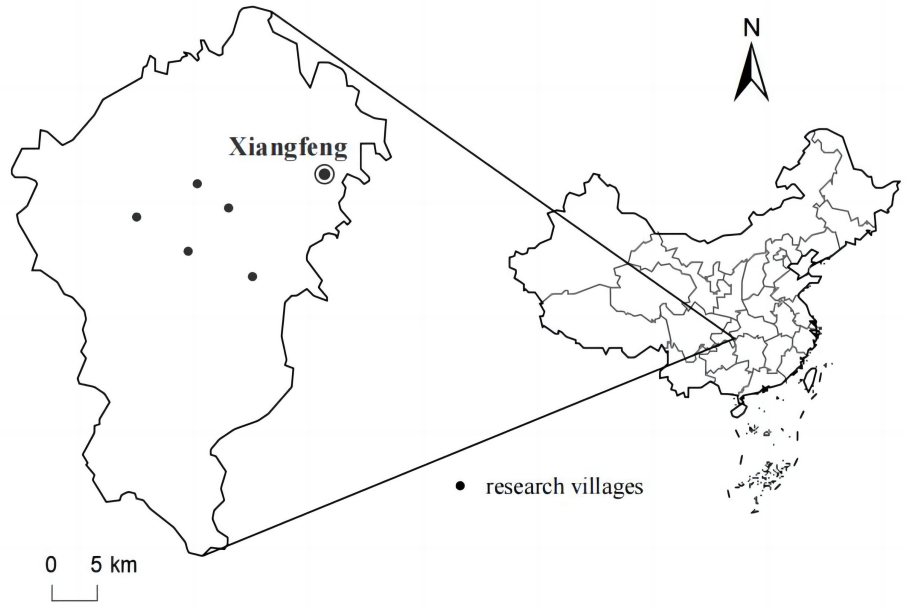

FIGURE 1
Location of research area.

the potential application of dihydromyricetin in the food industry through experiments. Furthermore, due to its elevated flavonoid content, vine tea is less susceptible to viral pests, and its cultivation commonly involves the use of organic fertilizers, resulting in slight environmental damage (Carneiro et al., 2020, 2021). These advantages have propelled the development of vine tea as a specialty industry in Laifeng County. Thus, investigating the correlation between the vine tea industry and the livelihood of farmers will yield significant insights for rural revitalization and the enrichment of farmers in Laifeng County and related areas.

In summary, this study centers on Laifeng County as the research object and aims to achieve the following objectives: (i) establish a livelihood capital index system based on the SLA framework and determine the comprehensive weights of each index using the AHP-CRITIC method; (ii) examine the impact of the vine tea industry on farmers of different income levels through statistical analysis of their income; (iii) utilize a binary logit model to study the impact of farmers' livelihoods on their participation in the vine tea industry at various income levels.

2 Methodology

2.1 Study area

Laifeng County, located at the intersection of latitude 30°N and longitude 110°E, is renowned as "the first county of vine tea in China." As shown in Figure 1, it is part of Enshi Tujia and Miao Autonomous Prefecture in Hubei Province, China. In Figure 1, the term "Xiangfeng" refers to Xiangfeng Town, which is a region within Laifeng County. With an average altitude of 680 meters, Laifeng has four distinct seasons and abundant rainfall, making it extremely suitable for the growth of vine tea. In the late 1950s, Laifeng County began to explore and domesticate the resources of wild vine tea. After years of field practice, technological innovation, and yield improvement, the county began to carry out large-scale imitation wild planting, which was expanded to the Wuling mountain area. As of 2023, the vine tea production area in Laifeng County has reached more than 5,700 hm^2. In the county, there are 65 enterprises dedicated to the production and operation of vine tea, with 36 primary processing plants and five advanced processing and production workshops established. In addition, there are a total of 82 professional cooperatives and more than 10,200 farmers growing vine tea.

2.2 Data collection and analysis

The data used in this study was obtained from a field survey conducted in Laifeng County in January 2022, which combined questionnaires with household interviews. The selection of seven representative villages was based on the economic status and the level of development in the vine tea industry for each village. We distributed 400 questionnaires and retained 334 valid responses, with an effective rate of 83.57%. The survey covered several aspects, including (i) the basic information of the respondents and their involvement in the vine tea industry; (ii) the cash income of farmers before and after the implementation of the vine tea policy; (iii) the farmers' livelihood capitals before and after the implementation of vine tea policy, including human capital, natural capital, physical capital, social capital, financial capital, environmental capital, and mental capital. The questions were mainly closed-ended to obtain statistical data. Household interviews were conducted mainly with village cadres, large-scale vine tea farmers, leaders of leading vine tea enterprises, and officials from relevant administrative departments.

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TABLE 1 Basic characteristics of interviewed farmers.

Basic characteristics		Farmers I	Farmers II	Farmers III	Respondents
Gender	Male	81	101	44	226
	Female	34	61	13	108
Age	Under 35 years old	34	37	10	81
	35–54 years old	27	51	37	115
	55–64 years old	20	34	10	64
	65 years old and above	34	40	0	74
Family size	2 people and below	3	17	17	37
	3–5 people	61	115	34	209
	6 or more people	51	30	7	88
Education level	Below primary school	10	27	3	40
	Primary school	40	40	13	94
	Junior high school	37	64	24	125
	High school or Technical secondary school	13	3	13	30
	Bachelor degree and above	13	27	3	44
Policy participation	Participants	24	30	27	81
	Non-participants	91	132	30	253

2.3 Classification of farmers' types

Based on the economic development situation of the villages and residents, farmers were categorized into three categories according to their per capita annual income as follows: Farmers I, with an income of <4,000 yuan; Farmers II, with an income between 4,000 and 10,000 yuan; and Farmers III, with an income of more than 10,000 yuan. Based on their participation in the vine tea industry, they were further divided into participants (PP) and non-participants (NP). The basic information of the respondents is presented in Table 1.

Overall, the ratio of male to female respondents was about 2:1, with the largest number of respondents in the 35–54 age group. Most households had 3–5 members, and the education level of respondents was generally low, with most having completed only primary or secondary school education. A separate analysis of the three types of farmers showed that the number of Farmers was descended as follows: Farmers II, Farmers I, and Farmers III. However, the proportion of Farmers III participants increases significantly, with the ratio of participants to non-participants approaching 1:1.

2.4 Research methods

2.4.1 Farmers' livelihood capital indicator evaluation system

At present, most of the similar researches in agricultural fields use mathematical modeling, statistical analysis and other methods (Ahmadini et al., 2024; Raghav et al., 2024; Sahu et al., 2024; Adichwal et al., 2022). In this study, the livelihood capital indicators of farmers in Laifeng County were developed based on the SLA framework and the local context, incorporating environmental and mental capital (Wang et al., 2017). The indicators consisted of seven primary and 26 secondary indicators, which are detailed in Table 1. To determine the indicator weights, both the Analytic Hierarchy Process (AHP) and the Criteria Importance Through Intercriteria Correlation (CRITIC) method were employed (Zhu et al., 2023; Zhang et al., 2022).

The AHP method is a well-established approach for determining indicator weights, particularly for complex multi-level and multi-factor systems, with high reliability and accuracy (Wang et al., 2016). However, the evaluation results are extremely subjective and ignore the information of the actual sample data. In order to reduce the subjective arbitrariness of hierarchical analysis, the CRITIC method, which was proposed by Diakoulaki, Mavrotas, and Papayannakis in 1995, is frequently used to objectively assign weights to indicators, and ultimately obtain a set of weight coefficients that reflect both the decision makers' subjective will and objective model attributes (Alinezhad and Khalili, 2019). Therefore, 20 experts were invited to score the indicators according to their impact on the livelihood of farmers, and the final subjective weights were obtained using the AHP method based on the scoring results. Subsequently, the CRITIC method is used to assign objective weights to the indicators, following the formula:

First, the original indicator data matrix X is constructed, as shown in Equation 1:

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1j} \\ \vdots & \ddots & \vdots \\ x_{i1} & \cdots & x_{ij} \end{bmatrix} \quad (1)$$

where i is the number of samples, j is the evaluation index quantity, and x_{ij} denotes the value of the i-th sample at the j-th evaluation index.

Second, normalize the data for each indicator and calculate the normalized matrix X':

Positive indicators are treated as shown in Equation 2:

$$x'_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \tag{2}$$

Negative indicators are treated as shown in Equation 3:

$$x'_{ij} = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}} \tag{3}$$

The normalized matrix X' is obtained:

$$X' = \begin{bmatrix} x'_{11} & \cdots & x'_{1p} \\ \vdots & \ddots & \vdots \\ x'_{n1} & \cdots & x'_{np} \end{bmatrix} \tag{4}$$

To perform the standard deviation operation in the normalized matrix X', as shown in Equation 5:

$$\begin{cases} \overline{x'_j} = \frac{1}{n}\sum_{i=1}^{n} x'_{ij} \\ S_j = \sqrt{\frac{\sum_{i=1}^{n}\left(x'_{ij} - \overline{x'_j}\right)^2}{n-1}} \end{cases} \tag{5}$$

where S_j denotes the standard deviation of the j-th indicator. The higher the standard deviation, the greater the fluctuation, and the higher the weight.

The conflict between indicators is represented by correlation coefficient R_j. If there is a strong positive correlation between two indicators, the smaller the conflict is, the lower the weight will be. The correlation coefficient R_j is calculated from the following Equation 6:

$$R_j = \sum_{i=1}^{p}\left(1 - r_{ij}\right) \tag{6}$$

where r_{ij} denotes the correlation coefficient between evaluation indexes i and j, p is the total number of indicators.

Information quantity C_j represents the amount of information contained in the j-th evaluation index. The information quantity C_j is used as an important reference for assigning weights, and the larger it is, the greater the role of the j-th evaluation index in the whole evaluation index system, then more weights should be assigned to it. The specific formula is shown in Equation 7:

$$C_j = S_j \sum_{i=1}^{p}\left(1 - r_{ij}\right) = S_j \times R_j \tag{7}$$

After the normalization of information quantity C_j, the objective weight W_j of each index is obtained. The objective weight W_j of the j-th indicator is shown in Equation 8:

$$W_j = \frac{C_j}{\sum_{j=1}^{p} C_j} \tag{8}$$

Finally, the total weight $x_{j,z}$ is obtained by combining the weights of the two categories of indicators, as shown in Equation 9:

$$x_{j,z} = \frac{x_{j,A}x_{j,C}}{\sum_{j=1}^{n}\left(x_{j,A}x_{j,C}\right)} \tag{9}$$

where $x_{j,A}$ is the weight coefficient obtained using the AHP method, $x_{j,C}$ is the weight coefficient obtained using the CRITIC method.

The final indicators of farmers' livelihood capital and their weights are shown in Table 2.

2.4.2 Evaluation methodology

2.4.2.1 Cash income increase calculation model

Annual income per capita is not only an essential component but also a visual representation of livelihood capital. This study presents a statistical analysis of farmers' annual income per capita and measures changes in farmers' cash income before and after the implementation of the vine tea policy. The change model of cash income is shown in Equation 10:

$$w = \frac{w_i - w_0}{w_0} \times 100\% \tag{10}$$

where w is the annual income growth rate of farmers, w_i is the per capita annual income of farmers after participating in the vine tea industry, and w_0 is the per capita annual income of farmers before participating in the vine tea industry.

2.4.2.2 Composite index method

The composite index method is applied to measure and evaluate the level of livelihood capitals of farmers, which involves standardizing indicators with different units of measurement and type through statistical processing, and to combine the weights of the indicators to arrive at a composite index to evaluate the level of livelihood capital of farmers (Abdollahzadeh et al., 2023).

2.4.2.3 Binary logit model

Since participation in the vine tea characteristic industry is a binary ordered variable, this paper employs the binary logit model to explore the impact of farmers' livelihood capitals on their willingness to participate (Zhang et al., 2018b; Khan et al., 2020; Duc Truong et al., 2022; Thakur et al., 2023). The specific steps are as follows:

The multiple regression model is constructed as shown in Equation 11:

$$y_n = \beta_0 + x_i\beta + \varepsilon_n \,(i = 1, \cdots n) \tag{11}$$

where y_n is the livelihood strategy choice of the farmer, $y = 1$ and $y = 0$ represent participation and non-participation in the vine tea specialty industry, respectively, x_i is the livelihood capital affecting the choice of livelihood strategy of the farmer, β_0 is the intercept term, and β is the model coefficient.

And y^* n is the estimate of y_n, defined by Equation 12:

$$y_n^* = \beta_o + x_i\beta + \varepsilon_n \,(i = 1, \cdots n) \tag{12}$$

TABLE 2 Livelihood capital index system for farmers.

Capital variables	Weight	Index meaning
Human capital	0.289	
H_1: Overall family labor capacity	0.100	0 (ages < 9 or >70); 0.5 (ages 10–15, and seniors 61–70); 1 (ages 16–60)
H_2: Education level of adult labor force	0.055	0 (illiteracy); 0.25 (primary school); 0.5 (junior high school); 0.75 (high school); 1 (college and above)
H_3: Health status of family members	0.135	Frequency of illness in the household: 0 (always); 0.25 (often); 0.5 (sometimes); 0.75 (seldom); 1 (never)
Nature capital	0.100	
N_1: Per capita paddy field area	0.041	Per capita paddy field contracted area (hm^2)
N_2: Per capita dry land area	0.038	Contracted dryland area per capita (hm^2)
N_3: Per capita forest area	0.021	Per capita contracted area of forest land (hm^2)
Physical capital	0.181	
P_1: Household fixed capital	0.063	Number of options held by survey respondents as a proportion of the options listed
P_2: Housing conditions	0.052	housing type and housing area are, respectively, given 50% weight 0.0 (grass house); 0.25 (tent); 0.5 (civil house); 0.75 (brick house); 1 (Concrete house)
P_3: Number of livestock	0.019	0 (1 room); 0.25 (2 rooms); 0.5 (3 rooms); 0.75 (4 rooms); 1 (5 rooms and above)
P_4: Road conditions	0.047	0 (very bad); 0.25 (not good); 0.5 (generally); 0.75 (good); 1 (very good)
Social capital	0.082	
S_1: Leadership	0.033	1 (there are village cadres in family); 0 (otherwise);
S_2: Participation in community organizations	0.015	0 (none); 0.25 (1 organization); 0.5 (2 organizations); 0.75 (3 organizations); 1 (≥4 organizations)
S_3: Trust in people around	0.015	0 (hardly trustworthy); 0.25 (few trustworthy); 0.5 (half trustworthy); 0.75 (mostly trustworthy); 1 (trust all)
S_4: Family circle	0.020	Number of relatives in the village
Financial capital	0.186	
F_1: Household cash income	0.061	Per capita cash income
F_2: Access to credit	0.035	Private lending is 1, not 0; financial loan is 1, not 0; private loans and loans from financial institutions are given 50% weights, respectively
F_3: Opportunities for free cash assistance	0.033	1 (have the opportunity to receive free cash assistance); 0 (otherwise)
F_4: Types of social security	0.057	0 (none); 0.25 (one specie); 0.50 (two species); 0.75 (3 species); 1.00 (4 species and above)
Environmental capital	0.077	
E_1: Economy of the farmers' location	0.025	0 (very poor); 0.25 (poor); 0.5 (general); 0.75 (better); 1 (very good)
E_2: Shopping convenience	0.012	0 (very poor); 0.25 (poor); 0.5 (general); 0.75 (better); 1 (very good)
E_3: School convenience	0.019	0 (very poor); 0.25 (poor); 0.5 (general); 0.75 (better); 1 (very good)
E_4: Medical convenience	0.021	0 (very poor); 0.25 (poor); 0.5 (general); 0.75 (better); 1 (very good)
Mental capital	0.085	
M_1: Expectations for future life improvement	0.026	0 (very small); 0.25 (small); 0.5 (general); 0.75 (high); 1 (very high)
M_2: Subjective wellbeing	0.011	0 (very unhappy); 0.25 (unhappy); 0.5 (general); 0.75 (happy); 1 (very happy)
M_3: Self-confidence	0.022	0 (very small); 0.25 (small); 0.5 (general); 0.75 (large); 1 (very large)
M_4: Resilience in times of difficulty	0.026	0 (very small); 0.25 (small); 0.5 (general); 0.75 (large); 1 (very large)

It can be seen in the estimated value:

$$y = \begin{cases} 0, & y^* < 0 \\ 1, & y^* > 0 \end{cases} \tag{13}$$

Bring Equation 13 into the explanatory variable, its calculation process is shown in Equation 14:

$$\begin{aligned} P &= \left(y = 1\right) = P\left(y^* > 0\right) = P\left(\beta_0 + x_i\beta + \varepsilon_n > 0\right) \\ &= P\left(\varepsilon_n > -\beta_0 - x_i\beta\right) \end{aligned} \tag{14}$$

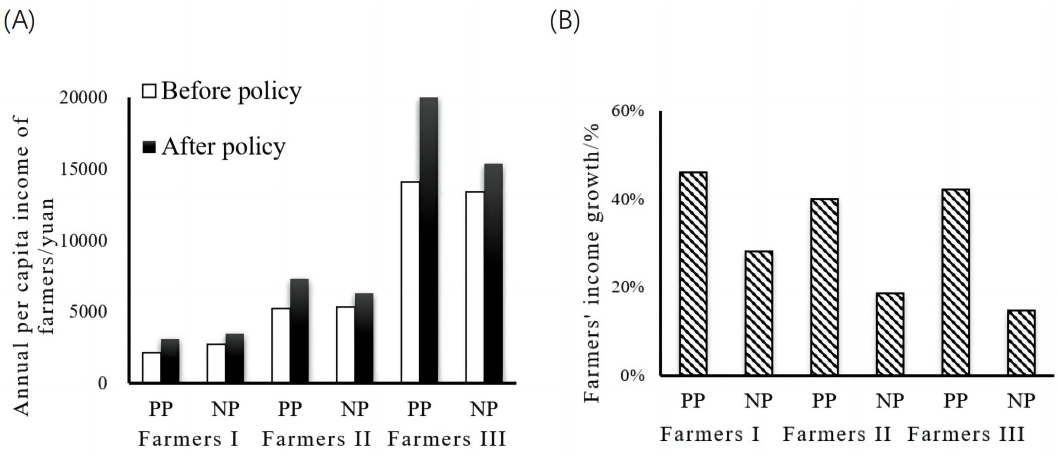

FIGURE 2
Changes and increases in annual per capita income of farm households. **(A)** Annual per capital income (yuan) of participants (PP) and non-participants (NP) before and after the policy implementation across three farmer categories (I: <4,000 yuan; II: 4,000–10,000 yuan; III: >10,000 yuan); **(B)** Income growth rate (%) comparison between PP and NP groups.

By further transforming the formula, we can get:

$$P\left(\varepsilon_n > -\beta_0 - x_i\beta\right) = 1 - Z(-\beta_0 - x_i\beta) = Z\left(\beta_0 + x_i\beta\right) \quad (15)$$

The final binary variable model of farmers' livelihood strategy choices is obtained:

$$P = \left(y = 1 \,|x\, \right) = Z\left(\beta_0 + x_i\beta\right) \quad (16)$$

When e follows the logistic distribution, Z represents the standard logistic cumulative distribution function, and in this context, the logit model can be derived as follows:

$$P_i = Z(z) = \frac{\exp(z)}{1 + \exp(z)} \quad (17)$$

Doing the logit transformation, we finally obtain the Equation 18:

$$logit(P_i) = In\left(\frac{P_i}{1 - P_i}\right) = \beta_0 + x_i\beta \quad (18)$$

Stata 16 software is used to implement the specific regressions.

3 Result

3.1 Results of measuring the increase in farm household income

The changes in annual per capita income of farmers before and after the implementation of the vine tea policy are shown in Figure 2, where "PP" represents "participants" and "NP" represents "non-participants." It can be seen that all farmers experienced an increase in cash income, with Farmers III participants experiencing the largest growth of 13,294 yuan and Farmers I participants seeing the smallest growth of 1,936 yuan. In addition, all participant groups recorded higher rates of cash income growth compared to non-participants, with Farmers I participants experiencing the fastest growth rate of 46% and Farmers III non-participants experiencing the slowest growth rate of 14.82%.

Table 3 shows the quantitative results of the household livelihood capitals for the three types of farmers in the study area. In general, farmers have relatively fertile physical, human, and mental capital, while their natural capital is relatively weak. Among the three types of farmers, participants in both Farmers II and III exhibit lower levels of livelihood capitals than non-participants, with the largest difference in Farmers III. In contrast, participants in Farmers I demonstrate higher livelihood capital than non-participants. When examining each livelihood capital separately, for Farmers I, participants exhibited significantly higher levels of physical, social, and environmental capital than non-participants; for Farmers II, participants possessed greater physical and mental capital relative to non-participants, while human capital was comparatively lower; and for Farmers III, non-participants had significantly higher human capital than participants. Furthermore, non-participants of Farmers III have the highest human capital, which gives them the highest capital for livelihood.

3.2 The influence of livelihood capital on farmers' choice to participate in the vine tea industry

3.2.1 For farmers I: the influence of livelihood capital on farmers' choice to participate

The relationship between Farmer I's livelihood capital and livelihood strategy is shown in Table 4. Physical capital, social capital, environmental capital, and mental capital all exert a profound influence on the choice of livelihood for Farmer I. When all four types of capital are increased by the same amount, the degree of impact on farmers' willingness to participate: social capital > physical capital > environmental capital > mental capital. In contrast, human capital, natural capital, and

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TABLE 3 Livelihood capital of different farmers.

Farmers	Farmers I		Farmers II		Farmers III	
Policy participation	PP	NP	PP	NP	PP	NP
Human capital	0.131	0.130	0.121	0.135	0.113	0.181
Natural capital	0.015	0.018	0.021	0.024	0.024	0.024
Physical capital	0.099	0.081	0.092	0.085	0.094	0.095
Social capital	0.030	0.021	0.024	0.025	0.027	0.022
Financial capital	0.034	0.035	0.036	0.038	0.050	0.044
Environment capital	0.035	0.028	0.029	0.033	0.032	0.033
Mental capital	0.062	0.063	0.064	0.060	0.059	0.058
Livelihood capital	0.405	0.376	0.387	0.400	0.399	0.458

PP, participants; NP, non-participants.

TABLE 4 Relationship between livelihood capital and livelihood strategy (Farmers I).

Capital type	Symbol	Results	Specific capital indicators	Symbol	Results
Human capital	H	−0.436 (−1.328)	The overall labor capacity of the family	H_1	−0.469 (−1.412)
			Educational attainment of the adult workforce	H_2	0.441 (1.339)
			Health status of family members	H_3	0.088 (0.459)
Natural capital	N	0.468 (1.528)	Per capita paddy field area	N_1	−1.496** (−3.007)
			Dry land area per capita	N_2	−3.157*** (−4.920)
			Forest area per capita	N_3	2.996*** (4.648)
Physical capital	P	1.311** (2.974)	Household fixed capital	P_1	−0.714* (−2.107)
			Housing conditions	P_2	2.022*** (4.693)
			Number of livestock	P_3	0.571** (2.637)
			Road conditions	P_4	−0.334 (−1.229)
Social capital	S	1.702*** (3.441)	Leadership	S_1	4.376 (0.001)
			Participation in community organizations	S_2	0.785*** (3.320)
			Trust in people around	S_3	−0.449 (−1.865)
			Family circle	S_4	0.675** (2.857)
Financial capital	F	−0.208 (−0.623)	Farmers' household cash income	F_1	−1.115*** (−3.538)
			Access to credit	F_2	0.086 (0.425)
			Opportunities for free cash assistance	F_3	0.064 (0.248)
			Types of social security	F_4	0.658* (2.475)
Environment capital	E	1.038** (3.159)	Economy of the farmers' location	E_1	0.415*** (0.978)
			Convenience of shopping	E_2	2.979*** (4.272)
			School convenience	E_3	−0.250 (−0.748)
			Medical convenience	E_4	−0.198 (−0.542)
Mental capital	M	1.015** (2.741)	Expectations for future life improvement	M_1	−0.566 (−1.914)
			Subjective wellbeing	M_2	−0.318 (−1.257)
			Self-confidence	M_3	0.707*** (4.657)
			Resilience in times of difficulty	M_4	1.924*** (4.525)

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. $p < 0.05$ was considered statistically significant.

financial capital have no significant effect on Farmer I's choice of livelihood strategy.

Further analysis of the impact of specific livelihood indicators on their willingness to participate in the vine tea industry shows

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TABLE 5 Relationship between livelihood capital and livelihood strategy (Farmers II).

Capital type	Symbol	Results	Specific capital indicators	Symbol	Results
Human capital	H	−0.305 (−1.341)	The overall labor capacity of the family	H_1	−0.797* (−2.144)
			Educational attainment of the adult workforce	H_2	0.862* (2.366)
			Health status of family members	H_3	−0.283 (−1.377)
Natural capital	N	−0.508 (−1.918)	Per capita paddy field area	N_1	−0.405 (−1.518)
			Dry land area per capita	N_2	−0.324 (−1.245)
			Forest area per capita	N_3	0.451 (1.718)
Physical capital	P	0.478 (1.817)	Household fixed capital	P_1	0.347 (1.488)
			Housing conditions	P_2	−0.289 (−1.286)
			Number of livestock	P_3	0.414* (2.080)
			Road conditions	P_4	0.248 (1.057)
Social capital	S	0.016 (0.064)	Leadership	S_1	−6.367 (−0.002)
			Participation in community organizations	S_2	0.162 (0.732)
			Trust in people around	S_3	0.069 (0.304)
			Family circle	S_4	0.858*** (3.762)
Financial capital	F	0.704* (0.442)	Farmers' household cash income	F_1	0.589* (2.575)
			Access to credit	F_2	1.205*** (4.672)
			Opportunities for free cash assistance	F_3	−0.902** (−2.821)
			Types of social security	F_4	−0.169 (−0.680)
Environment capital	E	0.801* (−2.240)	Economy of the farmers' location	E_1	0.578* (2.180)
			Convenience of shopping	E_2	0.581 (1.373)
			School convenience	E_3	0.378 (0.827)
			Medical convenience	E_4	1.639** (−3.065)
Mental capital	M	0.895** (1.959)	Expectations for future life improvement	M_1	0.856** (2.870)
			Subjective wellbeing	M_2	0.796 (3.237)
			Self-confidence	M_3	0.820** (2.672)
			Resilience in times of difficulty	M_4	1.635*** (4.090)

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. $p < 0.05$ was considered statistically significant.

that in terms of natural capital, the larger the area of paddy and dry land owned by farmers, the more likely they are to choose not to participate. In turn, the larger the area of forest land per capita, the more likely it is to choose to engage. Among physical capital, household fixed capital, housing conditions, and number of livestock significantly influence livelihood strategy choices. When household fixed capital is relatively high, farmers are more inclined to stay out of it. When housing conditions are better and livestock numbers are higher, farmers tend to participate. In relation to financial capital, households with higher cash incomes tend to favor non-participation, whereas farmers benefiting from diverse social security measures and have more relatives are inclined to prefer participation. Moreover, the better the economic situation in the villages where the residents live, the more accessible shopping becomes, and the greater the farmers' confidence and resilience in confronting challenges, will make it more likely that farmers will choose to participate. This suggests that a good social environment and state of mind have a positive effect on the choice of activities farmers engage in.

3.2.2 For farmers II: the influence of livelihood capital on farmers' choice to participate

The relationship between the livelihood capital and livelihood strategy of Farmers II is shown in Table 5. Unlike Farmers I, the livelihood strategy of Farmers II is predominantly influenced positively by financial capital, environmental capital, and mental capital. The more financial capital, environmental capital, and psychological capital farmers own, the more likely they are to choose to participate in the vine tea industry. When equivalent increments are applied to various forms of capital, mental capital exerts a more significant impact on farmers' willingness to engage in the tea industry compared to environmental and financial capital. In other words, when the mental capital increases, the probability of farmers choosing to participate is greater than when the environmental capital or financial capital increases by the same amount, and vice versa. On the other hand, human capital, natural capital, physical capital, and social capital did not have a significant effect on the choice of livelihood strategy of Farmers II.

TABLE 6 Relationship between livelihood capital and livelihood strategy (Farmers III).

Capital type	Symbol	Results	Specific capital indicators	Symbol	Results
Human capital	H	1.632*** (−4.268)	The overall labor capacity of the family	H_1	−1.243*** (−3.167)
			Educational attainment of the adult workforce	H_2	−0.150 (−0.389)
			Health status of family members	H_3	−1.622*** (−5.282)
Natural capital	N	−0.637 (−1.522)	Per capita paddy field area	N_1	1.630*** (3.794)
			Dry land area per capita	N_2	−2.085*** (−4.170)
			Forest area per capita	N_3	0.717* (2.210)
Physical capital	P	1.608* (2.386)	Household fixed capital	P_1	−0.060 (−0.282)
			Housing conditions	P_2	0.045 (0.195)
			Number of livestock	P_3	0.511* (2.525)
			Road conditions	P_4	0.154 (0.827)
Social capital	S	0.826*** (1.416)	Leadership	S_1	−0.006 (−0.031)
			Participation in community organizations	S_2	0.979*** (3.708)
			Trust in people around	S_3	−0.099 (−0.505)
			Family circle	S_4	0.076 (0.415)
Financial capital	F	−1.449* (−2.517)	Farmers' household cash income	F_1	−0.449* (2.189)
			Access to credit	F_2	0.279 (1.432)
			Opportunities for free cash assistance	F_3	−0.020 (−0.102)
			Types of social security	F_4	−0.015 (−0.079)
Environment capital	E	2.421** (−2.659)	Economy of the farmers' location	E_1	−0.483 (−1.915)
			Convenience of shopping	E_2	1.423** (−2.625)
			School convenience	E_3	1.658** (2.739)
			Medical convenience	E_4	0.082 (0.266)
Mental capital	M	2.548*** (3.498)	Expectations for future life improvement	M_1	0.699** (2.941)
			Subjective wellbeing	M_2	−0.388 (−1.664)
			Self-confidence	M_3	0.899*** (3.502)
			Resilience in times of difficulty	M_4	0.161 (0.799)

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. $p < 0.05$ was considered statistically significant.

Further analysis was conducted on the impact of specific livelihood indicators on Farmers II's willingness to participate in the vine tea industry. In contrast to Farmers I, a higher level of education among the adult workforce was positively correlated with farmers' willingness to engage in natural capital indicators. Additionally, an increase in the number of livestock and relatives was also found to increase the likelihood of farmers participating in the industry. With respect to financial capital, an increase in household cash income, access to credit, and free cash assistance were found to positively influence farmers' choice to participate, while the type of social security did not significantly influence this decision. Moreover, akin to Farmers I, enhanced economic conditions within the village, facile access to healthcare, elevated expectation of future life improvement, augmented self-assurance, and heightened resilience during challenging periods were all identified as positive determinants influencing farmers' propensity to engage in the vine tea industry.

3.2.3 For farmers III: the influence of livelihood capital on farmers' choice to participate

The relationship between the livelihood capital and livelihood strategies of Farmers III is shown in Table 6. Compared with Farmers I and II, all six types of capital, except natural capital, significantly affect the livelihood choices of Farmers III. Specifically, farmers with higher levels of human, physical, social, environmental, and mental capital are more inclined to engage in the vine tea industry, while those with more financial capital tend to refrain from participation.

Further analysis of the impact of specific livelihood indicators on their willingness to participate: unlike Farmers I and II, the overall labor capacity of the household and the health status of family members had a significant negative effect on the participation of Farmers III. This suggests that households with more young and healthy members are less likely to participate. Regarding natural capital, it was found that the more area of paddy land and forest land per capita, the more likely farmers are to choose to participate, while the increase in the dry land area makes them less inclined to join. In addition, as with Farmers I and II, an increase in the number of livestock significantly increases the likelihood of participation by farmers. In terms of social capital, active involvement in community organizations positively influences farmers' choice of livelihood strategy. To motivate farmers to participate, improving the convenience of shopping and schooling and increasing their expectations and self-confidence in their future lives are also crucial ways to achieve this.

4 Discussion

This study focused on a typical rural area in Laifeng County as the research subject, and the survey results revealed that the rural population was mainly composed of elderly people and children, characterized by generally low levels of education and limited high-income households. This finding is consistent with the trend of declining rural populations and lower levels of education and economic development in China. By analyzing the participation rates in the vine tea industry among three categories of farmers, it was found that the percentage of participants was significantly higher among Farmers III. This suggests that the vine tea industry has been more successful among farmers with higher income, and relatively affluent farmers are more likely to benefit from participation compared to their less well-off counterparts. Moreover, although the highest growth rate of cash income for Farmers I participants (46%), the absolute increase was only 1,936 yuan, significantly lower than that of Farmers III at 13,294 yuan. This shows that although low-income farmers benefit from industrial participation, they are limited by the low initial income base and the actual income increase is limited. With a higher initial capital endowment (land, capital, and social capital), Farmers III not only has a stable growth rate after participating in the industry, but also has a significant increase in absolute income, further widening the income gap.

As shown in Figure 2, the annual per capita income of farmers increased before and after the implementation of the tea policy, and the cash income of participants was significantly higher compared to that of non-participants. This indicates that the vine tea industry has a positive impact on farmers, with a particularly pronounced impact on participants. This supports the hypothesis that the development of the vine tea industry can drive farmers to become more prosperous and contribute to rural revitalization. As illustrated in Table 3, a comparative analysis of the livelihood capital among the three categories of farmers indicates that those with higher incomes typically possess greater livelihood capital. This finding underscores the significance of income as a key metric for assessing the livelihood capital of farmers. Interestingly, participants of Farmers II and III had lower livelihood capital than non-participants, with the exception of Farmer I. This can be attributed to the fact that, for farmers with lower incomes, the human and natural capital of participants and non-participants were essentially the same. However, due to the support of policies and social organizations, which improved infrastructure such as roads and housing conditions and facilitated participation in community activities to acquire knowledge and skills, participants accumulated higher levels of physical, social, and environmental capital compared to non-participants, ultimately resulting in greater livelihood capital. On the other hand, for farmers with moderate or higher income, participants had slightly higher physical capital than non-participants, but this did not compensate for the lack of human capital, resulting in lower livelihood capital. It is evident that to increase the livelihood capital of farmers, the local governments must take measures such as improving education levels, encouraging young adults to return to their hometowns to start businesses, and ensuring access to medical insurance.

Different levels of income have varying effects on the livelihood capital of farmers and their willingness to participate in the vine tea industry. Except for natural capital, six capitals affect the choice of livelihood strategy, among which environmental capital and mental capital being the most significant factors influencing farmers: improved access to shopping facilities and enhanced self-confidence significantly affect farmers' participation. Additionally, for farmers with lower income, better housing conditions, more livestock, and a larger number of relatives in the village increase their willingness to participate. This is mainly because the majority of farmers have strong traditional family values and they tend not to leave their homeland. Human capital has little impact on this category of farmers, likely due to their lower education level and limited family labor force. For farmers with a general income, financial capital has a significant influence on their choice of livelihood strategies.

With higher household incomes, farmers with better access to credit are more likely to participate. Therefore, the government and financial institutions should design and implement credit policies and programs tailored specifically for farmers to encourage participation. Unlike farmers with low or general incomes who are affected by only three or four types of capital, farmers with higher incomes are significantly affected by six types of capital. In addition to environmental capital and mental capital, the increase of physical capital and social capital will also play a crucial role in influencing farmers' decisions, the more livestock farmers own, the more they participate in community organizations, and the more relatives in the village will make them more inclined to engage. However, farmers with more human and financial capital tend to refrain from participating, as it may be a better choice for them to work or start their own businesses in cities and towns.

To promote farmer participation in the vine tea industry and enhance their livelihood capital, it is necessary to provide tailored support based on the diverse income levels of farmers. Increasing environmental capital and mental capital can increase farmers' inclination to participate, so practical and effective pathways would involve improving shopping and medical facilities for farmers and enhancing their expectations for their future livelihoods. This can be achieved by repairing road facilities, promoting vine tea-related policies, and recognizing exemplary farmers in vine tea cultivation. Additionally, for farmers with lower income, their residences can be refurbished, and participants can be organized to attend training sessions related to vine tea cultivation techniques and basic sales techniques, encouraged to join companies or cooperatives, even certain subsidies can be given to them to broaden sales channels. For farmers with general income, the local government and related departments formulate policies to enhance their risk resistance and provide them with more access to credit. For farmers with high income, the government can inject new vitality into the vine tea industry by introducing related policies applicable to them, encouraging non-participants to return to their hometowns and develop by providing incentives for higher returns or industrial innovation.

In addition, there are several directions to be further researched. First, this study only focuses on Laifeng County in Hubei Province, and it could only provide some reference significance to the townships in the surrounding region. Future

research should broaden its scope to encompass other areas and further comparative analysis can be carried out to facilitate the advancement of nationwide rural revitalization efforts. Second, in order to more sufficiently and comprehensively study the impact of the vine tea industry on the livelihoods of farmers, it is essential to continuously observe its dynamic changes over time. For example, implementing longitudinal follow-up studies, analyzing livelihood strategy trajectories, constructing role network diagrams of the industrial chain, and developing dynamic databases could all be potential future research directions. Due to the rapid evolution of the industry, it is challenging to assess the overall changes in livelihood capital before and after participation without sufficient longitudinal data. Addressing these research gaps will enable us to gain a more nuanced understanding of the impact of the vine tea industry on the livelihoods of farmers.

5 Conclusions

Based on the sustainable livelihood analysis framework and binary logit model, this study explored the livelihood characteristics of farmers in Laifeng County and investigated the impact of farmers' livelihood capitals on their willingness to participate in the vine tea industry. Results showed that the vine tea policy increased all farmers' incomes, with participants experiencing a more substantial increase in cash income compared to non-participants, particularly those with the lowest income. Furthermore, the impact of livelihood capitals on farmers' participation in the vine tea industry varied by income level. For farmers with low income, physical capital, social capital, environmental capital, and mental capital will significantly affect their participation. For farmers with general income, financial capital, environmental capital, and mental capital strongly influenced their decision. For farmers with high income, all types of capital except natural capital significantly impacted their willingness to engage. To encourage participation in the vine tea industry, provide tailored assistance to farmers based on income levels, create policies to attract non-participants, and support participants with improved cultivation techniques and education. This will significantly contribute to the industry's development as a critical part of industrial revitalization.

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

YX: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft. YY: Data curation, Formal analysis, Investigation, Writing – original draft. QZ: Writing – review & editing. ZZ: Writing – review & editing. ZH: Conceptualization, Methodology, Writing – review & editing.

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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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