frontiers | Frontiers in Environmental Science

TYPE Original Research
PUBLISHED 08 September 2022
DOI 10.3389/fenvs.2022.902153

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Environmental Economics and Management, a section of the journal Frontiers in Environmental Science

RECEIVED 23 March 2022
ACCEPTED 15 August 2022
PUBLISHED 08 September 2022

CITATION
Ning C, Xie F, Xiao H, Rao P and Zhu S (2022), Impact and mechanism of rural labor migration on forest management income: Evidence from the Jiangxi Province, China.
Front. Environ. Sci. 10:902153.
doi: 10.3389/fenvs.2022.902153

Impact and mechanism of rural labor migration on forest management income: Evidence from the Jiangxi Province, China

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This article explores how rural labor migration affects the forest management income. Based on consecutive annual surveys of 397 forest households in the Jiangxi Province from 2011 to 2018, the panel-Tobit and IV-Tobit and mediation models are conducted. The studies showed that the migration effect of labor migration inhibits forest management income, and the remittance effect of labor migration has a promoting effect, but the total effect of labor migration inhibited household forest management income. A heterogeneity analysis showed that, the labor migration effect in hilly and mountainous areas has a significant inhibitory effect on forest management income, while the promoting effect of the remittance effect of labor migration on forest management income is only significant in plain areas. At the same time, compared with the elderly group, the migration effect of labor migration of the youth group has a greater inhibitory effect on household forest management income, while the impact of the remittance effect of labor migration is only significant in the elderly group. A test of action mechanism showed that, cash investment plays a partial mediating role on the impact of labor migration effect on forest management income, but it has a suppressing role in the impact of the remittance effect. Labor input plays a partial mediating role on both the labor migration effect and the labor remittance effect on forest management income. Our analysis provides an important basis for policymakers to formulate pertinent policies to support forest management in collective forest regions.

KEYWORDS

labor migration, collective forestland, forest management income, IV-Tobit model, mediation model, migration effect, remittance effect

Introduction

Rural households' income is the key to solving China's "agriculture, rural areas, and farmers" problems, and the sustainability of its growth is related to a series of issues such as social order stability and healthy growth of the national economy (Cai and Wang, 2005; Wang et al., 2018; Zhang et al., 2020). Rural households' disposable income consists of wage income, operational income, property income, and transfer income (Zhao and Barry, 2014). In 2021, the per capita disposable income of rural residents in China was 18,931 yuan, of which the per capita operational income was 6,566 yuan, accounting for 34.68% (NBSC, 2022). Agricultural management income is still an important source of income for rural families (Yin et al., 2019; Yang et al., 2021). It is an effective way to increase rural households' income by promoting agricultural management income (Ojeda Luna et al., 2020; Yu et al., 2020). In many developing countries, forest resources play a critical role in supporting the livelihoods and increasing the household income of the poor (Rayamajhi et al., 2012; Asfaw et al., 2013; Oli et al., 2016; Siraj et al., 2016; Fonta et al., 2021), and forest management has made great contributions to poverty reduction (Siraj, 2019; Begazo Curie et al., 2021). In addition, forest management has also created ecological benefits such as a carbon sink and green environment for the whole society (Luyssaert et al., 2018; Hou et al., 2019). Therefore, it is of great practical significance to study rural households' forest management behavior and forestry income in developing countries.

China's forestland covers a total area of 218 million hectares, which is divided into state-owned forests and collective forests, of which 61.34% are collectively-owned forests and 6.94 billion cubic meters are collectively-owned forests (NFGA, 2018). Collective forestland is mainly concentrated in the central, southern, and southeast mountainous areas of China. For a long time, the productivity level of collective forestland was low, and so was the stock level of timber (Yin et al., 2013). The fundamental reason lies in the high degree of long-term public ownership of collective forest property rights in China, unclear property rights, and the responsibilities of forest resource management (Yao, 2003; Krul et al., 2020). Therefore, in June 2003, the state council issued *the Decision on Accelerating Forest Development*, and launched a new round of collective forest right system reform, the main contents of which were clarifying property rights, reducing taxes and fees, liberalizing management, and standardizing circulation. In the same year, the pilot implementation began in the Fujian, Jiangxi, Zhejiang, Yunnan, and Liaoning provinces. In 2008, the state council comprehensively promoted this reform throughout the country. At the same time, after the reform and opening-up, "the tide of migrant workers" has become the symbol of China's economic prosperity and development (Liu and Tian, 2005). In 2020, there were 286 million migrant workers in China, including 170 million migrant workers and 116 million local migrant workers (NBSC, 2021). It is an irreversible trend for rural labors to migrate out to non-farming sectors in developing countries (Fox, 2016). Many studies have shown that labor migration does not mean a full or final withdrawal from agricultural production, which only enriches family livelihood sources and becomes a characteristic of agricultural life in many developing countries (Rigg et al., 2016; Kelley et al., 2020). However, the outflow of a large number of high-quality rural laborers has caused great impact on forest production and management (Peluso and Purwanto, 2018). Therefore, under the background of forest tenure reform and rural labor migration in China, analyzing the impact of labor migration on households' forest management income and its mechanism can provide some enlightenment for other developing countries.

In the existing literature, the research results of labor migration on agricultural management and households' income are abundant, which laid the foundation for the development of this study. Relevant views are varied. Some scholars believe that non-farm employment can promote resource allocation, which is conducive to agricultural production and income (Zhang et al., 2017; Blakeslee et al., 2020). Due to technological progress and the popularity of mechanization and agricultural socialization services, non-farm employment may not lay a negative impact on agriculture (Hou and Chen, 2019; Van Loon et al., 2020). Conversely, it may promote the optimal allocation of labor resources and boost agricultural productivity (Khandker and Koolwal, 2010). Furthermore, studies have found that farmers use non-farm income for agricultural production (Davis and Lopez-Carr, 2014; Fox, 2016), such as expanding the scale of operation (Li et al., 2018; Pokharel and Featherstone, 2019; Zhang et al., 2019), purchasing agricultural trusteeship services (Sun and Su, 2012; Li and Zhuang, 2021), and improving infrastructure (Li et al., 2020; Oviedo et al., 2021), so as to increase the agricultural income. However, some scholars hold the opposite view. Some scholars suggest that non-farm work does not promote investment in agricultural production (Xie et al., 2013; Schmidt et al., 2017), farmers may remit cash for basic living improvement (Isoto and Kraybill, 2017; Kapri and Jha, 2020; Ajefu and Ogebe, 2021), conspicuous living expenses (Ngoma and Ismail, 2013), human capital investment (Calero et al., 2009; Askarov and Doucouliagos, 2020), and non-agricultural entrepreneurship (Wassink, 2020; Kharel et al., 2021). Because of the low relative income of farmland operations, based on the rational principle, farmers will reduce the farmland operation behavior and rent-in land (Rahman, 2010). It is also the main reason for numerous land abandonments in rural areas (Li et al., 2018; Han and Song, 2019; Xu et al., 2019).

There are relatively few studies on the impact of labor migration on forestland management and income. The existing research viewpoints are similar to those on the

impact on farmland management. In labor-intensive or low-replacement forest production (Eriksson, 2018; Mbeche et al., 2021), the outflow of high-quality rural labor has exacerbated the aging of rural labor and the degree of feminization (Killian and Hyle, 2020; Zhu et al., 2020; Shui et al., 2021). The decrease in the quality of the rural surplus labor force has inevitably led to an increase in the investment of employed labor, which greatly squeezes the actual profits of forest production and directly affects the farmers' enthusiasm for forest management (Lu et al., 2017), households may reduce their forest management behavior or even withdraw from forestry. On the other hand, due to the long cycle of forest management, some scholars believe that rural non-farm employment has little impact on forest management, and even non-farm income could promote management investment and increase forestry income (Xu et al., 2021). In addition, researchers also point out that the impact of labor migration on forest management is heterogeneous. Studies have shown that labor migration has different effects on households with different scales of forestlands: it encourages households with large-scale forestlands to increase investment while inhibiting forest management behaviors of those with small-scale forestlands (Zhu et al., 2019). The excessive labor migration in mountainous areas has led to a long-term inefficiency of the household economy, which has inhibited the growth of farmers' income (Lai and Xu, 2019).

In summary, there is no consensus in the academic community on the direction and path mechanisms of the impact of labor migration on households' forest management and forestry income. The two main reasons for this situation are: on one hand, the unreasonable use of research data. Scholars use annual cross-sectional data to study the problem of forestry management, which violates the long-term characteristics of forestry management. On the other hand, the accuracy of the study variable index is insufficient. Scholars rarely combine the duality (migration effect and income effect) of labor migration with the village and family endowment resources, which is not conducive to the formation of targeted conclusions and countermeasures. Therefore, based on the re-visited survey data of 397 households, 49 townships, 10 counties, in forest areas of the Jiangxi Province for 8 years, this article constructs a mechanism research framework of "labor migration–forest management investment–forest management income" with the help of the panel-Tobit model. The research conclusions and policy implications of this article will provide Chinese wisdom for improving the world forest development path. We mainly focus on the following two questions: 1) From the perspective of long-term data, what is the impact and mechanism of labor migration on forest management income? 2) Is there a heterogeneous impact of labor migration on the forest management income between households from different landform-type villages (plains, hills, and mountains) and operators of different ages of household heads (youth and elderly)?

The structure of this article is as follows: We expound the theory of the research framework and propose the corresponding research hypothesis in Section 2; In Section 3, we describe the data source and the variables and research methods. Then, in Section 4, we present the empirical research results, including the benchmark test, robustness and heterogeneity tests, and mechanism research. In section 5, we propose the discussion and conclusions.

Theoretical framework

For a long time, China's rural areas were in a state of labor surplus. Since the reform and opening-up in 1978, the improvement of the market economy system has accelerated the process of industrialization and created more jobs, but it has also greatly promoted the migration of rural surplus labor force to central cities or industrially developed areas (Carter, 1997; Li et al., 2021; Xiao et al., 2021), which has brought "demographic dividend" to Chinese development (Sun, 2008; Yang, 2021). However, with the deepening of rural labor migration, the shortage of a surplus labor force in China and the substantial increase of rural labor wages coexisted. *The Lewis turning point* has arrived, and rural labor was in short supply (Cai, 2007; Wang et al., 2020). From the perspective of rural households, the number of family laborers is limited, and the high-quality labor is prioritized for non-farm employment to obtain more returns, which leads to the aging and feminization of the existing rural labor force (Shang, 2018; Zou et al., 2018; Zhu et al., 2020). From the view of the migration effect, a large number of the rural high-quality labor force migrating out leads to the large use of weak labor force in forest production, which reduces the efficiency of forest management, directly leading to the increase of forest management costs and suppresses the forest management income. From the view of the remittance effect, households use the non-farm income for forest management investment, which has a certain role in promoting the forest management income. However, under the joint force from the two aspects, due to the limited mechanization of forest management and the generally low quality of labor force, substitution of the remittance effect for the migration effect is insufficient. The overall effect of labor migration on forest management income will be inhibitory.

The labor input is directly related to the efficiency of forest management (Xie et al., 2019a). Furthermore, forest-operating income is the biggest motivation for households to make decisions about labor migration or forest management. If the information is certain, people can easily compare the income between labor migration and forest management, and conduct more profitable labor-distributive decisions. However, it is rare to determine information, and people always make emotional decisions at uncertain informational situations (Agarwal et al., 2016; Elahi et al., 2021b; Elahi et al., 2022a). Therefore, farmers

will input labor to continue to maintain forest management when the stability of the non-farm job market is uncertain. Under the circumstance that mechanization cannot be widely used in forest management, if the family wants to maintain the original forestland scale, it is an inevitable choice to hire labor (Ospina et al., 2019). With the rise of labor wages, the fall of rural surplus labor quality, and extreme weather event risks to crop-production (Abid et al., 2019; Elahi et al., 2021a), hiring labor for forest management will lead to an increase in operating costs. As the hire costs more than the profit, farmers will reduce such decisions, thereby inhibiting the increase in family forest operating income. However, the remittance income of non-farm employment can provide funds for hiring labor, which will bring about the increase of forestry income. Hiring labor with remittance income can ensure forest production, which is a reasonable choice for farmers who cherish the forestry land.

On the other hand, cash outlay is also an important factor affecting the income of forestland management. Generally speaking, households can increase the cash input in forest management to optimize the structure of production factors or expand the scale of operation, so as to achieve the goal of improving the efficiency of forest management. However, with the deepening of labor migration, a large outflow of high-quality labor leads to the overall aging and weakening of the rural labor force (Wang et al., 2020; Lee et al., 2021). Under the case of incomplete forest mechanization, new technologies and new machinery are difficult to be effectively popularized and used, and the benefits brought by the households' blind increase in cash investments must be limited (Duan et al., 2021). Therefore, with the deepening of labor migration, especially the out-migration of young family laborers, households will reduce cash spending, thereby inhibiting the growth of the family forest management income. At the same time, the essence of deepening labor migration is the rational allocation of high-quality labor, so, different labor levels and different regions will inevitably have different research conclusions, and there are heterogeneity problems.

Based on the aforementioned discussion, this article proposes the following three research hypotheses: **H1:** Labor migration has an inhibitory effect on household forest management income. **H2:** There are differences in the impact of labor migration on forest management income between mountainous villages, hilly villages, and plain villages, as well as household heads with different ages. **H3:** Both labor input and cash outlay are effective paths of the effect of labors' migration on forest management income.

Data and methods

Data

Study area

The Jiangxi Province is a key forest province in southern China's collective forest areas, where nearly 2/3 of the rural population lives in mountainous areas, 2/3 of the land is mountainous, and 2/3 of the counties (cities) are key forest counties (cities). The province's forestland area reached 10.72 million hectares, and the collective forestland area was 9.13 million hectares, accounting for 85% of the province's forestland, with a forest coverage rate of 63.1 %, ranking second in the nation (NFGA, 2018). By the end of 2020, the total stock of living wood reached 685 million cubic meters, and the unit area of the arbor forest reached 78.9 cubic meters per hectare, and the total forest output value had increased from 306.3 billion yuan in 2015 to 511.2 billion yuan in 2019; the total output value of the forest was ranked sixth in China (JXPG, 2021). In 2020, the total number of migrant workers in the province was 12.373 million, including 4.202 million local migrant workers and 8.171 million migrant workers (JXBS, 2021).

An urgent problem facing local governments and management departments is how to transform the advantages of Jiangxi's forest resources into economic advantages, so as to achieve the goals of turning resources into assets, making forest industry prosperous, and increasing the income of forest farmers. The new round of forest tenure reform policies is on the agenda. The forest tenure reform in the Jiangxi Province mainly went through the following stages. The first was the pilot stage. In 2004, the Jiangxi Provincial Party Committee and the Provincial Government issued the *Decision on Accelerating Forest Development* and *Opinions on Deepening the Reform of the Forest Tenure System* and other documents, focused on deepening the reform of the collective forest tenure system. And in September 2004, the forest tenure reform pilot work was carried out in seven key forest counties (cities) including Chongyi and Tonggu. The second was the full implementation stage. In 2005, the forest tenure reform with the main content of "clarifying property rights, reducing taxes and fees, easing operation, and regulating circulation" was launched throughout the Jiangxi Province. At the end of 2006, the forest tenure reform, with "clarifying property rights and allocating forestland to households" as the core content, was basically implemented. Then, rural households became the main body of forestland management. The third is the perfecting and deepening reform stage. Since the basic completion of the forest tenure reform in 2009, the Jiangxi Province has successively issued a series of supporting reform policies to strengthen forest social services, improve forest logging management, standardize forest tenure transfer, establish a public financial system to support collective forest development, and promote forest investment and financing (Hyde, 2019; Xu and Hyde, 2019). The aim is to continuously improve and deepen the collective forest tenure reform in Jiangxi, improve farmers' enthusiasm for forest management, and stabilize income growth (Yin et al., 2013).

Data sources

The data used in this article are from annual re-visited surveys of rural households in the Jiangxi Province from 2011 to 2018. Each summer, we conducted a survey about the

living and production activities of sample households in the last year. In total, we have conducted eight annual surveys. Following the national statistical standards (JXBS, 2021) and previous research studies (Xiao et al., 2021), migrant laborers refer to those who migrate outside of the local townships to engage in non-farm work for more than 6 months during the survey year. The sample selection method was as follows: first, we selected 10 sample counties according to the geographical location and economic development level; then, we randomly chose five sample villages from each sample county and 10 sample households from each sample village. Finally, the sample consisted of 500 rural households from 50 villages in 10 counties. For each sample household, trained investigators conducted a face-to-face interview with a knowledgeable family member, usually the household head. The data collected in the questionnaire included family demographic characteristics, employment status of each family laborer, forest resources, forest management input and income, progress status of the collective forest tenure reform, forest financial policy and forest reform policy needs, etc. For each sample village, the survey team also conducted a village-level questionnaire survey with the village committee members. The survey contents included the villages' socioeconomic and forest management conditions. It usually took 45–60 min to finish a questionnaire. In addition, the study also extracted the topographic data of the sample villages through the Digital Elevation Model (DEM). The data collected are for the year before the survey.

Actually, it was very difficult to re-visit the same sample households over an 8-year period. Some sample households could not be contacted due to them moving out or other irresistible factors. Then, we selected another household with similar characteristics to ensure the sample size. This article focused on analyzing the impact of rural labor migration on family forest management and income. Therefore, we deleted the interrupted sample households, and finally got 397 sample households with continuous surveys from 49 sample villages in 10 counties.

Variable selection

This article focuses on the influence of labor migration on household forest management input and output. The factors affecting household forest management input and output are multifaceted. Table 1 shows the definition of various variables in this research.

Explained variable

Forest management income (*FoIn*) is the explained variable that the research focuses on. It is mainly measured by the household forest income and forestry-related government subsidies (Xie et al., 2019b), such as, timber forest income, bamboo forest income, economic forest income, non-timber forest product income, and forestland rent-out income.

Core variable

In order to deeply understand the impact of labor migration on forest management input and income, the study comprehensively analyzed the impact of labor migration from two aspects: migration effect and remittance effect. Among them, the migration effect is measured by three indicators: the ratio of migrant laborers to the total household laborers *(Tratio)*, the number of migrant laborers in the household (*Tnum*), and whether the household head migrated out *(Hnot)* (Xu et al., 2018). The remittance effect (*NoIn*) is represented by household non-farm income. Additionally, the total effect of migration is captured by whether the household has migration labors (*Tnot*) (Xie et al., 2019b).

Mediating variables

The research constructs the mechanism research framework of labor migration–forest management input–forest management income, and thus takes forest management input as an intermediary variable. We consider forestland management investment from two aspects: cash outlay (*Inv*) and labor input (*FoLa*). Cash outlay refers to the monetary expenditure in forest management, including costs of purchasing seedlings, chemical fertilizers, pesticides, machinery or livestock power, taxes, and fees (Xie et al., 2019a). Labor input consists of both households' own labor investment and hired labor, measured by the amount of time (person * days).

Control variables

For regional heterogeneity analysis, the study used the topographic data of the village where the sample households resided (*Type*) and the ages of the household heads as control variables (*Age*). Based on previous research studies and the actual situation of the study areas, we also chose family characteristic factors (education of household head (*Edu*), the number of laborers in a household (*Labor*), whether family members are village cadres (*Vcadres*), forest resource factors (timber forest area (*Timber_A*), economic forest area (*Economic_A*), bamboo forest area (*Bamboo_A*), and forest fragmentation (*Areatract*)), economic and geographical factors (village population (*V_pop*), per capita net income in the village (*V_income*), and the distance from village to nearby town (*Distance*)) (Bao et al., 2021; Lian et al., 2021; Wang et al., 2021; Liu et al., 2022).

Empirical strategy

First, because forest management requires a long period, the households' forest income is 0 yuan for many years, and when households are not active in forest management, their forest income is also 0 yuan. In this case, the Tobit model is more

TABLE 1 Descriptive statistics of the survey data.

Variable	Definitions	2010		2017	
		Mean	SD	Mean	SD
FoIn	Forest management income (yuan)	7765.72	16867.61	16183.63	46425.41
Tratio	The proportion of migrant laborers to total household laborers (migration effect) (%)	0.37	0.33	0.40	0.38
NoIn	Household non-farm income (remittance effect) (yuan)	3828.43	5145.16	9848.14	17507.27
Tnot	Whether there are migrant laborers in a household (1 = Yes, 0 = No)	0.64	0.48	0.62	0.49
Tnum	Number of migrant laborers in a household (persons)	1.30	1.40	1.28	1.38
Hnot	Whether the head of the household is a migrant (1 = Yes, 0 = No)	0.11	0.32	0.20	0.40
Age	The age of the head of the household	50.69	10.10	57.69	10.10
Type	Topographic type of the village (1 = plain, 2 = hill, 3 = mountain)	1.88	0.73	1.88	0.73
Vtratio	The proportion of migrant laborers to the total laborers in the village (%)	0.46	0.24	0.54	0.19
Inv	Households' cash outlay in forest management (yuan)	494.1	1372.1	7443.8	24528.8
FoLa	Households' labor input in forest management (days)	71.60	123.14	78.94	510.52
Edu	The education level of the head of household (1-elementary school and below, 2-junior high school, 3-high school (secondary technical secondary school), and 4-college and above)	1.89	0.83	1.91	0.82
Vcadres	Whether there are village officials in a household (1 = Yes, 0 = No)	0.30	0.46	0.41	0.49
Labor	The number of laborers in a household (persons)	3.07	1.63	2.75	1.59
Areatract	Average forestland area per tract (ha/tract)	1.70	3.23	1.45	2.08
Timber_A	The area of timber forest (ha)	2.43	5.50	2.71	6.24
Economic_A	The area of bamboo forest (ha)	1.47	6.15	0.98	3.04
Bamboo_A	The area of economic forest (ha)	2.24	4.51	3.16	6.83
Vpop	Population size of the village (hundreds persons)	15.16	9.69	16.68	10.81
Vincome	Per capita net income of the village (yuan)	3944.92	1548.27	5863.95	3796.22
Distance	The distance from the village to the nearby township (km)	7.21	6.03	7.21	6.03

1. Migrant laborers refer to those who migrate outside of the local townships to engage in non-farm employment for more than 6 months during the survey year. 2. *Inv*, *NoIn, FoIn* and *Vincome* were all processed at constant prices in 2010. And 1 USD = 6.65 yuan, in year 2010. 3. In order to eliminate heteroscedasticity, logarithmic transformation of *Inv*, *NoIn*, *FoIn*, *Timber_A*, *Economic_A*, *Bamboo_A*, and *Vincome* were performed in the Models. 4. To save space, this table only reports the data in 2010 and 2017.

suitable than the least squares model (De Souza Filho et al., 2019). The Tobit model can solve the problem of sample self-selection to some extent. Therefore, this article used survey data from 397 sample households for eight consecutive years to construct a panel Tobit model to study the impact of labor migration on forest management income. The specific model is as follows:

$$Y_{it} = Y_{it}^{*} = \begin{cases} \alpha_1 + \beta_1 migrate_{it} + \sum_{n=1}^{N} \gamma_{1n} X_{it} + \epsilon_{it}, Y_{it}^{*} > 0 \\ 0, Y_{it}^{*} \le 0 \end{cases} \quad (1)$$

In formula (1), Y_{it}^{*} represents the forest management income of the *i*th household in year t, $migrate_{it}$ represents the labor migration variables (including the remittance effect and migration effect, such as *NoIn* and *Tratio*) of the *i*th household in year t, and X_{it} denotes other control variables for the *i*th household in year t, α_1, β_1, and γ_{1n} indicate the corresponding coefficients to be estimated, ε_{it} shows random interference terms and satisfied to be normally distributed with zero mean value and constant variance (Wooldridge, 2010; Schmidt and Finan, 2017; Elahi et al., 2020; Elahi et al., 2021a; Elahi et al., 2022b), and this statement is also subject to several of the following models.

Second, there may be mutual, causal endogenous problems between labor migration and family forest management income. Based on the "herd effect" of household decision-making, this article selected the village-level labor migration ratio as an instrumental variable. On one hand, the labor allocation decisions of rural households are easily affected by those of other households in the village, which satisfies the principle of correlation of instrumental variables. On the other hand, the village-level labor behavior has little impact on the household forest management income, which also satisfies the exogenous principle of instrumental variables. The specific model is as follows:

$$migrate_{it}^{*} = \alpha_2 + \beta_2 Z_{it} + \sum \gamma_{2n} X_{it} + \sigma_{it} \quad (2)$$

$$Y_{\mathrm{it}} = \alpha_3 + \beta_3 migrate_{it}^{*} + \sum \gamma_{3n} X_{it} + \mu_{it} \quad (3)$$

In formula (2),Z_{it} is the instrumental variable (the proportion of migrant laborers to the total laborers in the village (*Vtratio*). The purpose of formula (2) is to capture the

exogenous influence of labor migration on forest management income through the prediction and regression of exogenous variables. Formula (3) is to return the explained variables on the exogenous influence captured in formula (2) to eliminate the biased estimation generated by endogeneity, so as to realize the unbiased estimation. Both σ_{it} and μ_{it} show random interference terms and are satisfied to be normally distributed with zero mean value and constant variance.

Finally, according to the theoretical analysis in the second section, and based on the basis of formula (1) and previous research studies (Wen and Ye, 2014), the stepwise method was used to test the mediation effect, and further analyze whether the rural labor migration affects the household forest management input, and then affects the forest management income. The specific model is as follows:

$$med_{it} = \alpha_2 + \beta_2 migrate_{it} + \sum \gamma_{2n} X_{it} + \xi_{it} \quad (4)$$

$$Y^*_{it} = \alpha_3 + \beta_3 migrate_{it} + \eta med_{it} + \sum \gamma_{3n} X_{it} + \upsilon_{it} \quad (5)$$

In formulas (4) and (5), med_{it} shows the mediating variable of labor migration to the income of household forest management, it includes cash investment (*Inv*) and labor input (*FoLa*). We further tested the mechanism of labor migration on the income of household forest management. Both ξ_{it} and υ_{it} showed random interference terms and were satisfied to be normally distributed with zero mean value and constant variance.

Empirical results

Summary statistics

Table 1 summarizes the means and standard deviations of the variables. To be concise, we only presented the data in 2010 and 2017. Overall, the income of the forest households in the Jiangxi Province has doubled, with the average forest income per household being 7,766 yuan in 2010, while the average forest income reached 16,184 yuan in 2017. This indicated that the forest tenure reform in the collective forest areas has effectively liberated the productive forces of forest households and activated the vitality of the forest industry. As to the investment in forest management, the average cash investment of households in forest management in 2010 was 494 yuan per household, while the cash investment in 2017 reached an average of 7,444 yuan per household, an increase of 15 times in 8 years. The average labor input per household was 71.6 days in 2010, and that was 78.94 days in 2017, indicating an increase in the labor input. In general, as the two main input factors of forest management, cash outlay and labor investment seem to have played a certain role in the growth of households' forest income, but the specific effect needs to be further tested.

There has been a trend for labor migration, and the proportion of labor migration in rural households remains high. Overall, 64% of the sample households had migrant laborers in 2010, and that was 62% in 2017. Furthermore, for the migration effect indicators, in 2010, the average number of household laborers in the sample reached 3.07, the number of migrant laborers reached an average of 1.3 persons per household, and the mean migration ratio of household laborers was 36.60%. In 2017, the households' laborer number was 2.75 people per household, the labor migration ratio reached 40.44%, and the average migrant laborer number reached 1.28 people per household. In terms of income effect indicators, the mean of the annual non-farm income increased from 3,828 yuan to 9,848 yuan.

As for the household head characteristics, the sample data show that household heads are of high age and low education level. In 2017, the average age of the household heads was 57.69 years of age, and the mean education level was between primary school and junior high school. In terms of family characteristics, the rate of the sample households of the village cadres had increased, from 30% in 2010 to 41% in 2017. The mean number of household laborers had decreased from 3.07 persons in 2010 to 2.75 persons in 2017. In terms of forestland characteristics, the average area of a timber forest was 2.43 ha in 2010, and it increased to 2.71 ha in 2017. The average area of an economic forest was 1.47 ha in 2010, and it decreased to 0.98 ha in 2017. The average area of a bamboo forest was 2.24 ha in 2010, and it increased to 3.16 ha in 2017. While the degree of fragmentation of forestlands increased slightly, in terms of village economic geography factors, the average village population was 1,516 in 2010 and 1,668 in 2017, the average village income increased from 3,945 to 5,864 yuan, and the average distance from the village to the nearby town was 7.2 km, 33.5% of the villages belonged to the plain type, 45.3% of the villages belonged to the hill type, and 21.2% of the villages belonged to the mountain type.

Estimated results

Benchmark regression model

This article uses the statistical software Stata16 to estimate the data of 397 households for a total of 8 years. Aiming at clarifying the impact of labor migration on the income of household forest management income, the models were constructed following the research content and the principle of going from simple to complex. The regression results are shown in Table 2.

Models 1–3 show that, without considering endogeneity, only the migration effect (*Tratio*) and remittance effect (*NoIn*) of labor migration on the income of forest management were concerned. The results showed that *Tratio* has a significantly

TABLE 2 Results of benchmark regression of labor migration on forest management income.

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model7
Tratio	−0.411***		−0.393***	−0.410***	−0.337***	−3.585***	
	(0.118)		(0.120)	(0.118)	(0.117)	(0.830)	
NoIn		−0.041	−0.026	−0.029	−0.043	0.085*	
		(0.027)	(0.028)	(0.028)	(0.028)	(0.048)	
Tnot							−2.764***
							(0.675)
Age				−0.006	0.003	0.011**	0.005**
				(0.005)	(0.005)	(0.005)	(0.002)
Type				0.684***	0.470***	0.544***	0.525***
				(0.079)	(0.076)	(0.067)	(0.069)
Edu					0.144**	0.055**	0.098*
					(0.066)	(0.027)	(0.055)
Vcadres					0.046	−0.199*	−0.209*
					(0.086)	(0.111)	(0.116)
Labor					0.063**	0.228***	0.392***
					(0.025)	(0.048)	(0.091)
Areatract					0.012	0.009	−0.007
					(0.020)	(0.019)	(0.020)
Timber_A					0.085*	0.057	0.096*
					(0.049)	(0.049)	(0.050)
Economic_A					0.322***	0.241***	0.252***
					(0.059)	(0.067)	(0.068)
Bamboo_A					0.441***	0.366***	0.402***
					(0.056)	(0.068)	(0.069)
Vincome					−0.579***	−0.614***	−0.555
					(0.161)	(0.186)	(0.414)
Vpop					−0.008	−0.005*	−0.006
					(0.005)	(0.002)	(0.004)
Distance					−0.006	−0.006*	0.001
					(0.009)	(0.004)	(0.007)
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	1.563***	1.526***	1.627***	0.661*	1.442**	1.596***	2.177**
	(0.114)	(0.132)	(0.135)	(0.358)	(0.586)	(0.595)	(0.958)
Observations	3176	3176	3176	3176	3176	3176	3176
Wald χ^2	286.75***	297.8***	402.17***	377.05***	528.35***	590.36***	529.37***
Endogenous Wald χ^2	—	—	—	—	—	18.01***	19.57***

Standard errors are in parentheses ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

negative influence on household forest income, and the effect of *NoIn* does not pass the statistical significant test. That is to say, the higher the migration ratio of household labor, the lower the forest management income is.

The village type (*Type*) and household head age (*Age*) were added in Model 4. The coefficient of *Tratio* is negative and significantly correlates with the household forest management income, while *Type* has the opposite effect. This indicates that households in mountainous villages could have higher forest incomes than those in plain villages. However, both the age of the household head and non-farm income have no significant impact on the forest management income.

In Model 5, other control variables were added. The results of the migration effect (*Tratio*) and remittance effect (*NoIn*) are consistent with those in Models 1–4. In Model 6, following previous studies (Xie et al., 2019b; Xiao et al., 2021), we introduced the village-level labor migration ratio as an instrumental variable (*Tratio*) to deal with possible endogenous problems. *Tratio* had a significantly negative influence on the forest management income, with its coefficient being -3.585. Non-

TABLE 3 Test of the robustness of the benchmark model.

Variable	2sls	Replace variable	
	Model 8	Model 9	Model 10
Tratio	−2.436***		
	(0.518)		
Tnum		−1.124***	
		(0.258)	
Hnot			−14.266**
			(6.959)
Noin	0.055*	0.051*	0.225*
	(0.032)	(0.031)	(0.136)
Age	0.006*	0.014***	−0.092*
	(0.003)	(0.005)	(0.047)
Type	0.349***	0.528***	0.805***
	(0.043)	(0.064)	(0.067)
Edu	0.009	0.049	−0.253
	(0.037)	(0.056)	(0.222)
Vcadres	−0.136**	−0.163	−1.149*
	(0.069)	(0.105)	(0.626)
Labor	0.149***	0.658***	0.039
	(0.031)	(0.141)	(0.055)
Areatract	0.013	0.016	−0.008
	(0.014)	(0.019)	(0.042)
Timber_A	0.06*	0.046	−0.185
	(0.033)	(0.048)	(0.167)
Economic_A	0.177***	0.262***	0.213
	(0.045)	(0.064)	(0.148)
Bamboo_A	0.279***	0.383***	0.395***
	(0.043)	(0.065)	(0.137)
Vincome	−0.145*	−0.649***	−0.724*
	(0.084)	(0.181)	(0.384)
Vpop	−0.003	−0.004	−0.025**
	(0.003)	(0.004)	(0.011)
Distance	0.002	−0.001	−0.014
	(0.005)	(0.007)	(0.015)
Year	Yes	Yes	Yes
Constant	1.003***	0.419**	9.737**
	(0.219)	(0.185)	(3.862)
Observations	3176	3176	3176
Wald χ^2	66.76***	605.90***	133.37***
Endogenous Wald χ^2	70.988***	17.80 ***	11.36***

Standard errors are in parentheses ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

farm income is significantly positively related to forest management income. The coefficient is 0.085, indicating that for every 1% increase in household non-farm income, the forest income increases by 0.085%.

Furthermore, in order to study the overall effect of labor migration on the household forest income, in Model 7, we used *Tnot* to replace *Tratio* and *NoIn*. The results showed that labor migration has an overall negative effect on the household forest management income. That is to say, research hypothesis 1 has been effectively verified.

Regarding the remaining control variables, after considering the possible endogeneity (Model 6), both *Age* and *Type* are significantly positively related to the household forest income, which provides ideas for the follow-up research on heterogeneity. Among the household characteristics, both *Edu* and *Labor* have significantly positive effects on the forest management income, reflecting that the comprehensive improvement of the rural laborer's human capital is an effective mechanism to achieve a sustainable growth of rural income. *Vcadres* had a significantly negative effect on the household forest income. Among forest resource factors (Model 6), both *Economic_A* and *Bamboo_A* had a significantly positive influence on the household forest income, and *Timber_A* did not pass the statistical significant test, which confirms that the income from different forest types is different. *Areatract* positively affected household forest income, but it was not statistically significant. The variables representing the village characteristics (*Vincome*, *Vpop*, and *Distance*) are all negatively related to the forest management income (Model 6).

Test of robustness

To verify the reliability of the aforementioned analysis, we replaced the regression method and key independent variables of Model 6. On one hand, the 2sls method was applied to replace the IV-Tobit method. The results are shown as Model 8 in Table 3. It indicated that *Vratio* is still an effective instrument variable. *Tratio* still has a significantly negative effect on the forest management income, and *Noin* is positively related to the forest management income, which is consistent with the benchmark regression estimates (Model 6). On the other hand, we used *Tnum* and *Hnot* to substitute for *Tratio*. The results are shown in Model 9 and Model 10, and both *Tnum* and *Hnot* are significantly negatively related to the income of the household forest management, which is still consistent with the benchmark regression results.

Heterogeneity analysis

The aforementioned studies have shown that the household labor migration had a significant inhibitory effect on the household forest management income, and the conclusion was robust. However, whether there are regional or group differences in this inhibitory effect still needs to be further explored. Therefore, we performed a heterogeneity analysis according to the village type and household head age.

On one hand, the sample households were grouped by the village type (Chen, 2020). The topographical locations of the Jiangxi Province are divided into plains, hills, and mountains, and there are obvious differences in the livelihood and forestland resource endowments. Based on this, we tested separate models for households from plain, hilly, and

TABLE 4 Heterogeneity analysis of the village types and ages for labor migration.

Variable	Plain	Hill	Mountain	Youth	Elderly
	Model 11	Model 12	Model 13	Model 14	Model 15
Tratio	−2.871	−5.345**	−4.086**	−4.373***	−2.856***
	(1.761)	(1.300)	(1.688)	(1.287)	(1.088)
Noin	0.200**	0.054	0.011	−0.009	0.183**
	(0.092)	(0.121)	(0.086)	(0.059)	(0.082)
Age	0.024**	0.014*	0.001	0.028***	−0.020*
	(0.012)	(0.008)	(0.008)	(0.011)	(0.011)
Type				0.599***	0.418***
				(0.093)	(0.100)
Edu	0.048	0.154*	−0.307**	0.020	0.074
	(0.122)	(0.091)	(0.136)	(0.082)	(0.095)
Vcadres	−0.537**	−0.162	0.007	−0.237	−0.093
	(0.243)	(0.233)	(0.157)	(0.145)	(0.166)
Labor	0.402***	0.173**	0.232**	0.192**	0.214***
	(0.118)	(0.088)	(0.104)	(0.079)	(0.063)
Areatract	−0.084	0.097*	0.034	−0.044	0.042*
	(0.052)	(0.050)	(0.022)	(0.034)	(0.025)
Timber_A	0.203*	0.016	0.117	−0.020	0.135*
	(0.112)	(0.081)	(0.091)	(0.070)	(0.072)
Economic_A	0.518***	0.183*	−0.068	0.292***	0.169
	(0.134)	(0.109)	(0.147)	(0.083)	(0.110)
Bamboo_A	0.227	0.477***	0.256**	0.480***	0.244**
	(0.158)	(0.165)	(0.107)	(0.083)	(0.118)
Vincome	−1.284***	−0.422	−0.619	−1.022***	0.075
	(0.403)	(0.391)	(0.674)	(0.227)	(0.328)
Vpop	−0.014	0.003	−0.035**	0.002	−0.011*
	(0.011)	(0.006)	(0.014)	(0.006)	(0.006)
Distance	0.031*	−0.005	−0.001	0.020*	−0.011
	(0.017)	(0.012)	(0.014)	(0.011)	(0.010)
Year	Yes	Yes	Yes	Yes	Yes
Constant	3.193**	1.390**	5.431**	1.933**	1.941*
	(1.376)	(0.656)	(2.115)	(0.801)	(1.128)
Observations	1064	1440	672	1720	1456
Observations Wald χ^2	112.02***	237.20***	186.32***	357.40***	262.84***
Endogenous Wald χ^2	11.66***	4.28**	6.82***	4.8**	13.77***

Standard errors are in parentheses ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

mountainous villages, respectively. The results are shown in Table 4. From the perspective of the labor migration effect, *Tratio* is not significant for households in plain areas. The negative impact of *Tratio* on the household forest income is stronger in hilly areas than that in mountainous areas. In terms of the remittance effect, only in the plain group, *Noin* has a significant promoting effect on household forest management income. On the other hand, the sample households were grouped by the age of the household head. Generally speaking, the age of the household head basically means the age of the entire household labor. Therefore, according to the distribution of Age, sample households with the household head's age above the average were classified into the elderly group, and the others were divided into the youth group. Similarly, we ran separated models for the two different groups. The results are shown in Models 14–15. In both the elderly group and youth group, *Tratio* has significant inhibitory effects on the forest management income, and the inhibitory effect of the youth group was greater than that of the old group. At the same time, only in the elderly group, *Noin*

TABLE 5 Mechanism of the effect of labor migration on the forest management income.

Variable	Inv	FoIn	FoLa	FoIn
	Model 16	Model 17	Model 18	Model 19
Inv		0.297***		
		(0.039)		
FoLa				0.333***
				(0.021)
Tratio	−2.622**	−2.813***	−3.157***	−2.533***
	(1.256)	(0.812)	(0.990)	(0.754)
Noin	−0.153**	0.089*	0.039*	0.072*
	(0.071)	(0.047)	(0.021)	(0.024)
Age	0.005	0.011**	−0.005	0.012***
	(0.007)	(0.004)	(0.005)	(0.004)
Type	−0.085	0.545***	0.219***	0.46***
	(0.101)	(0.065)	(0.079)	(0.059)
Edu	0.149*	0.044	−0.075	0.086*
	(0.086)	(0.055)	(0.068)	(0.050)
Vcadres	−0.350**	−0.163	−0.068	−0.166*
	(0.170)	(0.108)	(0.132)	(0.098)
Labor	0.209***	0.207***	0.223***	0.158***
	(0.074)	(0.047)	(0.058)	(0.044)
Areatract	0.032	0.004	0.009	0.003
	(0.027)	(0.018)	(0.023)	(0.017)
Timber_A	−0.164**	0.040	0.207***	0.002
	(0.073)	(0.047)	(0.058)	(0.043)
Economic_A	0.245**	0.209***	0.334***	0.146**
	(0.100)	(0.065)	(0.08)	(0.058)
Bamboo_A	0.024	0.366***	0.288***	0.281***
	(0.105)	(0.066)	(0.082)	(0.059)
Vincome	−0.393	−0.584***	−0.154	−0.589***
	(0.278)	(0.180)	(0.223)	(0.163)
Vpop	−0.011*	−0.004	−0.010**	−0.003
	(0.006)	(0.004)	(0.005)	(0.004)
Distance	−0.039***	0.006	−0.020**	0.007
	(0.011)	(0.007)	(0.009)	(0.006)
Year	Yes	Yes	Yes	Yes
Constant	1.582***	1.249**	3.425***	1.105**
	(0.369)	(0.578)	(0.715)	(0.442)
Observations	3176	3176	3176	3176
Wald χ^2	188.16***	687.42***	365.46***	729.63***
Endogenous Wald χ^2	3.87 **	15.63 ***	7.97 ***	10.64 ***

Standard errors are in parentheses ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

showed significantly positive influence on the household forest management income.

Mechanism analysis

To clarify the specific impact mechanism of labor migration on forest management income, we used the stepwise regression test from two aspects of forest management investment: labor input and cash outlay.

Model 16 and Model 17 in Table 5 are the results of the mediation effect of cash investment in forest management. In the first step of regression (Model 16), both *Tratio* and *NoIn* have significant negative influence on the cash outlay behavior (*Inv*) in

forest management. In the second step of regression (Model 17), the results showed that *Tratio* inhibits and *Inv* promotes the forest management income significantly. Therefore, according to the significance of variables and the consistency of the signs of direct effects and indirect effects, it is shown that the cash investment in forest management plays a mediating role in the impact of the labor migration effect on household forest income, with the mediation effect being 21.7%. It has a suppressing effect in the impact of the remittance effect on forest management income.

Model 18 and Model 19 in Table 5 are the results of the mediation effect of labor input in forest management. The same estimation method was used for the stepwise regression test. In the first step (Model 18), *Tratio* significantly inhibited labor input (*FoLa*), and *Noin* played a role in promoting household labor input. In the second step test (Model 19), the labor migration effect has a significant inhibitory effect on the forest income, the remittance effect has a promoting effect on the forest income, and labor input has a positive effect on the forest income. Therefore, according to the significance of variables and the consistency of the signs of direct effects and indirect effects, it is shown that labor input plays a mediating role in the effect of the remittance effect on forest management income, with the mediation effect being 29.3%, and it also plays a mediating role in the effect of labor migration effect on forest income, with the mediation effect being 15.3%.

Discussion and conclusions

Discussion

First, the re-visit panel data of typical sample households spanned up to 8 years, enabling us to consider the long-term effects of forest inputs and outputs more effectively. It not only ensures the individual information of farmers, but also the smooth error of tree species with different growth cycles. Furthermore, we analyzed both migration and remittance effects of rural labor migration on forest management income. Whether there are migrant laborers in a household was applied to capture the overall effect; the non-farm income of a household was chosen to represent the remittance effect of labor migration. We also measured the migration effect from multiple enumerations—the proportion of migrant laborers to the total household laborers, how many migratory laborers in a household, whether the household head in a household migrates, etc. It is found that the overall effect of labor migration performed an inhibitory effect on forest management income. This is consistent with previous studies (Xie et al., 2013; Dash et al., 2016; Xie et al., 2019b; Zhu et al., 2019). Specially, the migration effect of labor inhibited the income of family forest management, while the remittance effect was positive to the household forest income. The possible reason is that the large number of high-quality rural migrants has led to the general aging and weakening of the retained labor force. The increase in the cost of forest management has led to a decline in forest income. The increase in non-farm income in households can provide financial support for household production, which is conducive to households' forest management income in forest areas. However, the non-farm income cannot cover the negative effect of rural labor migration, which leads to the overall inhibition of labor migration on forest management income. By applying different regression methods and considering different enumerations of labor migration, we have also confirmed the robustness of our results.

Second, through the comparison of households from different landform types and operators of different ages, we examined the heterogeneous effect of labor migration on forest land management income. Previous studies have paid little attention to landform types and labor structures of the sample households. According to the topographic type of the households' geographical location, we divided the sample households into plain, hilly, and mountainous groups. Similarly, we also divided them into a youth group and elderly group according to the age of the household heads. Our study revealed that, in terms of landform heterogeneity, labor migration in hilly areas and mountainous areas had a significant inhibitory effect on the forest management income. Remittance effect was only significantly positive in plain areas. This is consistent with the conclusion that there was heterogeneity in the impact of labor migration on forestland management by the village types in previous studies (Liu et al., 2016; Xu et al., 2019; Zhu et al., 2019). Luo et al. (2019) showed that rural labor migration does not affect land-use efficiency in the low-hill areas, while our findings are different. Households in the plains are not very motivated in forest management due to their small-scale of the forestlands and diversification of livelihoods, which is also the possible reason why migration effect in the plains did not significantly inhibit the household forest income. Contrarily, farmers in hilly and mountainous areas were more motivated in forest management. However, the irreversible outflow of high-quality laborers led to the severe phenomenon of land abandonment and inhibited the growth of the household forest income (Lu Z. et al., 2018). On the other hand, compared with farmlands in hilly and mountainous areas, forestlands in plain areas are more suitable for mechanized operations. Non-farm income may increase households' forest investment. Therefore, the increase in the household non-farm income is more likely to promote the income of household forest management.

In terms of household heads' age, the migration effect of the youth group has a greater inhibitory effect on the household forest income than that of the elderly group. The remittance effect of the elderly group is significantly positive, while that of the youth group is not statistically significant. It is in line with

previous studies (Lu H. et al., 2018). The possible reason is that, the youth group has a stronger learning ability and better labor ability than the elderly group to conduct forest management, so they also have greater opportunities to obtain non-farm employment. Therefore, forest management was not taken as an obvious livelihood strategy by the majority of the youth (Robson et al., 2020). As labor-intensive forest management requires higher labor ability, the migration effect in the youth group has a greater inhibitory effect on the forest management income than that in the elderly group. However, it is difficult for the elderly to change the existing knowledge structure and production behavior, once their non-farm income increases, they will be more likely to increase investment in forest management (such as bamboo forests) (Yang et al., 2018). In addition, the age of the head of the household (*Age*) had a positive effect on household forest income in the youth group and a negative effect in the old group. Our findings indicate that the relationship between age and households' forest income is non-linear, which is in line with previous studies (Xie et al., 2013; Guo et al., 2015; Huang et al., 2020).

Third, based on the research of Xie et al. (2019b), this article analyses the mechanism of labor migration on forest management income from the aspects of labor input and cash input. Cash investment plays a partial mediating role in the impact of the migration effect on forest management income, but it has a suppressing role in the impact of remittance effect. Duan et al. (2021) found that labor migration had little influence on forest cash investment, and had significant negative influences on labor input and forest management income. However, we did not found any such evidence. The reason is that, on one hand, when households want to maintain or increase the scale of forestlands, they deal with labor constraint by purchasing new technologies or forest socialization services. However, the general decline in the labor quality seriously hinders the effective improvement of new technologies or new machinery on production efficiency (Xu et al., 2020; Zheng et al., 2020). The result of cash investment may often be that the sunk cost of forest production rises. When households want to reduce the scale of the forestland or remain a small-scale forestland, they inevitably will not increase the cash input. Therefore, rural labor migration can inhibit cash outlay in forest management, thereby inhibiting the increase of the household forest income. On the other hand, with the increase in the household non-farm income, forest income is no longer an important source of household income, and purchasing new technologies or forest socialization services cannot bring a significant forest income growth and have a great risk to increase the management cost (Zhu et al., 2019). Then, they will take the initiative to reduce cash outlay in forest management, which inhibits the promotion effect of non-farm remittances, thus playing a suppressing effect.

Additionally, labor input plays a mediating role in both the labor migration effect and the labor remittance effect on forest management income. From the perspective of labor migration, with the intensification of aging and weakening of the rural labor force, this has seriously hindered the enthusiasm of households to hire laborers for forest management. It also weakens the effect of the labor input on the forest management income. Liu et al. (2017) pointed out that with the deepening of forestland fragmentation, farmers need more labor input in the forest management in China. From the perspective of labor remittance, the cost of hiring labor or purchasing forest socialization service is much lower than the purchase of new technologies or equipment, and purchasing forest socialization services can always not satisfy the demand of forest production. It is more affordable for households to use remittance income to hire labor. Therefore, when the remittance income is certain and income from forest management is still regarded as an inalienable part of household livelihood or a form of social security, households will re-invest the non-farm income to hire labor for ensuring the normal production of forest management.

Conclusion

The article focused on clarifying the effect of rural labor migration on the forest management income. We conducted consecutive annual surveys of 397 forest households in the Jiangxi Province from 2011 to 2018. The panel data enabled us to applying panel-Tobit and IV-Tobit and other mediation models to explore the relationship between labor migration and households' forest management income. The main conclusions of the study are as follows: *1*) The migration effect of labor inhibited the income of household forest management, with an influencing coefficient of -3.585, while the remittance effect was positive to household forest income, with an influencing coefficient of 0.085. The overall effect of labor migration performed an inhibitory effect on forest management income, with an influencing coefficient of −2.764. *2*) The effect of labor migration on forest land management income is heterogeneous for households from different landform-type areas and households from different age groups. The labor migration effect in hilly and mountainous areas has had a significant inhibitory effect on forest management income, with influencing coefficients −5.345 and −4.086, while the remittance effect of labor migration on forest management income is only significantly positive in plain areas. Compared with the elderly group, the migration effect of labor migration of the youth group has a greater inhibitory effect on the households' forest management income, while the impact of the remittance effect of labor migration is only significant in the elderly group. *3*) The cash investment in forest management played a mediating role in the impact of the labor migration effect on household forest income, with the mediation effect of 21.7%. It had a suppressing effect in the impact of the remittance effect on forest management income. Labor input played a mediating

role in the effect of remittance effect on forest management income, with the mediation effect being 29.3%, and it also played a mediating role in the effect of labor migration effect on forest income, with the mediation effect being 15.3%.

Both the aforementioned discussion and conclusions have important policy implications for developing countries. It is common that a large number of high-quality laborers migrate out of rural areas, which has created a great challenge for forest management. Therefore, encouraging forestland transfer and consolidation should also be an important policy direction in the collective forest regions. Moreover, the main reason why agricultural mechanization cannot completely replace the labor is that the production capacity of the existing forest production equipment is far less from the ideal level of people, and the government and scientific institutes should strengthen the research and development of forest production equipment. Additionally, for different areas and different households, the policies to activate the vitality of forest management should be different. Firstly, labor migration in hilly and mountainous villages has a significant inhibitory impact on forest management income. Therefore, in hilly and mountainous areas, the government should improve the infrastructure (such as roads and information networks) to support farmers to develop forest management and ensure the smooth progress of forest income. Secondly, the effect of household heads' age on forest management income is not a simple linear relationship, which indicates the influence of forest management skill accumulation on income. Therefore, useful skill training in forest management should be carried out among household heads. The training should be tailored to the types and needs of the households.

This study still has some deficiencies that can be cleared in future research. First, rural labor migration is a broad concept that includes many facets, such as the gender makeup of migrants and migration location. In order to fully capture the effects of rural migration on forest management income, the effects of these and other dimensions of labor migration are also worth further exploration. Second, our study was conducted in collective forest areas in the Jiangxi Province. The economic development levels and habits of different regions have a significant impact on the management decisions of farmers. Therefore, our findings may vary from those of other regions. Thus, the results need to be interpreted with caution. More research studies should be made to analyze variations in household forest income between areas with diverse forestry, socioeconomic characteristics.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not provided for this study on human participants because, for this research, we used a sample survey dataset with all individual identified information removed. All final participants were informed about the research purposes and gave their written consent to use their responses in future analyses. Participants were also informed that their participation was voluntary and anonymous. No ethical approval was required due to the type and nature of the dataset used. The patients/participants provided their written informed consent to participate in this study.

Author contributions

CN and FX conceived of the idea for this study, and wrote the first manuscript draft. CN, FX, HX, and PR collected data and conducted the statistical analysis. FX and SZ revised them critically. All authors have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Funding

We are grateful for the financial support by the National Natural Science Foundation of China (Grant No. 42161053, 41701622, 71840013, and 72003177), the Scientific Research Development Fund Project of Zhejiang A&F University (2022FR014) and Jiangxi Province Selenium-rich Agriculture Special Project 2021 (JXFXZD-2021-02).

Acknowledgments

The valuable comments and suggestions of the editors and reviewers are gratefully acknowledged, and we also gratefully acknowledge the investigated households for their time and sincere cooperation and the cadres of the 50 villages of Dexing, Yanshan, Yifeng, Wuning, Lichuan, Le'an, Yongfeng, Suichuan, Xinfeng, and Chongyi Counties for their selfless help in the survey process.

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.

Publisher's note

References

Abid, M., Scheffran, J., Schneider, U. A., and Elahi, E. (2019). Farmer perceptions of climate change, observed trends and adaptation of agriculture in Pakistan. *Environ. Manage.* 63 (1), 110–123. doi:10.1007/s00267-018-1113-7

Agarwal, A., Verma, A., and Agarwal, R. K. (2016). Factors influencing the individual investor decision making behavior in India. *J. Appl. Manag. Investments* 5, 211–222.

Ajefu, J. B., and Ogebe, J. O. (2021). The effects of international remittances on expenditure patterns of the left-behind households in Sub-Saharan Africa. *Rev. Dev. Econ.* 25, 405–429. doi:10.1111/rode.12721

Asfaw, A., Lemenih, M., Kassa, H., and Ewnetu, Z. (2013). Importance, determinants and gender dimensions of forest income in eastern highlands of Ethiopia: The case of communities around Jelo Afromontane forest. *For. Policy Econ.* 28, 1–7. doi:10.1016/j.forpol.2013.01.005

Askarov, Z., and Doucouliagos, H. (2020). A meta-analysis of the effects of remittances on household education expenditure. *World Dev.* 129, 104860. doi:10.1016/j.worlddev.2019.104860

Bao, X., Zhang, F., Deng, X., and Xu, D. (2021). Can trust motivate farmers to purchase natural disaster insurance? Evidence from earthquake-stricken areas of sichuan, China. *Agriculture* 11, 783. doi:10.3390/agriculture11080783

Begazo Curie, K., Mertens, K., and Vranken, L. (2021). Tenure regimes and remoteness: When does forest income reduce poverty and inequality? A case study from the Peruvian amazon. *For. Policy Econ.* 128, 102478. doi:10.1016/j.forpol.2021.102478

Blakeslee, D., Fishman, R., and Srinivasan, V. (2020). Way down in the hole: Adaptation to Long-Term water loss in rural India. *Am. Econ. Rev.* 110, 200–224. doi:10.1257/aer.20180976

Cai, F. (2007). Growth and structural changes in employment in transitional China. *Econ. Res. J.* 42, 12. doi:10.3969/j.issn.1004-9290.2008.08.004

Cai, F., and Wang, D. (2005). Changes in economic growth components andsources of farmers' income. *Manag. World* 5, 77–83. doi:10.19744/j.cnki.11-1235/f.2005.05.011

Calero, C., Bedi, A. S., and Sparrow, R. (2009). Remittances, liquidity constraints and human capital investments in Ecuador. *World Dev.* 37, 1143–1154. doi:10.1016/j.worlddev.2008.10.006

Carter, C. A. (1997). The urban-rural income gap in China: Implications for global food markets. *Am. J. Agric. Econ.* 79, 1410–1418. doi:10.2307/1244354

Chen, Z. (2020). Farmers′ professional differentiation, scale of operation and efficiency of agricultural land production. *J. Hebei Univ. Econ. Bus.* 41, 72–79. doi:10.14178/j.cnki.issn1007-2101.20200525.001

Dash, M., Behera, B., and Rahut, D. B. (2016). Determinants of household collection of non-timber forest products (NTFPs) and alternative livelihood activities in Similipal Tiger Reserve, India. *For. Policy Econ.* 73, 215–228. doi:10.1016/j.forpol.2016.09.012

Davis, J., and Lopez-Carr, D. (2014). Migration, remittances and smallholder decision-making: Implications for land use and livelihood change in Central America. *Land Use Policy* 36, 319–329. doi:10.1016/j.landusepol.2013.09.001

De Souza Filho, H. M., Carrer, M. J., Saes, M. S. M., Gomes, L. A. D. V., and Nicolella, A. C. (2019). Performance heterogeneity and strategic orientation: An analysis of small farmers of an agrarian reform project in Brazil. *Land Use Policy* 86, 23–30. doi:10.1016/j.landusepol.2019.04.018

Duan, W., Hogarth, N. J., Shen, J., Zhang, Y., and Chen, Q. (2021). Effects of Rural-Urban labour migration on household forest management in the context of rural reform and development in China. *Small-scale For.* 20, 543–568. doi:10.1007/s11842-021-09480-x

Elahi, E., Khalid, Z., Cui, W., and Zhang, H. (2020). The public policy of agricultural land allotment to agrarians and its impact on crop productivity in Punjab province of Pakistan. *Land Use Policy* 90, 104324. doi:10.1016/j.landusepol.2019.104324

Elahi, E., Khalid, Z., Tauni, M. Z., Zhang, H., and Xing, L. (2021a). Extreme weather events risk to crop-production and the adaptation of innovative management strategies to mitigate the risk: A retrospective survey of rural Punjab, Pakistan. *Technovation* 2021, 102255. doi:10.1016/j.technovation.2021.102255

Elahi, E., Khalid, Z., and Zhang, Z. (2022a). Understanding farmers' intention and willingness to install renewable energy technology: A solution to reduce the environmental emissions of agriculture. *Appl. Energy* 309, 118459. doi:10.1016/j.apenergy.2021.118459

Elahi, E., Zhang, H., Khalid, Z., and Xu, H. (2021b). Understanding cognitive and socio-psychological factors determining farmers' intentions to use improved grassland: Implications of land use policy for sustainable pasture production. *Land Use Policy* 102, 105250. doi:10.1016/j.landusepol.2020.105250

Elahi, E., Zhixin, Z., Khalid, Z., and Xu, H. (2022b). Application of an artificial neural network to optimise energy inputs: An energy-and cost-saving strategy for commercial poultry farms. *Energy* 244, 123169. doi:10.1016/j.energy.2022.123169

Eriksson, L. (2018). Explaining gender differences in private forest risk management. *Scand. J. For. Res.* 33, 716–723. doi:10.1080/02827581.2018.1453944

Fonta, W. M., Nwosu, E. O., Thiam, D. R., and Ayuk, E. T. (2021). The development outcomes of remittance inflows to Nigeria: The case of the southeastern geo-political zone. *Migr. Dev.* 11, 1087–1103. doi:10.1080/21632324.2020.1866879

Fox, J. (2016). Community forestry, labor migration and agrarian change in a Nepali village: 1980 to 2010. *J. Peasant Stud.* 45, 610–629. doi:10.1080/03066150.2016.1246436

Guo, G., Wen, Q., and Zhu, J. (2015). The impact of aging agricultural labor population on farmland output: From the perspective of farmer preferences. *Math. Problems Eng.* 2015, 1–7. doi:10.1155/2015/730618

Han, Z., and Song, W. (2019). Spatiotemporal variations in cropland abandonment in the Guizhou–Guangxi karst mountain area, China. *J. Clean. Prod.* 238, 117888. doi:10.1016/j.jclepro.2019.117888

Hou, J., Yin, R., and Wu, W. (2019). Intensifying Forest Management in China: What does it mean, why, and how? *For. Policy Econ.* 98, 82–89. doi:10.1016/j.forpol.2017.10.014

Hou, Y., and Chen, P. (2019). Research on the relationship between price mechanism and short-term behavior in Chinese farmland trusteeships. *Sustainability* 11, 5708. doi:10.3390/su11205708

Huang, X., Lu, Q., Wang, L., Cui, M., and Yang, F. (2020). Does aging and off-farm employment hinder farmers' adoption behavior of soil and water conservation technology in the Loess Plateau? *Int. J. Clim. Chang. Strateg. Manag.* 12, 92–107. doi:10.1108/IJCCSM-04-2019-0021

Hyde, W. F. (2019). The experience of China's forest reforms: What they mean for China and what they suggest for the world. *For. Policy Econ.* 98, 1–7. doi:10.1016/j.forpol.2018.09.009

Isoto, R. E., and Kraybill, D. S. (2017). Remittances and household nutrition: Evidence from rural Kilimanjaro in Tanzania. *Food Secur.* 9, 239–253. doi:10.1007/s12571-017-0656-4

Jiangxi Provincial Bureau of Statistics (JXBS) (2021). Statistical bulletin of national economic and social development of Jiangxi province in 2020. AvaliableAt: http://tjj.jiangxi.gov.cn/art/2021/3/23/art_38564_3298128.html (accessed Oct, 2021).

Jiangxi Provincial People's Government (JXPG) (2021). The total forestry output value of our province in the "13th Five-Year Plan" is the sixth in the country. AvaliableAt: http://www.jiangxi.gov.cn/art/2021/2/22/art_393_3197304.html (accessed Jan, 2022).

Kapri, K., and Jha, S. (2020). Impact of remittances on household health care expenditure: Evidence from the Nepal Living Standards Survey. *Rev. Dev. Econ.* 24, 12666–21008. doi:10.1111/rode.12666

Kelley, L. C., Peluso, N. L., Carlson, K. M., and Afiff, S. (2020). Circular labor migration and land-livelihood dynamics in Southeast Asia's concession landscapes. *J. Rural. Stud.* 73, 21–33. doi:10.1016/j.jrurstud.2019.11.019

Khandker, S. R., and Koolwal, G. B. (2010). How infrastructure and financial institutions affect rural income and poverty: Evidence from Bangladesh. *J. Dev. Stud.* 46, 1109–1137. doi:10.1080/00220380903108330

Kharel, P., Dávalos, J., and Dahal, K. (2021). International remittances and nonfarm entrepreneurship among the left-behind: Evidence from Nepal. *Rev. Dev. Econ.* 26 (1), 208–241. doi:10.2139/ssrn.3631373

Killian, B., and Hyle, M. (2020). Women's marginalization in participatory forest management: Impacts of responsibilization in Tanzania. *For. Policy Econ.* 118, 102252. doi:10.1016/j.forpol.2020.102252

Krul, K., Ho, P., and Yang, X. (2020). Incentivizing household forest management in China's forest reform: Limitations to rights-based approaches in Southwest China. *For. Policy Econ.* 111, 102075. doi:10.1016/j.forpol.2019.102075

Lai, J., and Xu, B. (2019). The impact of poverty vulnerability on farmers' labor migration. *J. Appl. Statistics Manag.* 38, 580–590. doi:10.13860/j.cnki.sltj.20181207-001

Lee, J., Oh, Y., Yoo, S., and Suh, K. (2021). Vulnerability assessment of rural aging community for abandoned farmlands in South Korea. *Land Use Policy* 108, 105544. doi:10.1016/j.landusepol.2021.105544

Li, F., Zhou, M., Shao, J., Chen, Z., Wei, X., and Yang, J. (2020). Maize, wheat and rice production potential changes in China under the background of climate change. *Agric. Syst.* 182, 102853. doi:10.1016/j.agsy.2020.102853

Li, H., Hu, C., Ji, Y., and Li, M. (2021). Agricultural labor migration, productivity gains and macroeconomic growth - an international comparison based on 55 economies worldwide. *Issues Agric. Econ.* 7, 117–129. doi:10.13246/j.cnki.iae.2021.07.011

Li, Y., Wu, W., and Liu, Y. (2018). Land consolidation for rural sustainability in China: Practical reflections and policy implications. *Land Use Policy* 74, 137–141. doi:10.1016/j.landusepol.2017.07.003

Li, Z., and Zhuang, J. (2021). Impact of land trusteeship on the economic welfare of farmers' families - the intermediation effect based on non-agricultural employment and agricultural outpu. *J. Agrotechnical Econ.* 1, 20–31. doi:10.13246/j.cnki.jae.2021.01.002

Lian, P., Zhuo, Z., Qi, Y., Xu, D., and Deng, X. (2021). The impacts of training on farmers' preparedness behaviors of earthquake disaster - evidence from earthquake-prone settlements in rural China. *Agriculture* 11, 726. doi:10.3390/agriculture11080726

Liu, C., Liu, H., and Wang, S. (2017). Has China's new round of collective forest reforms caused an increase in the use of productive forest inputs? *Land use policy* 64, 492–510. doi:10.1016/j.landusepol.2017.03.011

Liu, G., Wang, H., Cheng, Y., Zheng, B., and Lu, Z. (2016). The impact of rural out-migration on arable land use intensity: Evidence from mountain areas in Guangdong, China. *Land Use Policy* 59, 569–579. doi:10.1016/j.landusepol.2016.10.005

Liu, X., Huang, L., Du, J., Xie, F., and Zhu, S. (2022). Forestland transfer between rural households in Jiangxi, China: Differentiated effects of actual and perceived tenure security. *Nat. Resour. Model.* 35, e12327. doi:10.1111/nrm.12327

Liu, X., and Tian, W. (2005). Analysis of the contribution of rural labor transfer to economic growth in China. *Manag. World* 1, 91–95. doi:10.19744/j.cnki.11-1235/f.2005.01.012

Lu, H., Xie, H., and Yao, G. (2018a). Impact of land fragmentation on marginal productivity of agricultural labor and non-agricultural labor supply: A case study of jiangsu, China. *Habitat Int.* 83, 65–72. doi:10.1016/j.habitatint.2018.11.004

Lu, Q., Zhang, C., and Chou, H. (2017). The effect of aging of agricultural labor force and part-time farming on the outsourcing of agricultural production. *Issues Agric. Econ.* 38, 27–34. doi:10.13246/j.cnki.iae.2017.10.004

Lu, Z., Tan, S., Liu, C., and Wang, S. (2018b). Influence of labor transfer on farmland sustainable development: A regional comparison of plain and hilly areas. *Qual. Quant.* 52, 431–443. doi:10.1007/s11135-017-0476-9

Luo, X., Zhang, Z., Lu, X., and Zhang, L. (2019). Topographic heterogeneity, rural labour transfer and cultivated land use: An empirical study of plain and low-hill areas in China. *Pap. Reg. Sci.* 98, 2157–2178. doi:10.1111/pirs.12444

Luyssaert, S., Marie, G., Valade, A., Chen, Y., Njakou Djomo, S., Ryder, J., et al. (2018). Trade-offs in using European forests to meet climate objectives. *Nature* 562, 259–262. doi:10.1038/s41586-018-0577-1

Mbeche, R., Ateka, J., Herrmann, R., and Grote, U. (2021). Understanding forest users' participation in participatory forest management (PFM): Insights from Mt. Elgon forest ecosystem, Kenya. *For. Policy Econ.* 129, 102507. doi:10.1016/j.forpol.2021.102507

National Bureau of Statistics of China (NBSC) (2021). 2020 migrant workers monitoring survey report. AvaliableAt: http://www.stats.gov.cn/tjsj/zxfb/202104/t20210430_1816933.html (accessed Oct, 2021).

National Bureau of Statistics of China (NBSC) (2022). Household income and consumer expenditure in 2021. AvaliableAt: http://www.stats.gov.cn/xxgk/sjfb/zxfb2020/202201/t20220117_1826442.html (accessed Jan, 2022).

National Forestry and Grassland Administration (NFGA (2018). The national intelligent management platform for forest resources. AvaliableAt: http://www.stgz.org.cn/ (accessed Dec, 2021).

Ngoma, A. L., and Ismail, N. W. (2013). Do migrant remittances promote human capital formation? Evidence from 89 developing countries. *Migr. Dev.* 2, 106–116. doi:10.1080/21632324.2013.786883

Ojeda Luna, T., Zhunusova, E., Günter, S., and Dieter, M. (2020). Measuring forest and agricultural income in the Ecuadorian lowland rainforest frontiers: Do deforestation and conservation strategies matter? *For. Policy Econ.* 111, 102034. doi:10.1016/j.forpol.2019.102034

Oli, B. N., Treue, T., and Smith-Hall, C. (2016). The relative importance of community forests, government forests, and private forests for household-level incomes in the Middle Hills of Nepal. *For. Policy Econ.* 70, 155–163. doi:10.1016/j.forpol.2016.06.026

Ospina, D., Peterson, G., and Crépin, A.-S. (2019). Migrant remittances can reduce the potential of local forest transitions—A social-ecological regime shift analysis. *Environ. Res. Lett.* 14, 024017. doi:10.1088/1748-9326/aaf0ee

Oviedo, J. L., Campos, P., and Caparrós, A. (2021). Contingent valuation of landowner demand for forest amenities: Application in Andalusia, Spain. *Eur. Rev. Agric. Econ.* 49, 615–643. doi:10.1093/erae/jbab022

Peluso, N. L., and Purwanto, A. B. (2018). The remittance forest: Turning mobile labor into agrarian capital. *Singap. J. Trop. Geogr.* 39, 6–36. doi:10.1111/sjtg.12225

Pokharel, K. P., and Featherstone, A. M. (2019). Estimating multiproduct and product-specific scale economies for agricultural cooperatives. *Agric. Econ.* 50, 279–289. doi:10.1111/agec.12483

Rahman, S. (2010). Determinants of agricultural land rental market transactions in Bangladesh. *Land Use Policy* 27, 957–964. doi:10.1016/j.landusepol.2009.12.009

Rayamajhi, S., Smith-Hall, C., and Helles, F. (2012). Empirical evidence of the economic importance of Central Himalayan forests to rural households. *For. Policy Econ.* 20, 25–35. doi:10.1016/j.forpol.2012.02.007

Rigg, J., Salamanca, A., and Thompson, E. C. (2016). The puzzle of East and Southeast Asia's persistent smallholder. *J. Rural. Stud.* 43, 118–133. doi:10.1016/j.jrurstud.2015.11.003

Robson, J. P., Wilson, S. J., Sanchez, C. M., and Bhatt, A. (2020). Youth and the future of community forestry. *Land* 9, 406. doi:10.3390/land9110406

Schmidt, A. F., and Finan, C. (2017). Linear regression and the normality assumption. *J. Clin. Epidemiol.* 146, 151. doi:10.1016/j.jclinepi.2017.12.006

Schmidt, E., Chinowsky, P., Robinson, S., and Strzepek, K. (2017). Determinants and impact of sustainable land management (slm) investments: A systems evaluation in the blue nile basin, Ethiopia. *Agric. Econ.* 48, 613–627. doi:10.1111/agec.12361

Shang, C. (2018). Rural married women's non-agricultural employment and rural households' land subcontracting. *J. Asian Rural. Stud.* 2, 153. doi:10.20956/jars.v2i2.1428

Shui, Y., Xu, D., Liu, Y., and Liu, S. (2021). The influence of human capital and social capital on the gendered division of labor in peasant family in Sichuan, China. *Soc. Indic. Res.* 155, 505–522. doi:10.1007/s11205-020-02598-z

Siraj, M. (2019). Forest carbon stocks in woody plants of Chilimo-Gaji Forest, Ethiopia: Implications of managing forests for climate change mitigation. *S. Afr. J. Bot.* 127, 213–219. doi:10.1016/j.sajb.2019.09.003

Siraj, M., Zhang, K., Xiao, W., Bilal, A., Gemechu, S., Geda, K., et al. (2016). Does participatory forest management save the remnant forest in Ethiopia? *Proc. Natl. Acad. Sci. India Sect. B. Biol. Sci.* 88, 1–14. doi:10.1007/s40011-016-0712-4

Sun, X., and Su, X. (2012). Land trust, total benefit, Grain-Growing wish: Based on the view angle of increasing grain production and increasing non-farm income of concurrently part-time farm household. *Issues Agric. Econ.* 33, 102–108. doi:10.13246/j.cnki.iae.2012.08.017

Sun, Z. (2008). Has China entered the "lewis inflection point"? - on the demographic dividend of economic growth. *Economist* 1, 117–119. doi:10.16158/j.cnki.51-1312/f.2008.01.010

Van Loon, J., Woltering, L., Krupnik, T. J., Baudron, F., Boa, M., and Govaerts, B. (2020). Scaling agricultural mechanization services in smallholder farming systems: Case studies from sub-Saharan Africa, South Asia, and Latin America. *Agric. Syst.* 180, 102792. doi:10.1016/j.agsy.2020.102792

Wang, W., Luo, X., Zhang, C., Song, J., and Xu, D. (2021). Can land transfer alleviate the poverty of the elderly? Evidence from rural China. *Int. J. Environ. Res. Public Health* 18, 11288. doi:10.3390/ijerph182111288

Wang, X., Chen, M., He, X., and Zhang, F. (2018). Credit constraint, credit adjustment, and sustainable growth of farmers' income. *Sustainability* 10, 4407. doi:10.3390/su10124407

Wang, Y., Xiang, J., and Zhong, F. (2020). Return migration, aging and the"lewis turning point". *Issues Agric. Econ.* 12, 4–16. doi:10.13246/j.cnki.iae.2020.12.002

Wassink, J. (2020). International migration experience and entrepreneurship: Evidence from Mexico. *World Dev.* 136, 105077. doi:10.1016/j.worlddev.2020.105077

Wen, Z., and Ye, B. (2014). Analyses of mediating effects: The development of methods and models. *Adv. Psychol. Sci.* 22, 731–745. doi:10.3724/SP.J.1042.2014.00731

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data*. Cambridge, Massachusetts, United States: MIT Press.

Xiao, H., Ning, C., Xie, F., Kang, X., and Zhu, S. (2021). Influence of rural labor migration behavior on the transfer of forestland. *Nat. Resour. Model.* 34, e12293. doi:10.1111/nrm.12293

Xie, F., Kang, X., Du, J., Liu, X., and Zhu, S. (2019a). Labor off-farm employment and household forest management investment in Jiangxi, China: A perspective from gender influence of rural labor. *Nat. Resour. Model.* 33, 12246. doi:10.1111/nrm.12246

Xie, F., Zhu, S., Cao, M., Kang, X., and Du, J. (2019b). Does rural labor outward migration reduce household forest investment? The experience of Jiangxi, China. *For. Policy Econ.* 101, 62–69. doi:10.1016/j.forpol.2019.01.010

Xie, Y., Wen, Y., Zhang, Y., and Li, X. (2013). Impact of property rights reform on household forest management investment: An empirical study of southern China. *For. Policy Econ.* 34, 73–78. doi:10.1016/j.forpol.2012.12.002

Xu, D., Cao, S., Wang, X., and Liu, S. (2018). Influences of labor migration on rural household land transfer: A case study of sichuan province, China. *J. Mt. Sci.* 15, 2055–2067. doi:10.1007/s11629-018-4973-7

Xu, D., Deng, X., Huang, K., Liu, Y., Yong, Z., and Liu, S. (2019). Relationships between labor migration and cropland abandonment in rural China from the perspective of village types. *Land Use Policy* 88, 104164. doi:10.1016/j.landusepol.2019.104164

Xu, J., Chu, Y., and Zhou, Z. (2020). Impact of agricultural mechanization development on corn production: Promoting or restraining? Based on panel data collected in 20 provinces. *J. Agro-Forestry Econ. Manag.* 19, 559–568. doi:10.16195/j.cnki.cn36-1328/f.2020.05.59

Xu, J., He, W., and Zhang, H. (2021). How does forest right mortgage loan availability increase farmers' income? *For. Econ.* 43, 32–46. doi:10.13843/j.cnki.lyjj.20210709.002

Xu, J., and Hyde, W. F. (2019). China's second round of forest reforms: Observations for China and implications globally. *For. Policy Econ.* 98, 19–29. doi:10.1016/j.forpol.2018.04.007

Yang, H., Huang, K., Deng, X., and Xu, D. (2021). Livelihood capital and land transfer of different types of farmers: Evidence from panel data in Sichuan province, China. *Land* 10, 532. doi:10.3390/land10050532

Yang, S. (2021). A political and economic study of China's urban and rural labor mobility-reflection on lewis' turning point research paradigm. *Theory Mon.* 11, 72–80. doi:10.14180/j.cnki.1004-0544.2021.11.008

Yang, S., Xu, X., and Shi, D. (2018). Impacts of the aging labor force on bamboo land-use efficiency —an empirical analysis based on mediation effect. *Sci. Silvae Sinicae* 54, 132–142. doi:10.11707/j.1001-7488.20181016

Yao, S. (2003). Non-public forestry with incomplete property right. *Issues Agric. Econ.* 6, 29–33. doi:10.13246/j.cnki.iae.2003.06.007

Yin, R., Yao, S., and Huo, X. (2013). China's forest tenure reform and institutional change in the new century: What has been implemented and what remains to be pursued? *Land Use Policy* 30, 825–833. doi:10.1016/j.landusepol.2012.06.010

Yin, Y., Hou, Y., Langford, C., Bai, H., and Hou, X. (2019). Herder stocking rate and household income under the grassland ecological protection award policy in northern China. *Land Use Policy* 82, 120–129. doi:10.1016/j.landusepol.2018.11.037

Yu, Y., Cheng, Q., Yu, W., Chen, Q., Chen, N., Gong, Y., et al. (2020). Study on impact of rural-household differentiation on forest land circulation behavior. *For. Econ.* 42, 23–31. doi:10.13843/j.cnki.lyjj.20201028.002

Zhang, B., Niu, W., Ma, L., Zuo, X., Kong, X., Chen, H., et al. (2019). A company-dominated pattern of land consolidation to solve land fragmentation problem and its effectiveness evaluation: A case study in a hilly region of guangxi autonomous region, southwest China. *Land Use Policy* 88, 104115. doi:10.1016/j.landusepol.2019.104115

Zhang, K., Deng, X., Shen, Q., and Qi, Y. (2017). Technological progress in agriculture, rural labor transfer and farmers' Income-Analysis of grouped PVAR model based on agricultural labor productivity. *J. Agrotechnical Econ.* 6, 28–41. doi:10.13246/j.cnki.jae.2017.06.003

Zhang, K., Sun, X., Jin, Y., Liu, J., Wang, R., and Zhang, S. (2020). Development models matter to the mutual growth of ecosystem services and household incomes in developing rural neighborhoods. *Ecol. Indic.* 115, 106363. doi:10.1016/j.ecolind.2020.106363

Zhao, J., and Barry, P. J. (2014). Income diversification of rural households in China. *Can. J. Agric. Economics/Revue Can. d'agroeconomie.* 62, 307–324. doi:10.1111/cjag.12033

Zheng, Y., Jiang, S., Chen, B., Lu, H., Wan, C., and Kang, F. (2020). Review on technology and equipment of mechanization in hilly orchard. *Trans. Chin. Soc. Agric. Mach.* 51, 1–20. doi:10.6041/j.issn.1000-1298.2020.11.001

Zhu, Z., Xu, Z., Shen, Y., Huang, C., and Zhang, Y. (2019). How off-farm work drives the intensity of rural households' investment in forest management: The case from Zhejiang, China. *For. Policy Econ.* 98, 30–43. doi:10.1016/j.forpol.2018.04.006

Zhu, Z., Zhou, J., Li, B., Shen, Y., and Zhang, Y. (2020). How feminization of forest management drives households' adoption of technologies: Evidence from non-timber forest products operations in China. *For. Policy Econ.* 115, 102154. doi:10.1016/j.forpol.2020.102154

Zou, B., Mishra, A. K., and Luo, B. (2018). Aging population, farm succession, and farmland usage: Evidence from rural China. *Land Use Policy* 77, 437–445. doi:10.1016/j.landusepol.2018.06.001