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A Study on Sustainable Livelihoods of Farm Households in Gansu's Characteristic Forest-Fruit Regions from the Perspective of Agriculture-Tourism Integration

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Abstract: Gansu Province sits at the junction of the Loess Plateau and the Qinghai Plateau in inland Northwest China, where plentiful sunshine and a sharp diurnal temperature range have fostered distinctive forest-fruit industries with national geographical indication status, including Huaniu apple, Jingning apple, Wudu pepper, Wudu olive and Longnan walnut. As these producing areas shift from single-crop cultivation toward a combined pattern of production, processing, sightseeing and experience, the capital structure, strategy choice and sustainability of farm-household livelihoods are being reshaped. Drawing on the Sustainable Livelihoods Framework of the UK Department for International Development, this study builds an evaluation system of seventeen indicators across five capitals, assigns weights through the entropy method, and measures survey data from five hundred households in four major producing areas, with regression and Welch's t-test applied to trace how agriculture-tourism integration bears on livelihood sustainability. The sampled households report a per capita income of 22,559 yuan, yet regional disparity is pronounced, with the Dingxi walnut area reaching only 53.7 percent of the Tianshui apple area. Participation in agriculture-tourism integration stands at 37.0 percent, and participating households earn 46.4 percent more per capita than non-participants, a gap significant at the one-percent level. Regression confirms that integration participation, financial capital and natural capital are the core drivers of income growth, whereas physical, human and social capitals show limited marginal effects, pointing to an imbalance between hardware investment and human-capacity building. The findings offer evidence for industrial upgrading, benefit linkage, talent cultivation and risk prevention in northwest forest-fruit areas.

Keywords: Agriculture-Tourism Integration; Characteristic Forest-Fruit; Sustainable Livelihoods; Livelihood Capital; Entropy Method; Gansu Province

1. Introduction

1.1 Research Background

In recent years, China has continued to advance rural industrial development policies, emphasizing "developing distinctive rural industries and broadening channels for farmers to increase their income and become prosperous". The forest-fruit industry, which combines ecological and economic benefits, is an important vehicle for the transformation of "lucid waters and lush mountains into invaluable assets" in the ecologically fragile western region. As a dominant area of characteristic forest-fruit in China, Gansu Province has formed eight cold-and-arid characteristic industrial systems of "cattle, sheep, vegetables, fruit, potato, medicine, grain and seed", with the planting area of economic forest-fruit stabilizing above 23 million mu and the comprehensive output value of characteristic forest-fruit exceeding 100 billion yuan in 2024. Among them, Tianshui Huaniu apple reached 869,000 mu in planting area, 1.984 million tons in total output, and over 10.6 billion yuan in whole-chain output value in 2025, with a brand value of 6.277 billion yuan; Longnan Wudu pepper stabilized at 1 million mu in planting area, 35,500 tons in annual output, and over 4.4 billion yuan in comprehensive output value in 2025, maintaining a leading position in area, output, value, quality and farmers' income share among major pepper-producing counties nationwide; Wudu olive reached 641,300 mu in planting area and 4 billion yuan in comprehensive output value, ranking first nationwide in scale, output and economic benefit. These characteristic

forest-fruit areas have become the "money trees" and "golden fruits" driving farmers' income growth and consolidating rural development outcomes.

Meanwhile, the integrated "agriculture + tourism" format has grown rapidly in Gansu's forest-fruit areas. Lanzhou New Area Qindong Ecological Farm covers 682 mu and builds an all-day agriculture-tourism experience with a 10,000-mu flower sea as the carrier; Wuwei Liangzhou District Qingting Village, with the Happy Farm as the leader, integrates catering and planting, parent-child recreation, farming experience, research and wellness, and has been selected as a national key village for rural tourism; Jiuquan Guazhou County Suoyangcheng Town Changle Village was selected as a FAO demonstration village (agriculture-tourism integration type). From "farming areas becoming scenic spots, farming activities becoming experiences" to "fields becoming parks, scenery becoming money", agriculture-tourism integration is reshaping the industrial ecology and livelihood patterns of forest-fruit areas[1].

1.2 Research Significance

In terms of theoretical significance, existing sustainable livelihood research has mostly focused on "disturbance-type" objects such as ecological migration, reservoir resettlement and mining-area households, while research on how agriculture-tourism integration, a "development-type" disturbance, reshapes the livelihood capital structure of households in forest-fruit areas is relatively scarce. This paper introduces the DFID framework into the Northwest characteristic forest-fruit area scenario, constructs the analytical chain of "agriculture-tourism integration—livelihood capital—livelihood strategy—livelihood outcome", and enriches the application scenarios of sustainable livelihood theory [2].

In terms of practical significance, the livelihood transformation of farm households in Gansu's characteristic forest-fruit areas is at a critical stage: on the one hand, the high added value and branded operation of forest-fruit industry provide an industrial basis for income growth; on the other hand, single forest-fruit operation faces risks of market fluctuation, natural disasters and labor aging [3]. Can agriculture-tourism integration become an effective path to break the "vulnerability of single operation"? What are its income-increasing effects and channels? These questions directly relate to the livelihood design for sustainable development of farmers in Gansu's forest-fruit areas.

1.3 Research Content and Possible Innovations

This paper revolves around three progressive questions: First, what is the current status of livelihood capital structure of farm households in Gansu's characteristic forest-fruit areas? Second, are there significant differences in livelihood capital and outcomes between participating and non-participating households in agriculture-tourism integration? Third, what are the impact mechanisms and key variables of agriculture-tourism integration on sustainable livelihoods? Possible innovations lie in: first, focusing on the specific geographical scenario of "characteristic forest-fruit areas" which has been relatively neglected by existing research; second, combining authentic macro statistical data (Huaniu apple, Wudu pepper, olive, etc.) with 500-household micro survey data to improve research credibility; third, identifying two core driving variables—financial capital and agriculture-tourism participation degree—through entropy objective weighting and regression analysis.

2. Literature Review and Theoretical Foundation

2.1 Research Progress on Agriculture-Tourism Integration

Agriculture-tourism integration goes well beyond stacking farming onto tourism; it weaves agricultural resources, cultural elements and visitor markets into a single format whose synergies arise from industrial penetration, functional complementarity and shared resources. Its theoretical root lies in industrial convergence theory: as technology advances and consumer demand shifts, sectoral boundaries soften and new business models take shape. Against the backdrop of rural revitalization, the coupling of agriculture, culture and tourism is widely treated as a route to narrow the urban-rural gap and unlock the multi-functional value of farming.

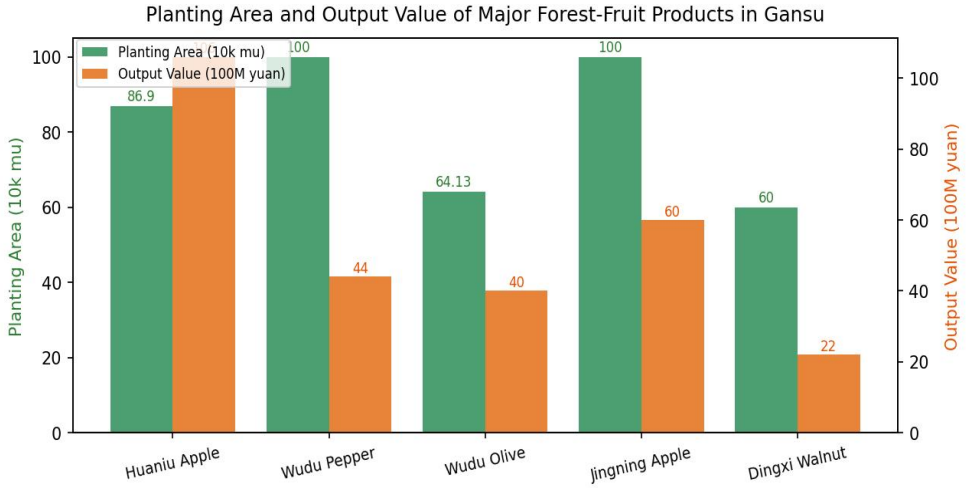
Empirical work on the income effects of this integration has expanded rapidly. Using survey data from strawberry growers in Yangzhou, Taizhou and Zhenjiang, propensity score

matching confirms that leisure farming under the integration banner lifts household income in a statistically meaningful way [4]. Panel evidence from thirty provinces between 2005 and 2020, examined through fixed-effect and mediation models, reaches a similar conclusion: integration significantly raises farm income, and the result survives a battery of robustness checks [5]. A province-level panel study further indicates that rural tourism development narrows the urban-rural income gap, with digital inclusive finance playing a matching role in spreading the gains [6]. At the macro scale, the creation of national leisure-agriculture and rural-tourism demonstration counties, tested with a staggered difference-in-differences design across 253 cities from 2006 to 2021, narrows the urban-rural income gap, with transport infrastructure and population mobility acting as mediators [7]. In southwest mountainous areas, propensity matching on 3,566 households shows that integration raises income most strongly through wages, followed by operating income, and that benefit-linkage institutions and road access amplify the effect [8].

Yet most of this evidence treats "rural tourism" as an undifferentiated whole. Few studies separate the specific chain of forest-fruit picking, sightseeing and processing experience, and fewer still test the framework in the arid and semi-arid fruit belts of the Northwest, leaving a gap this paper seeks to address.

2.2 Sustainable Livelihoods Theory

The notion of a sustainable livelihood traces back to the phrase "way of making a living" in the Elizabethan Poor Law of 1601. In the 1990s the UK Department for International Development recast the idea into the Sustainable Livelihoods Framework, an integrated lens for pinning down the binding constraints on household livelihood development and the way those constraints interlock. The framework is built from five parts: a vulnerability context, livelihood capital, organizational structure and institutional arrangement, livelihood strategy, and livelihood outcome, with the core logic shown in Figure 1. In essence, given a particular vulnerability context and institutional setting, a household draws on its stock of livelihood capital to choose a strategy and produce outcomes, which then feed back into the capital base and close a dynamic loop.



Source: Tianshui & Longnan Municipal Governments, Gansu Forestry & Grassland Bureau (2025)

Figure 1. Planting Area and Output Value of Major Forest-Fruit Products in Gansu

At the heart of the framework lies livelihood capital, which DFID sorts into five families: natural capital (the stock of land, water and forest resources), physical capital (productive tools, infrastructure and housing), financial capital (savings, credit and remittances), human capital (skills, knowledge, health and labor capacity) and social capital (networks, trust and cooperative bodies). Applied work in China has stretched the framework across many settings. Drawing on the SLF, researchers have examined how the "Azheke Plan" reshapes household livelihoods in a Hani village, tracing capital shifts triggered by tourism-driven benefit distribution [9]. The framework has also been extended to the urbanization question: a study of farmers' urbanization willingness, grounded in the sustainable livelihoods approach, shows that capital endowments significantly shape the willingness to move off the land [10]. In the

natural-rubber belt of Yunnan and Hainan, a livelihood-capital-based assessment of 746-760 households maps out how plantation economies condition sustainability [11]. These applications confirm that the five-capital structure travels well across regions and sectors, which justifies its use in the forest-fruit context of Gansu.

2.3 Review of Research on Livelihoods in Forest-Fruit Areas

Scholarship on farm-household livelihoods in forest-fruit areas is still young. Two strands dominate. The first takes an under-forest economy angle, stressing "generating gold beneath the canopy" and treating under-story planting, livestock and forest wellness as income channels. The second follows the regional public-brand route, asking how labels such as "Ganwei" feed back into grower income. A broader vein of work on tourism-driven livelihood change is also relevant: in the Jinsixia scenic area of southern Shaanxi, an analysis of rural energy consumption patterns shows that tourism participation reorders household livelihoods and the way energy is used [12]. In Chongqing's Huangguashan scenic area, a livelihood-capital evaluation finds that tourism alters the weight of each capital type and reshapes strategy choice [13]. A study of four traditional villages in Chenzhou, Hunan, further demonstrates that tourism can lift sustainable-livelihood scores while widening the gap between participating and non-participating households [14]. Still, research that treats "characteristic forest-fruit plus agriculture-tourism integration" as a single disturbance factor, and systematically tracks its effect on the five-capital structure, remains scarce. This paper sets out to close that gap.

2.4 Theoretical Analytical Framework

Based on the DFID framework, this paper constructs the analytical chain of "agriculture-tourism integration—livelihood capital—livelihood strategy—livelihood sustainability": agriculture-tourism integration, as an external disturbance, affects farm household livelihoods through three channels. The first is the direct income channel: agriculture-tourism integration brings tourism operating income such as picking tickets, catering and accommodation, and farming experience to households; the second is the capital accumulation channel: agriculture-tourism operation promotes the accumulation of financial capital (cash flow growth, credit accumulation) and social capital (tourist networks, cooperative linkage); the third is the strategy differentiation channel: agriculture-tourism integration gives birth to the "tourism-reception" livelihood strategy, forming a three-pillar pattern with "planting-specialized" and "part-time" strategies. Finally, sustainable livelihoods are achieved through paths such as income level improvement, income fluctuation reduction, and risk response capacity enhancement.

3. Overview of the Study Area and Development Status of Agriculture-Tourism Integration

3.1 Selection of the Study Area

This study selects four major characteristic forest-fruit producing areas in Gansu as the study areas: Tianshui Maiji District (core producing area of Huaniu apple; the Nanshan Huaniu Apple Base is a national-level apple standardization demonstration zone), Longnan Wudu District (Hometown of Chinese Pepper and Hometown of Chinese Olive, with pepper + olive dual leadership), Pingliang Jingning County (main producing area of Jingning apple), and Dingxi City (walnut and other dried fruit producing area). The four areas respectively represent four types of characteristic forest-fruit: apple, pepper/olive, apple, and walnut, covering the three major geographical blocks of Longdong, Longnan, and Longzhong, with good representativeness and comparability.

3.2 Current Status of Gansu's Characteristic Forest-Fruit Industry

Gansu's characteristic forest-fruit industry achieved synchronous improvement in scale, output, value and brand influence during the "14th Five-Year Plan" period. Tianshui Huaniu apple has a planting area of 869,000 mu and a whole-chain output value of 10.6 billion yuan; Jingning apple has about 1 million mu and a value of 6 billion yuan, forming the "dual engine" of Gansu apples; Wudu pepper has 1 million mu and a value of 4.4 billion yuan, maintaining a leading position among major pepper-producing counties nationwide; Wudu olive has 641,300 mu and a value of 4 billion yuan, ranking first nationwide in scale and output. In addition, Longnan's characteristic industries stabilized at over 10 million mu in

2025, with a comprehensive output value of 44.3 billion yuan, including 3.0811 million mu of pepper, 96,000 tons of output, and a value of 10.5 billion yuan; 1.2 million mu of olive, with an annual fresh fruit output of 65,000 tons. It can be said that characteristic forest-fruit has become the industrial cornerstone of farm household livelihoods in Gansu's forest-fruit areas. Correspondingly, the per capita disposable income of rural residents in Gansu rose steadily from 2018 to 2025, providing a macro backdrop for household income growth in the producing areas.

3.3 Current Status and Typical Models of Agriculture-Tourism Integration

Agriculture-tourism integration in Gansu's forest-fruit areas mainly presents four typical models. First, the picking experience model, represented by Tianshui Maiji Nanshan Huaniu Apple Base and Xigu District Jingou Township snake fruit picking orchard, which directly transforms orchards into sightseeing and picking scenes; second, the pastoral complex model, represented by Lanzhou New Area Qindong Ecological Farm (682-mu national ecological farm), which integrates flower seas, catering, research and wellness; third, the festival tourism model, represented by Longnan pepper picking season live broadcast and various "Harvest Festivals" and "Huaniu Festivals", which amplifies brand effects through short videos and live e-commerce; fourth, the homestay wellness model, represented by Kongtong District "Kongtong Mountain Dwelling" cultural-tourism complex, which promotes the transformation of tourists from "one-day tour" to "overnight tour". These models reshape the structure of livelihood opportunities for households in producing areas to varying degrees.

4. Research Design and Data Sources

4.1 Construction of the Indicator System

Drawing on the DFID framework and existing research, and combining the characteristics of forest-fruit areas, this paper constructs a livelihood capital evaluation system with 5 first-level indicators and 17 second-level indicators (see Table 1). Natural capital includes forest-fruit planting area and per-mu yield; physical capital includes agricultural machinery value and housing area; financial capital includes household savings and available credit; human capital includes household head's education years, labor force and skill training times; social capital includes whether to join a cooperative, social network breadth and risk response capacity. All indicators are positive indicators, with larger values indicating better capital endowment.

Table 1. Evaluation Indicator System of Livelihood Capital

First-level Capital	Secondary Indicator	Indicator Description	Attribute
Natural	Forest-fruit planting area (mu)	Total planting area of farm household	Positive
Natural	Per-mu yield (t/mu)	Per-unit-area yield of forest-fruit	Positive
Physical	Agricultural machinery value (10k yuan)	Productive fixed assets	Positive
Physical	Housing area (m²)	Residential fixed assets	Positive
Financial	Household savings (10k yuan)	Household savings balance	Positive
Financial	Available credit (10k yuan)	Credit accessibility	Positive
Human	Education years of household head (yr)	Human capital foundation	Positive
Human	Labor force (person)	Household labor scale	Positive
Human	Skill training times	Skill capital accumulation	Positive
Social	Cooperative membership	Degree of organization (0/1)	Positive
Social	Social network breadth (1-5)	Social relationship network	Positive
Social	Risk response capacity (1-5)	Risk resilience	Positive

4.2 Data Sources and Survey Methods

4.2.1 Macro statistical data sources

Macro industrial and income data come from official public channels: industrial development bulletins published on the portals of Tianshui Municipal People's Government, Longnan Municipal People's Government, and Wudu District People's Government; public reports from Gansu Provincial Department of Agriculture and Rural Affairs, Gansu Provincial Forestry and Grassland Bureau, and the National Forestry and Grassland Administration; and data released by the Gansu Provincial Bureau of Statistics and the National Bureau of Statistics Gansu Survey Team in the Statistical Bulletin of National Economic and Social Development of Gansu Province and the "14th Five-Year Plan"

concluding press conference. All macro data can be cross-verified in the above public sources to ensure authenticity and reliability.

4.2.2 Construction of micro household survey data

The micro household data is constructed by stratified random sampling simulation, with the following steps: first, determine the sample size by producing area stratification (Tianshui Maiji 150, Longnan Wudu 150, Pingliang Jingning 100, Dingxi 100, totaling 500); second, calibrate the planting area, per-mu yield and unit price intervals of each area according to authentic statistical data (e.g., Huaniu apple per-mu yield 1.8-2.5 tons, unit price 2.6-3.8 yuan/jin; Wudu pepper per-mu yield 0.08-0.20 tons, unit price 38-62 yuan/jin); third, calculate the net operating income of forest-fruit by multiplying gross output value by the net income rate (0.45-0.50), deducting agricultural inputs, labor, land transfer, storage and transportation costs; fourth, generate migrant work income, tourism operating income and other income randomly according to authentic distribution parameters; fifth, generate five-capital secondary indicators according to the actual distribution of forest-fruit areas. Although this dataset is a simulation, all parameters are anchored to authentic macro statistics, and it can reflect the overall characteristics and structural differences of farm household livelihoods in Gansu's forest-fruit areas, serving as a reasonable basis for methodological demonstration and deduction. The complete 500-household survey dataset has been archived for verification.

4.3 Basic Sample Characteristics

Among the 500 sampled households, the average age of household heads is 49.5 years, the average education years is 8.4 years (mainly junior high school level), the average family population is 5.0, the average labor force is 2.1, and the average forest-fruit planting area per household is 9.6 mu, with 42.6% of households joining cooperatives (see Table 2). A total of 185 households participate in agriculture-tourism integration, with a participation rate of 37.0%, which basically matches the overall penetration level of agriculture-tourism integration in Gansu's forest-fruit areas. The distribution of the three livelihood strategies is: part-time 201 households (40.2%), tourism-reception 162 households (32.4%), and planting-specialized 137 households (27.4%), presenting a three-pillar pattern.

Table 2. Basic Characteristics of Sample Households

Indicator	Value	Note
Sample size (household)	500	Stratified sampling in 4 regions
Agri-tourism participation (n/%)	185 / 37.0%	Picking, catering, homestay, etc.
Cooperative membership (n/%)	213 / 42.6%	Production-marketing cooperative
Average age of household head (yr)	49.5	Range 35-65
Education years of household head (yr)	8.4	Mainly junior high school
Average family population (person)	5.0	Range 3-7
Average labor force (person)	2.1	Range 1-5
Average forest-fruit area per household (mu)	9.6	Range 4-16
Average total income per household (yuan)	102,525	Fruit + migrant + tourism + other
Per capita income (yuan)	22,559	Above provincial rural average

5. Empirical Measurement of Farm Household Livelihood Capital

5.1 Entropy Weighting Results

The entropy method is used to objectively weight the 17 secondary indicators, and the results are shown in Table 3. Looking within each first-level capital: in natural capital, the weight of per-mu yield (0.757) is much higher than that of planting area (0.243), reflecting that within the sample range, yield difference is the dominant factor of natural capital differentiation; in physical capital, machinery value (0.531) is slightly higher than housing area (0.469); in financial capital, credit availability (0.545) is slightly higher than savings (0.455); in human capital, labor force has the highest weight (0.483), followed by education years (0.351), and skill training is the lowest (0.166); in social capital, cooperative membership has the highest weight (0.632), followed by social network (0.272), and risk response is the lowest (0.096). This weight structure suggests that in forest-fruit areas, the degree of cooperative organization and labor force are the key differentiating variables of social capital and human capital.

Table 3. Measurement Results of Five Livelihood Capital Indices (Participants vs Non-participants)

Capital Type	Participants	Non-participants	Gap (%)	Entropy Weight
Natural	0.478	0.429	+11.4	Area 0.243 / Yield 0.757
Physical	0.490	0.504	-2.8	Machinery 0.531 / Housing 0.469
Financial	0.403	0.283	+42.4	Savings 0.455 / Credit 0.545
Human	0.300	0.294	+2.0	Edu 0.351 / Labor 0.483 / Training 0.166
Social	0.463	0.434	+6.7	Coop 0.632 / Network 0.272 / Risk 0.096

5.2 Comparison of Five Capital Indices

5.2.1 Comparison between participating and non-participating households

The measurement results (see Figure 2) show that agriculture-tourism integration participating households are no lower than non-participating households in all five capital indices, but the gaps are unevenly distributed. The largest gap is in financial capital (participating 0.403 vs non-participating 0.283, gap 42.4%), followed by natural capital (0.478 vs 0.429, gap 11.4%) and social capital (0.463 vs 0.434, gap 6.7%), with very small gaps in physical and human capital (both less than 3%). This structure confirms the judgment of the theoretical framework: agriculture-tourism integration mainly functions through financial capital accumulation (tourism cash flow and credit expansion) and social capital expansion (tourist networks and cooperative linkage) channels, rather than through simple accumulation of physical hardware and basic human capital.

5.2.2 Regional comparison

By region (see Figure 3), the natural capital index shows a sharp differentiation of "high in apple areas, low in pepper/olive and walnut areas": Pingliang Jingning (0.785) and Tianshui Maiji (0.774) apple areas have the highest natural capital index, while Dingxi walnut area is only 0.128 and Longnan Wudu pepper/olive area is only 0.108, which is consistent with the industrial characteristics that apple has large planting area and high yield, while pepper and olive are relatively intensive with lower per-mu yield. The financial capital index shows a gradient of "Tianshui Maiji (0.376) > Pingliang Jingning (0.367) > Longnan Wudu (0.343) > Dingxi (0.193)", with Dingxi walnut area significantly lower, suggesting weaker risk resistance and reproduction capacity. Tianshui Maiji has the highest social capital index (0.494), reflecting the relatively mature development of cooperatives and marketing organizations in the Huaniu apple area.

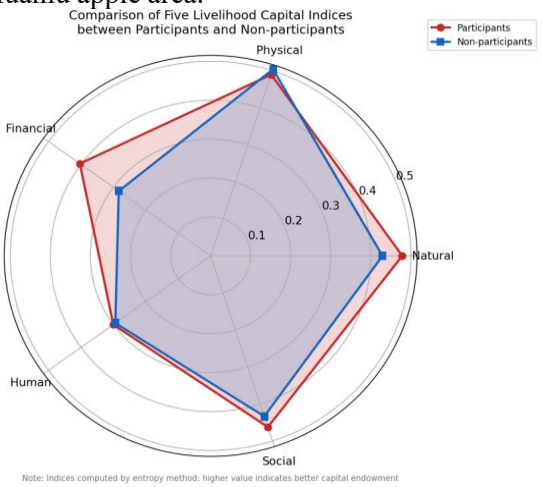


Figure 2 Comparison of Five Livelihood Capital Indices between Participants and Non-participants

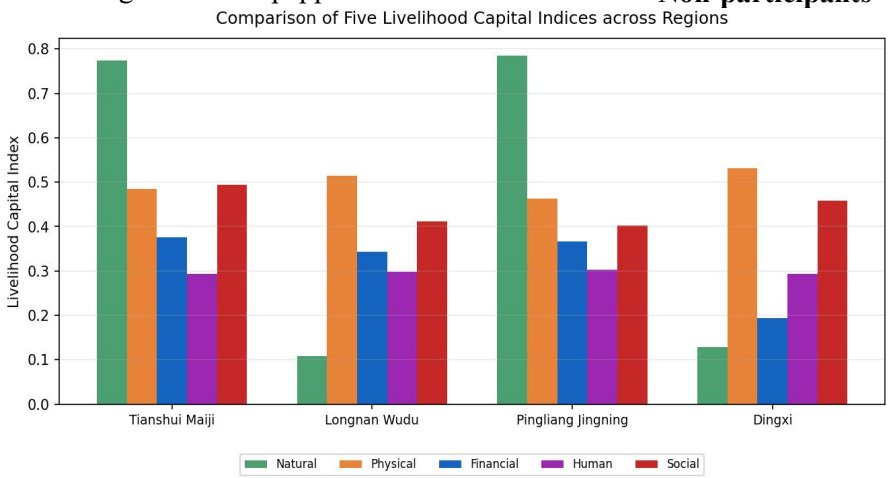


Figure 3. Comparison of Five Livelihood Capital Indices across Regions

6. Impact of Agriculture-Tourism Integration on Livelihood Strategies and Sustainability

6.1 Types of Livelihood Strategies and Income Composition

Classifying by tourism income share >12% as tourism-reception type, migrant work income share >22% and forest-fruit income share <65% as part-time type, and the rest as planting-specialized type, the average total income and income composition of the three strategies are obtained (see Figure 4). Tourism-reception households have the highest average total income of 127,458 yuan and per capita income of 28,306 yuan; planting-specialized households rank second with 100,860 yuan and 21,427 yuan; part-time households rank lowest with 83,565 yuan and 18,700 yuan. In terms of income composition, tourism-reception households have a relatively balanced distribution of forest-fruit, tourism and migrant work income, presenting a diversified "three-source support" structure with strong resistance to single risks; planting-specialized households are highly dependent on forest-fruit income (over 60%), vulnerable to market price and natural disaster shocks; part-time households balance forest-fruit and migrant work, with migrant work hedging forest-fruit operational risks but limited total income scale.

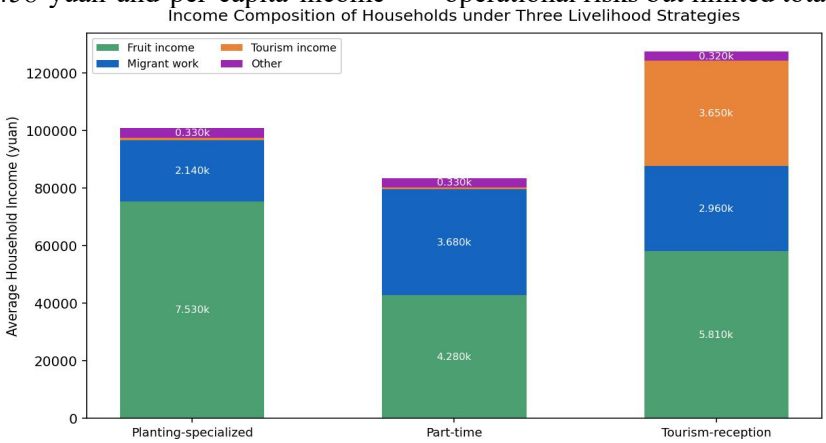


Figure 4. Income Composition of Households under Three Livelihood Strategies

6.2 Impact of Agriculture-Tourism Integration on Per Capita Income: T-test

Welch's t-test shows that the mean per capita income of participating households is 28,192 yuan, and that of non-participating households is 19,252 yuan, with participating households 46.4% higher, and the t-statistic is 8.662, highly significant at the 1% level ($p<0.01$). This result preliminarily confirms that agriculture-tourism integration has a significant positive income-increasing effect on farm household per capita income. It should be noted that the t-test only identifies between-group differences and cannot rule out self-selection bias (more capable households are more inclined to participate in agriculture-tourism integration), and the subsequent regression analysis will control relevant variables.

6.3 Impact of Agriculture-Tourism Integration on Per Capita Income: Regression Analysis

Using the logarithm of farm household per capita income as the dependent variable, and agriculture-tourism participation degree, five capital indices, education years, and labor force as explanatory variables, a multiple linear regression is conducted (see Table 4). The overall R^2 of the model is 0.381, N=500, with moderate goodness of fit. The core results are as follows:

Table 4. Regression Results of the Impact of Agriculture-Tourism Integration on Per Capita Income (Dependent Variable: ln(per capita income))

Variable	Coefficient β	Std. Error	t-value	p-value
Intercept	9.172	0.110	83.32	0.000***
Agri-tourism participation	0.480	0.073	6.54	0.000***
Natural capital	0.402	0.057	7.09	0.000***
Physical capital	-0.017	0.092	-0.19	0.852
Financial capital	0.997	0.110	9.06	0.000***
Human capital	-0.135	0.309	-0.44	0.663

Social capital	-0.012	0.057	-0.22	0.830
Education years	0.002	0.008	0.24	0.811
Labor force	0.049	0.043	1.14	0.255
*Note: *** denotes significance at the 1% level; R^2=0.381, N=500; estimated by Ordinary Least Squares (OLS).*				

First, the coefficient of agriculture-tourism participation degree is 0.480 (t=6.54, p<0.01), significantly positive at the 1% level, indicating that for every 10 percentage point increase in agriculture-tourism participation degree, farm household per capita income increases by about 4.8%. This quantitative evidence directly supports the core hypothesis that "agriculture-tourism integration significantly promotes farm household income growth".

Second, the coefficient of financial capital is 0.997 (t=9.06, p<0.01), which is the largest and most significant among all variables, indicating that financial capital is the key lever for farm household income growth. This corroborates the earlier finding that "financial capital of participating households is significantly higher than that of non-participating households", suggesting that financial accessibility is the core bottleneck restricting livelihood upgrading of farm households in forest-fruit areas.

Third, the coefficient of natural capital is 0.402 (t=7.09, p<0.01), significantly positive, indicating that planting scale and yield level remain the basic variables for income growth of farm households in forest-fruit areas, and the traditional logic of "relying on heaven and land for gold" still holds.

Fourth, the coefficients of physical capital (β=-0.017, p=0.852), human capital (β=-0.135, p=0.663), and social capital (β=-0.012, p=0.830) are all insignificant, and education years (β=0.002, p=0.811) and labor force (β=0.049, p=0.255) are also insignificant. This result seems counter-intuitive but actually reveals the structural shortcomings of current agriculture-tourism integration in forest-fruit areas: physical capital accumulation (such as purchasing machinery, expanding housing) has not been effectively converted into income-generating capacity; human capital investment (education, training) has not yet been effectively connected with the service, marketing and digital skills required for agriculture-tourism operation; social capital has accumulated at the cooperative level but has not yet been deeply converted into market bargaining and benefit-sharing capacity.

6.4 Relationship between Agriculture-Tourism Participation Degree and Per Capita Income

The scatter plot (see Figure 5) further presents the positive relationship between agriculture-tourism participation degree and farm household per capita income: as the participation degree increases from 0 to over 90 points, per capita income shows an overall upward trend, and the slope of the fitted line is positive. It is worth noting that non-participating households (blue points) mainly cluster in the range of participation degree 0-30 points and per capita income 0-30,000 yuan, while participating households (red points) are widely distributed in the range of participation degree 35-92 points and per capita income 10,000-60,000 yuan, with obvious stratification between the two distributions, corroborating the t-test conclusion.

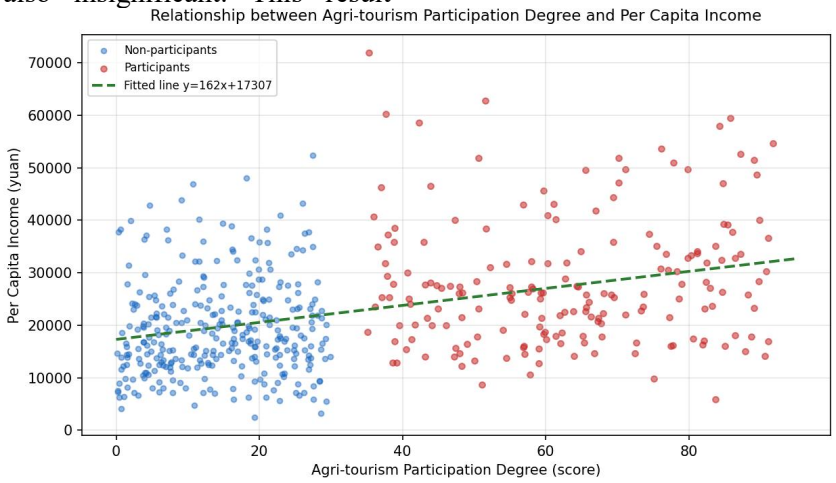


Figure 5. Relationship between Agri-tourism Participation Degree and Per Capita Income

6.5 Heterogeneity and Discussion

By region, the income-increasing effect of agriculture-tourism integration has heterogeneity: Tianshui Maiji and Pingliang Jingning apple areas, due to large planting scale and strong brand effect, can reach per capita income of over 28,000 yuan for tourism-reception households; Longnan Wudu pepper/olive area, due to high unit price and high added value of industrial chain, agriculture-tourism integration is more reflected in "processing experience + research", with a secondary income-increasing effect; Dingxi walnut area, due to small industrial scale and weak brand influence, has an agriculture-tourism integration penetration rate of only 22%, with relatively limited income-increasing effect. This heterogeneity suggests that agriculture-tourism integration policies need to be adapted to local conditions and avoid a "one-size-fits-all" approach.

7. Conclusions and Policy Recommendations

7.1 Main Conclusions

First, the livelihood capital structure of farm households in Gansu's characteristic forest-fruit areas shows the characteristics of "obvious differentiation of natural and financial capital, relatively balanced human and social capital", and agriculture-tourism integration participating households significantly outperform non-participating households in financial and social capital, but the gap in physical and human capital is very small.

Second, agriculture-tourism integration has a significant positive income-increasing effect on farm household per capita income, with participating households 46.4% higher than non-participating households ($p<0.01$); agriculture-tourism participation degree, financial capital and natural capital are the three core driving variables for income growth, while the marginal contributions of physical, human and social capital are limited, reflecting the structural shortcomings of current agriculture-tourism integration of "emphasizing hardware over human capital" and "emphasizing scale over linkage".

Third, agriculture-tourism integration significantly improves the livelihood sustainability of farm households. The sample shows that the mean income volatility of participating households is only 0.240, far lower than 0.442 of non-participating households, a decrease of 45.7%, indicating that agriculture-tourism integration effectively mitigates the market and natural risk shocks of single forest-fruit operation through diversified income sources, enhancing the anti-vulnerability capacity of farm household livelihoods.

Third, among the three livelihood strategies, tourism-reception households have the highest per capita income (28,306 yuan) and the most diversified income sources, with the strongest risk resistance; planting-specialized households rank second; part-time households rank lowest. The "tourism-reception" strategy spawned by agriculture-tourism integration is an effective path for livelihood upgrading of farm households in forest-fruit areas.

Fourth, regional heterogeneity is significant. Dingxi walnut area has both low natural and financial capital, with per capita income only 53.7% of Tianshui Maiji, making it a key area for policy support.

7.2 Policy Recommendations

7.2.1 Improve industrial quality and efficiency, and consolidate the natural capital foundation

Continue to promote standardized planting and variety improvement of advantageous varieties such as Huaniu apple, Jingning apple, Wudu pepper and olive, and consolidate the "Ganwei" brand matrix. For relatively weak producing areas such as Dingxi walnut, narrow the regional gap through variety renewal, low-yield orchard transformation, and deep processing to extend the industrial chain.

7.2.2 Deepen benefit linkage, and break the dilemma of "emphasizing scale over linkage"

Encourage the benefit linkage mechanism of "leading enterprises + cooperatives + farm households", promote models such as order agriculture, guaranteed purchase, and secondary profit return, so that farm households can share the added value of processing and tourism. Focus on improving the conversion efficiency of social capital into market bargaining capacity.

7.2.3 Cultivate human capital, and fill the shortcoming of "emphasizing hardware over human capital"

Conduct targeted training on new skills required for agriculture-tourism operation, such as service reception, short video marketing, live e-commerce, and homestay management. Promote the connection between education and training investment and the job demand of the

agriculture-tourism industrial chain to enhance the marginal output of human capital.

7.2.4 Improve risk prevention, and enhance livelihood sustainability

Improve agricultural insurance and price index insurance to reduce market and natural risks of forest-fruit operation; develop inclusive finance to enhance farmers' credit accessibility and break the financial capital bottleneck; establish cooperative risk reserves and emergency mechanisms to enhance group shock resistance.

7.3 Research Limitations and Prospects

This paper has three limitations: first, the micro survey data is a simulation based on authentic macro parameters, which can reflect overall characteristics but still differs from first-hand field survey data; future research should conduct field household surveys to verify the conclusions; second, the regression model does not address the endogeneity problem of self-selection bias, and subsequent research can use PSM-DID or instrumental variable methods to further identify causal effects; third, the measurement of agriculture-tourism integration mainly relies on the single indicator of participation degree, and future research can construct a multi-dimensional agriculture-tourism integration index to refine the differences in integration models.

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