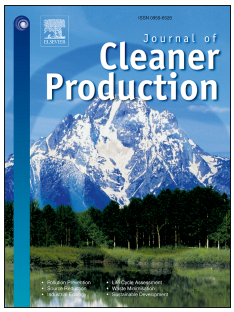

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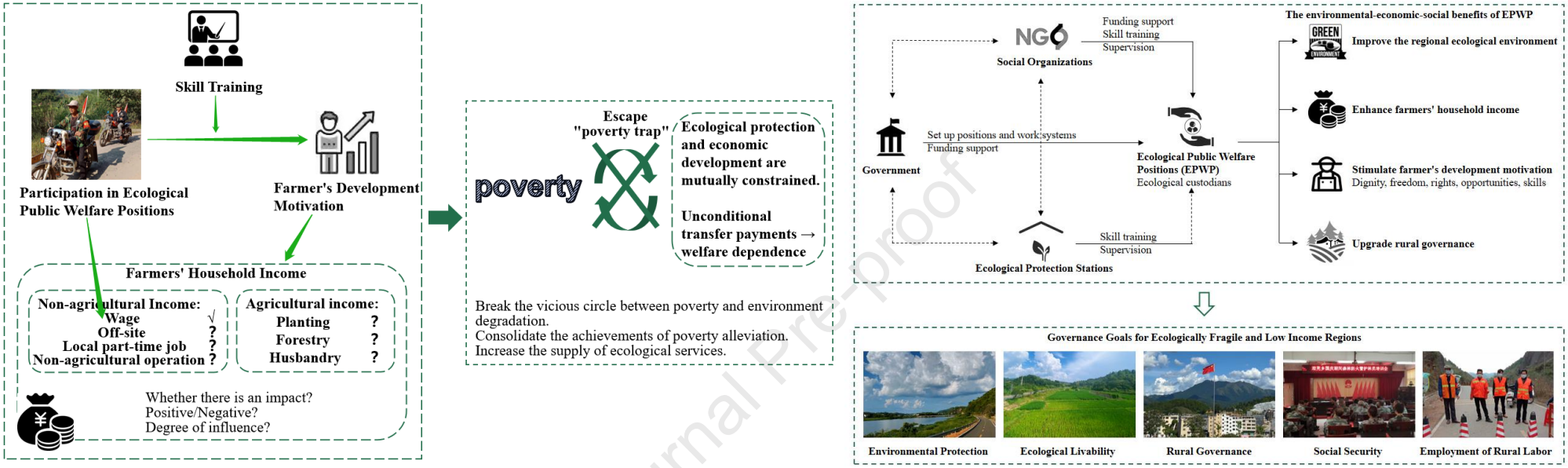
Credit Author Statement

Authors contributed to this work as follows: **Ke Xu** (conceptualization, questionnaire development, methodology, data curation, software, formal analyses, writing original draft, visualization, writing review and editing, validation). **Changbin Yin** (supervision, writing original draft, resources, project administration, funding acquisition). **Boyang Shi** (data curation, writing-review and editing, validation). **Jie Pang** (data visualization, writing-review and editing).

The Effect of Participation in Ecological Public Welfare Positions on Farmers' Household Income Composition and the Internal Mechanism

GRAPHICAL ABSTRACT



The Effect of Participation in Ecological Public Welfare Positions on Farmers' Household Income Composition and the Internal Mechanism

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ABSTRACT

The ecological public welfare positions policy, which involves low-income people in ecological conservation work, is an essential practical innovation for China to achieve mutual benefits in ecological protection and poverty alleviation. This study explored the effect of participation in ecological public welfare positions (PEPWP) on farmers' household income composition and clarified the internal mechanism by propensity score matching (PSM) and conditional process analysis, based on the field data from 508 formerly registered impoverished households in Jiangxi Province and Hubei Province, China. Results showed that (1) PEPWP was characterized by "self-selection", which significantly increased farmers' wage level, planting income in Jiangxi Province, and husbandry income in Hubei Province after the elimination of selectivity bias. However, the effect on other sub-incomes was insignificant. (2) There was a moderated mediating model between PEPWP and agricultural income, which demonstrated that farmer's development motivation (FDM) played a partially mediating effect between PEPWP and FDM, and the frequency of skill training (FST) moderated the first part path of this model. (3) EPWP policy steadily increased farmers' income at the vulnerable livelihood level and greatly improved the regional environment. At the same time, it also played an active role in stimulating FDM and rural governance. Conclusions indicated that it was significant to diversify the channels for promoting growth in rural incomes, and pay attention to skill training and the multi-functional role of ecological custodians, in order to activate FDM and assist farmers in eradicating poverty sustainably.

1. Introduction

China has accomplished poverty alleviation by 2020, while 10 years ahead of schedule in achieving the UN 2030 Agenda for Sustainable Development's poverty reduction goal. In China, there were 60% of poverty-stricken population,

Abbreviations: EPWP, Ecological Public Welfare Position; PEPWP, Participation in Ecological Public Welfare Positions; EPA, Ecological Poverty Alleviation; PES, Payment for Environmental Services; FST, Frequency of Skill Training; FDM, Farmer's Development Motivation; PSM, Propensity Score Matching.

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80% of severely poverty-stricken population, 14 concentrated destitute areas, and more than 500 state-supported impoverished counties, which distributed in ecological function zones or ecologically fragile regions (Department of Household Surveys National Bureau of Statistics of China, 2016). The UN-Sustainable Development Goals (SDGs) have proposed two critical issues for poverty reduction in conjunction with environment protection[1]. In response, Chinese government has developed a series of Payment for Environmental Services (PES) projects to promote the concept that "lucid waters and lush mountains are invaluable assets" in practice, and to assist persons in low-income regions to develop a path where ecological protection and livelihood enhancement are mutually reinforcing (Li and Imura, 2007).

Ecological public welfare position (EPWP) is an essential initiative by the Chinese government to consolidate the achievements of poverty alleviation and promote rural revitalization, especially representing an important practice innovation in the PES program. EPWP policy based on the idea of "work for welfare" by employing qualified rural low-income people as ecological custodians. It can not only provide employment opportunities nearby, but also motivate farmers, community groups, conservation stations, and other organizations to participate in ecological conservation work (Gonedelé Bi et al., 2019). From 2016 to 2020, central government has arranged funds of 20.1 billion CNY and hired 1.1 million ecological custodians in 22 provinces across the central and western China, accurately addressing more than 3 million rural low-income people to escape poverty, as well as creating nearly 60 million ha of forest and grassland resources to the area under management[2]. The value of ecosystem services in farmers' livelihood-vulnerable regions has been successfully transformed into livelihood capitals.

EPWP policy provides farmers with more employment opportunities than simply cultivating. As an ecological poverty alleviation (EPA) measure, EPWP is, to a considerable extent, a solution to the problem of poverty alleviation for micro-farmers. Actually, income is at the core of farmers' well-being, which is the critical indicator for measuring poverty and achieving sustainable livelihoods (Begazo Curie et al., 2021; Cao et al., 2017; Shen et al., 2015). It is important to investigate the effect of participation in ecological public welfare positions (PEPWP) on farmers' household income composition and reveal the internal mechanism in order to further improve EPWP policy. Existing researches have provided useful enlightenment and reference, however, there are still several shortcomings. Firstly, most of them concentrated on the influence of PES on farmers' total income and lacked specific analysis of various sources of sub-incomes. Nevertheless, the exploration on participation in a new position involves the reallocation of personal time and family human resources, and the effect of PEPWP on income composition is unclear. Therefore, the first objective of this study is to analyze the effect of PEPWP on farmers' household sub-incomes from the perspective of income composition. In addition, this paper had regard to the "self-selection" characteristics and farmers' heterogeneity, and used propensity score matching (PSM) to cope with the bias problems caused by traditional OLS, multi categorical logit, DID, and other estimation methods.

Secondly, the mechanism of PES's effect on income has not been thoroughly investigated, the process of participation

[1] Sustainable Development Report 2022 (https://www.sdgindex.org/)
[2] Consolidate the achievements of ecological poverty alleviation (http://www.forestry.gov.cn/main/6193/20220302/153917238546723.html)

policy's influence on income has not been revealed, lack of in-depth analysis of possible mediating or moderating mechanisms. EPWP policy emphasized the significance of providing jobs and skill training to stimulate farmers' development motivation (FDM) so as to steadily promote growth in rural incomes (Wu and Jin, 2020). Therefore, it is the second concern on this study to analyze the internal mechanisms of PEPWP on income.

It is necessary, significant, and innovative to systematically reveal the influence of PES on income and the internal mechanism. This study explored the potential for participation in PES to increase farmers' household income and clarified the reason and mechanisms for boosting rural income. Identifying the effect of PEPWP on farmers' household income composition and the internal mechanism. Furthermore, it expanded the research perspective and analyzed the effect of PEPWP on various sources of sub-incomes by propensity score matching (PSM). In addition, it controlled for both estimation bias and heterogeneity of treatment effects due to "self-selection" endogeneity, which ensured conclusions were more accurate and reliable. Moreover, it introduced conditional process analysis (Hayes, 2017) and constructed a theoretical framework of the effect of PEPWP on income, which complemented and improved the research on participation in PES to promote growth in rural resident incomes.

2. Theoretical background and hypotheses

2.1. Description of EPWP

As an important practice innovation in the development-oriented support policy, the concept of public work was initially stated in Amartya Sen's welfare development concept (Sen, 2000), who advocated that work was an effective way to promote the freedom of human development and to strengthen the viability of individuals. EPWP policy employs ecological custodians to conduct safety patrols and environmental protection publicity for ecological resources such as forests, wetlands, grasslands, and sandy areas, so as to timely stop deforestation, reclamation, quarrying, and hunting of wild animals in the protected areas. It not only could form an ecological resource management network with clear responsibilities, but also provide employment opportunities for low-income people in ecologically fragile regions (Zuo et al., 2018). It is conducive to the integration of environmental protection, ecological revitalization, rural governance, social security, and employment of rural labor, and contributes to the consolidation of poverty eradication and the implementation of the rural revitalization strategy.

EPWP requires that areas of responsibility be designated based on the difficulty of management, according to the criteria of 66.67-133.4 ha per capita in principle. Ecological custodians need to patrol for more than 22 days per month. There are several requirements for selecting ecological custodians, who belong to formerly registered impoverished households, have the ability to work, and don't have jobs outside the county.

Sustainable cooperation between government, social organizations (such as NGOs, etc.), and ecological protection stations (such as forestry stations, etc.) is required to ensure the efficient implementation of EPWP. The first step includes the work systems and funding support by both government and social organizations. Then, set up the EPWP with the village

ecological conservation and social development through the county-level departments or village committees. Following that, community villagers compete for positions and perform their duties publicly. Next, ecological protection stations and social organizations are commissioned to participate in providing regular skill training and supervision in the form of purchased services (Zuo et al., 2018). The basic principles and framework of policy implementation are illustrated in Fig. 1.

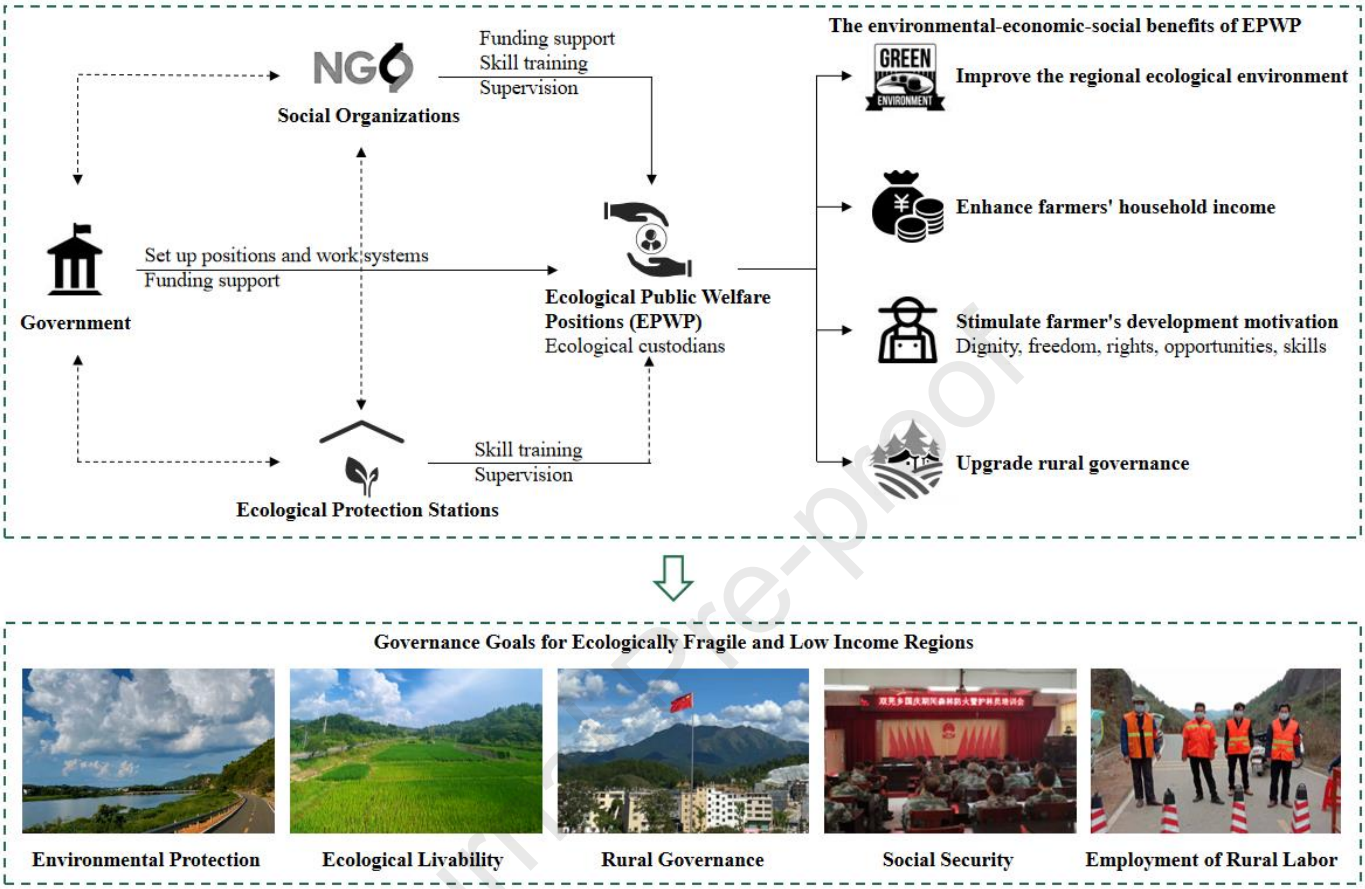

Fig. 1. Basic Implementation Principles and Frameworks of EPWP.

2.2 The environmental-economic-social benefits of PES

2.2.1 Summary of the impact of PES in different countries

Despite the lack of robust empirical evidence to assess the benefits of PES to environmental and socioeconomic issues, this study has attempted to review the existing researches that contribute to this discussion. Overall, researches showed that PES has positive effects on income, environment, and society (Table 1).

Table 1 Summary of the impact of PES in different countries.

Country	Program	Impact on Income	Impact on environment or society
Thailand	Forest ranger (O'Donnell, 2014)	PES increased wage income of farmers.	Thai forest rangers have largely established with the local people their legitimacy to regulate the environment.
China	Sloping Land Conversion Program (SLCP)[3]	The central government has invested more than 500 billion CNY, directly benefiting 158 million farmers.	More than 33 million ha of cropland has been returned to forest and grassland, contributing more than 4% of the global net green growth area.
Philippines	Mangrove forest payments for ecosystem	Mangrove carbon PES could contribute an additional 2.3–5.8% to	PES may require multi-level and multi-actor governance with local participation.

[3] Ten major events of Sloping Land Conversion Program in 2020. (http://www.forestry.gov.cn/main/216/20210113/100028109119067.html)

	services (Thompson et al., 2017)	current village income.	
Vietnam	forest environmental services (PFES) (Pham et al., 2021)	PES programs expand income sources, total income, and income per laborer.	PES has a positive effect on enhancing conservation attitudes
USA	Wetland mitigation bank (Dahl, 1990; Dahl, 2011)	Promoting wetland compensation through market behavior	Annual wetland loss decreased from $45.8 \cdot 10^4$ acres (1955-1975) to $1.38 \cdot 10^4$ acres (2004-2009).
Mexico	Program for Hydrological Environmental Services (PSAH) (Arriagada et al., 2018)	PES has a neutral effect on livelihoods.	PES program raised awareness of forest ecosystem service provision, and forest management training played an important role.
Costa Rica	Programa por Pago de Servicios Ambientales (PPSA) (Murillo et al., 2012)	PES paid cash to farmers and developed sustainable agroforestry programs.	PES helped to protect forest resources and reduced deforestation.
Uganda	Deforestation and forest degradation (REDD+) (Jayachandran et al., 2017)	PES paid cash to farmers and supported sustainable agriculture.	PES helped to reduce deforestation and greenhouse gas emissions.

2.2.2 Comparison of EPWP and PES

Researches on the impact of participation in EPWP, a specific PES program, were relatively sparse. Cash compensation and EPWP compensation were complementary, as EPWP compensation only had a significant effect on low-income farmers, while cash compensation had a significant effect on middle- and high-income groups (Wu and Jin, 2020). In some rural areas of China, EPWP was an effective way to increase farmers' social participation, which could increase farmers' income and motivation for ecological protection (Zhang et al., 2022).

As an important practical innovation in the development-oriented support policy, EPWP steadily increased the income of farmers at the vulnerable livelihood level and greatly improved the regional environment, while it also played an active role in stimulating FDM and rural governance. These advantages will be further described in discussion.

2.3 Mechanism analysis and research hypothesis

2.3.1 The effect of PEPWP on farmers' household income composition

EPA is an assistance approach based on the concept of green development that promotes the coordination of environmental protection with the development of the population's sustainable livelihood capability in farmers' livelihood-vulnerable regions (Fisher et al., 2014; Sandhu and Sandhu, 2014). As a critical practice of EPA, the mechanism of EPWP can be described as the central government providing funds to enroll impoverished people with labor ability for ecological patrol, which closely integrates ecological preservation with poverty alleviation. PEPWP is a process of reallocation of personal time and family human resources. As rational economic people, farmers will conduct a cost-benefit analysis to determine the predicted net benefit of participation, which is a key factor in whether to join in. The constraint is labor time. Farmers' option as ecological custodians means foregoing the opportunity to work locally or outside, which is the cost

of participation. The primary effect of PEPWP is a rise in wage income. In addition, farmers involved in EPWP can be part-time planting and breeding at the same time. According to the management and protection agreement, ecological custodians and their family members can carry out a certain scale of characteristic agricultural planting and breeding without destroying ecological resources. Moreover, ecological custodians can access a variety of agricultural technology training, which can help them refine personal abilities while broadening horizons, and the family's revenue may improve as a result involving planting, forestry, and husbandry. Generally, PEPWP may increase farmers' household income accompanying with sub-income diversification.

2.3.2 Internal mechanism of the effect of PEPWP on farmers' household income

Recently, the goal of pro-poor governance has gradually transformed from poverty alleviation to livelihood empowerment (Wang et al., 2019), and the focus on poverty also shifted from income to individual endowments. Poverty manifested as low income, however, the underlying causes are the limitation of earning capacity and development opportunities (Sen, 1982). EPWP policy replaces the government's unconditional transfer payments with "work for welfare", which is a shift from welfarism to workism. It avoids the problem of welfare dependence that tends to arise in poverty alleviation work and helps low-income farmers escape “poverty trap”. As a development-oriented assistance, EPWP policy is, in essence, an "empowerment" (Handler, 2004) that enables people who lack employment opportunities to gain social acceptance and recognition through labor. EPWP policy has significantly improved farmers’ survival guarantee ability, production development ability, and property revenue ability through skill training and successive support for ambition and wisdom. And the improvement of personal ability will have a positive effect on household income. Specifically, there may be a mediating and moderating mechanism for the effect of PEPWP on farmers' household income.

First, FDM played a mediating effect. The process of development motivation formation is a system-led, spatially-scoped, family-based process of autonomous development of individuals in a specific context. The core is the accumulation of new capabilities and the improvement of the matching guarantee system. Farmers' development capacity is farmers' ability to proactively gather information and take activities to improve their own and their family's living standards in a market economy, and ultimately to continuously improve themselves (Kumari and Khanduri, 2019). Farmers' mental distress and anxiety can be alleviated by PEPWP. Simultaneously, social interactions with other ecological custodians, community groups, conservation stations, and other organizations would have a "social norm" effect, i.e., farmers would recognize that they should abandon their reliance on the government and activate their labor spirit. It can be seen that PEPWP can improve FDM through the "positive psychological effect" and "social norm effect", and improve farmers' household income indirectly.

Second, frequency of skill training (FST) played a moderating effect. The cultivation of FDM requires multi-dimensional approaches, among which the core factor is education (Sun and Chen, 2019). Fan and Zhu (2016) discussed the way to innovate education and training mechanisms to cultivate "high-quality farmers". The level of skill-based human

capital is one of the "critical thresholds" for income generation for rural low-income groups (Mincer, 1991). Information access and risk response are prominent shortcomings in FDM. Skill training brings the "information effect", which is the most effective way to overcome farmers' information constraints. Skill training provides farmers with options to change their lifestyles and production conditions, while it provides opportunities for farmers to acquire and learn new ideas and skills (Clarkson et al., 2022). In practice, the academic institution will provide pre-service training to the newly appointed ecological custodians, to promote the better performance of their duties and responsibilities through the explanation of environmental protection laws and regulations, and patrol duties. In addition, ecological custodians are also trained in agricultural techniques to help farmers access production and management knowledge, through knowledge dissemination and post-technology adoption results presentation sessions (Gautam et al., 2017). As a positive factor, Generally, PEPWP can broaden farmers' horizons, make more effective use of new technologies, improve the efficiency of production operations, and increase their income and the capacity for self-development.

The effect of PEPWP on income is mainly reflected in income diversification, in which there are mediating and moderating mechanisms. The influence path is illustrated in Fig. 2. Accordingly, this study proposed the following research hypothesis.

H1: PEPWP can significantly increase farmers' household income accompanying with sub-income diversification.

H2: FDM played a mediating effect between PEPWP and household income.

H3: FST positively moderated the mediating effect of FDM between PEPWP and household income.

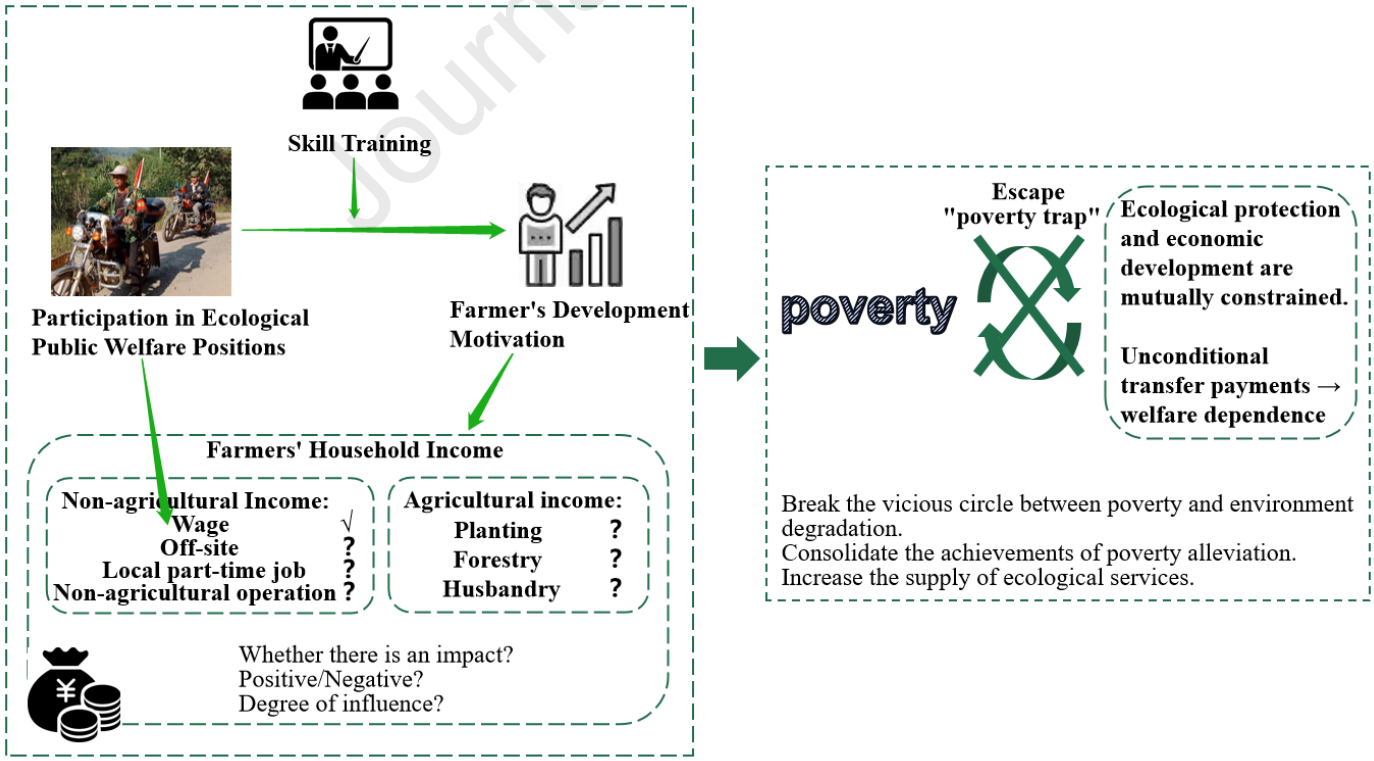

Fig. 2. The research framework of this study.

3 Research Design

3.1 Data Sources

The study is based on county-level data collection from August to September 2020, with Xunwu and Anyuan counties of Ganzhou city in Jiangxi Province, and Yunyang and Fang counties of Shiyan city in Hubei Province as study regions. The study regions are representative of China and could be used as a reference for similar ecologically fragile and low-income regions in the Asia-Pacific region or in a wider range for three reasons. First, study regions are practice regions of PES with rich natural resources. Ganzhou City is located in the upper reaches of the Ganjiang River, the Yangtze River system, and is an important ecological barrier in the Poyang Lake region. Shiyan City is located in the Qinba Mountainous Region and is the water source of the National South-North Water Diversion Project. Second, they are typical application areas of EPA and EPWP, where regional environmental issues and people's livelihood issues are intertwined. Third, the two regions are typical demonstration counties in the EPWP policy pilot. However, there are significant differences in wages, with 10,000 CNY and 4,000 CNY per capita per year in Jiangxi Province and Hubei Province, respectively, which could represent various level regions of ecological custodian wages in China. The wage in Hubei Province is subsidized by the central government, while Jiangxi Province is subsidized by the central and local governments. And part of local subsidies is extracted from the public welfare forest subsidies (the public welfare forest subsidy standard is 315 CNY/ha, the actual distribution to farmers is 267.75 CNY/ha, and the difference is used to subsidize wages). Comparing the two provinces, it is found that the work intensity and requirements in Jiangxi Province are significantly higher than that in Hubei Province.

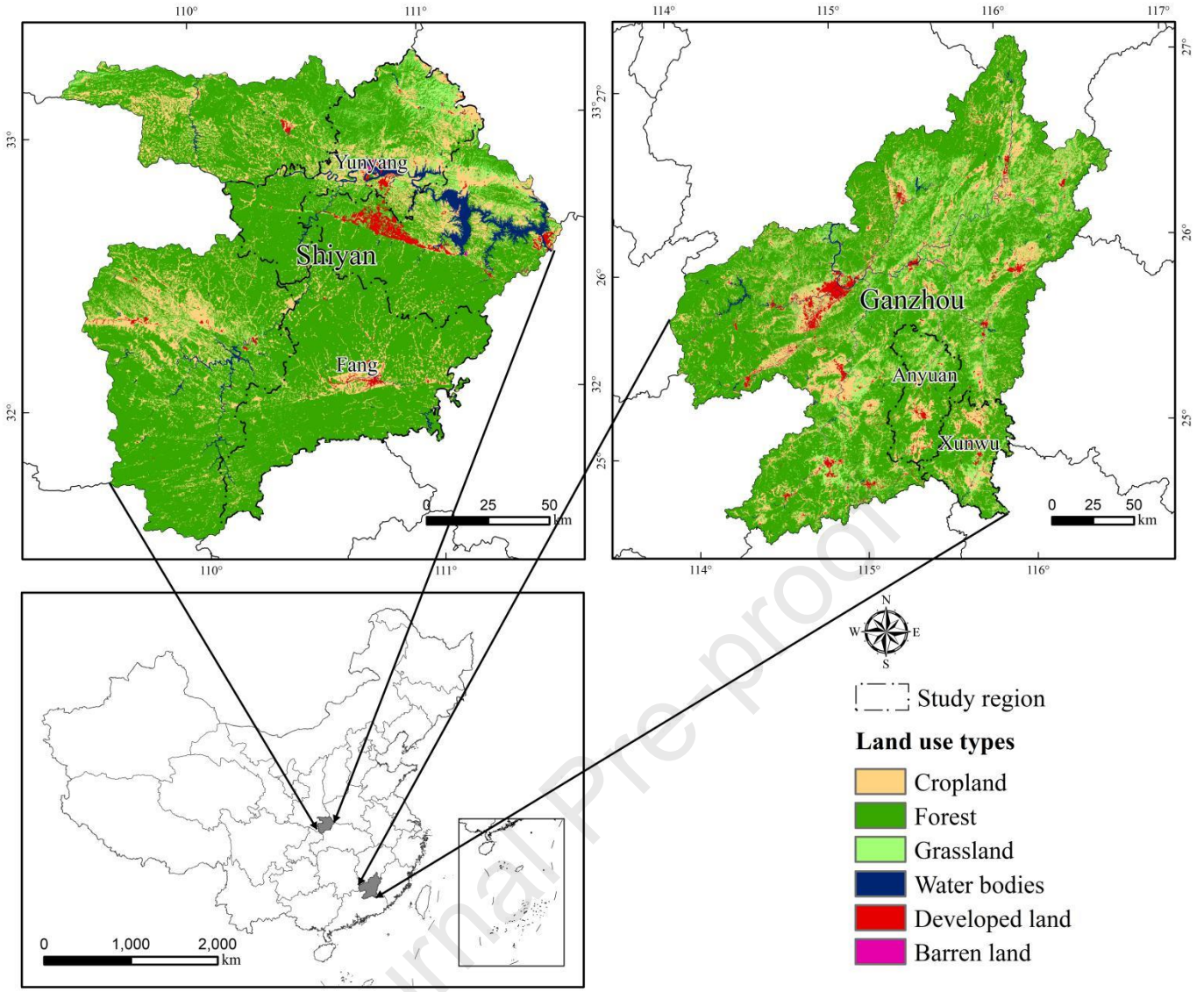

Fig. 3. Study region and land use types.

A stratified random sample was used to select 21 townships in the study region, involving 52 villages. Interviews with county government agencies were required beforehand to obtain information on overall production, living conditions, and sub-income (Appendix Table 1). Subsequently, collect data in the form of questionnaires by face-to-face interviews with farmers. Because the threshold for participation in EPWP is formerly registered impoverished households[4], this study selected 508 formerly registered impoverished households as the research sample, with an effective rate of 95.85%. The sample distribution is shown in Fig. 4.

[4] Formerly registered impoverished households refer to the households registered as living under the poverty line in China before 2020.

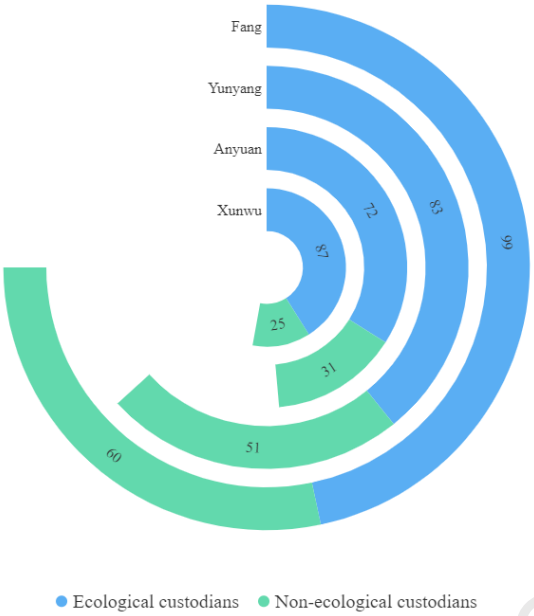

Fig. 4. Sample distribution.

Note: Xunwu and Anyuan are counties in Jiangxi Province, Yunyang and Fang are counties in Hubei Province.

This study examined the rationality of sample size, and the minimum sample size suitable for this study was assessed according to the formula proposed by Agidew and Singh (2018).

$$n=\frac{N}{1+N\cdot e^2} \quad (1)$$

Where N is the population size of the study area (unit: ten thousand people), n is the minimum sample size, and e is 5% accuracy. In 2019, the number of rural households in Hubei Province was 7.96 million and in Jiangxi Province was 5.98 million[5]. After calculation, the minimum number of sample households suitable for this study is 103, which verifies that the sample is adequate.

3.2 Research methods

3.2.1 Propensity score matching (PSM)

Farmers with various characteristics have different preferences for policies (Ma and Wen, 2019). PEPWP is voluntary, and it is up to the farmers to decide whether or not to participate rather than being randomly assigned. In identifying the effect of PEPWP on income, participation as a dummy variable suffers from endogeneity due to self-selection. The use of traditional OLS regression suffers from estimation bias, which affects the identification effect. PSM method can better solve endogeneity estimation bias caused by sample self-selection and is used in policy evaluations (Gautam et al., 2017; Liu et al., 2019). The basic idea is to construct a "counterfactual" analytical framework that minimizes sample bias by finding a control group that is most similar to the treatment group. In this study, we used PSM to identify the effect of PEPWP on farmers' household income composition to test H1.

Firstly, a simple baseline model was required:

$$income_i=\alpha_0+\alpha_1 participation_i+\alpha_2 X_i+\mu_i \quad (2)$$

[5] China Statistical Yearbook 2020 (http://www.stats.gov.cn/tjsj/ndsj/2020/indexch.htm)

In the formula, $income_i$ represented various types of income, and the logarithmic form was used in this study. $participation_i$ was whether to participate, and the value of 0 meant not participating, and the value of 1 meant participating. X_i represented control variables, including the basic characteristics of interviewees and household resource endowments. α_0, α_1, α_2 were the corresponding regression coefficients, and μ_i was the random error term.

Secondly, a counterfactual framework was introduced to approximately randomize the non-random data of PEPWP, that was, used the "propensity score" as the probability of participation, finding a score similar to that of participation among non-participating farmers of the control group, constructing an approximately randomized data. This study used the Logit model to estimate the propensity score $p(X_i)$, and the calculation formula was as follows:

$$p(Xi)=Pr(participation_i=1|X_i)=\exp(\beta X_i)/[1+\exp(\beta X_i)] \quad (3)$$

The left side was the conditional probability fitting value, and the right side represented the cumulative distribution function. X was a set of matching variables. β was the coefficient of matching variables.

Finally, the average treatment effect for the treated (ATT) of the treatment groups was calculated based on the matched sample, which meant the average difference between the factual income and the "counterfactual" income of participation:

$$ATT=\frac{1}{N_1}\sum_{i:Di=1}(income_{1i}\text{-}income_{0i})=E(income_i^1|patrol_{i=1})\text{-}E(income_i^0|patrol_{i=1}) \quad (4)$$

In the formula, $income_{1i}$ represented factual income; $income_{0i}$ was “counterfactual” income.

There are different matching methods for PSM. The results are usually compared, and if basically consistent, the results are robust. This study used k-nearest neighbor matching method (k=3), caliper matching (r=0.01) and kernel matching method for robustness testing.

3.2.2 Moderated mediation model

The regression coefficients were tested for significance by the Bootstrap method (resampled 5000 times). Compared with the stepwise regression method, the Bootstrap method has the following advantages, (1) directly tests the mediating effect without first testing whether the main effect of the independent variable on the dependent variable is significant, avoiding the influence of the "masking effect" on the results. (2) places the mediation analysis of the moderator at different levels in the same framework, avoiding the occurrence of missing variables. (3) test the mediating and moderating effects of binary dependent variables, which compensates for the deficiency that stepwise regression can only test continuous dependent variables.

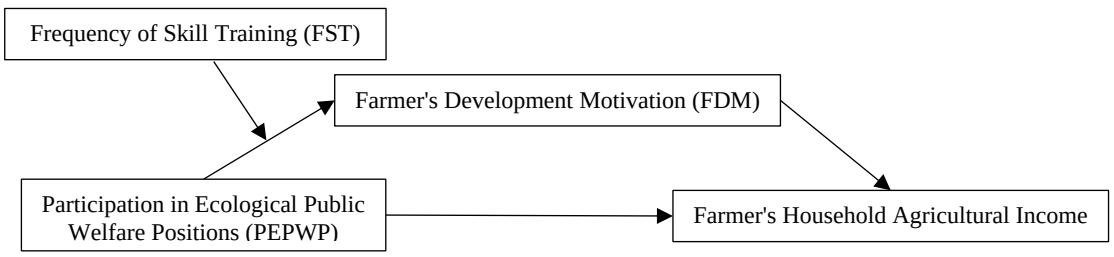

Fig. 5. Internal mechanisms of the effect of PEPWP on farmer's household agricultural income.

3.3 Variable selection

3.3.1 Explained variables

Farmers' household income includes total income and 7 sub-incomes, covering planting, forestry, husbandry, wage, off-site, local part-time job, and non-agricultural operation (see Appendix Table 2). Income variables are all in natural logarithmic form to reduce heteroscedasticity problems[6].

3.3.2 Treatment variables

Whether to participate in EPWP was set as a discrete binary variable. The relevant question was, "Do you serve as ecological custodians?" If the answer was "yes", the assignment was 1; otherwise, the assignment was 0.

3.3.3 Matching variables and control variables

According to Heckman et al. (1997), the selection of matching variables must impact both participation decision-making and income, but it should not be affected by participation behavior. On the basis of referring to other researches, this study selected basic characteristic variables, and household resource endowment variables, as matching variables for calculating propensity scores (Table 2). Among them, material capital was referenced by Li et al. (2007), which is a standardized score obtained based on the household housing situation and fixed assets (see Appendix B for calculation). Mediator, moderator, and control variables[7] were used in conditional process analysis.

Table 2 Definition of variables and statistical description of differences in means.

Variables		Variable description	Jiangxi Province			Hubei Province		
			PEPWP	Not PEPWP	Variance t-test	PEPWP	Not PEPWP	Variance t-test
Income status	lny_{total}	Logarithm of total income	10.574 (0.52)	10.032 (0.648)	0.542***	9.977 (0.695)	9.417 (0.786)	0.560***
	lny_{plant}	Logarithm of planting income	6.543 (4.068)	4.094 (4.268)	2.449***	2.302 (3.444)	1.689 (3.135)	0.613
	lny_{forest}	Logarithm of forestry income	0.099 (0.92)	0 (0)	0.099	0.454 (1.816)	0.43 (1.689)	0.024
	lny_{husb}	Logarithm of husbandry income	2.444 (3.74)	2.957 (3.745)	-0.513	3.887 (4.346)	1.52 (3.073)	2.367***
	lny_{wage}	Logarithm of wage income	9.227 (0.076)	1.635 (3.353)	7.592***	8.305 (0.093)	0.517 (2.13)	7.788***
	lny_{off}	Logarithm of off-site income	1.645 (3.675)	2.162 (4)	-0.517	0.842 (2.557)	1.12 (3.05)	-0.278
	lny_{part}	Logarithm of local part-time job income	5.442 (4.551)	4.323 (4.736)	1.119*	4.686 (4.603)	3.512 (4.51)	1.174*
	lny_{opera}	Logarithm of non-agricultural operation income	0.491 (2.161)	0.668 (2.431)	-0.177	0.389 (1.79)	0.416 (1.853)	-0.027
Basic Character-	Age	Actual age of interviewees	50.83 (9.063)	56.107 (9.773)	-5.277***	55.2 (9.666)	58.343 (12.495)	-3.143*

[6] In order to avoid the situation that when the original income takes the value of 0, its natural logarithm is negative infinity, this study added 1 uniformly to the original income value and then takes the natural logarithm.

[7] Control variables included age, gender, health, and education

istics of Interview-ees	Gender	0=female, 1=male	0.969 (0.175)	0.982 (0.134)	-0.013	0.833 (0.374)	0.699 (0.46)	0.134**
	Health	1=healthy, 2=slight illness does not affect work, 3=chronic dis-ease, weak working ability, 4=unable to work	1.327 (0.651)	1.804 (0.942)	-0.477***	1.9 (0.903)	2.469 (1.006)	-0.569***
	Education	1=primary school and below, 2=junior high school, 3=high school, 4=college, 5=undergraduate and above.	1.597 (0.628)	1.643 (0.699)	-0.046	1.44 (0.67)	1.42 (0.665)	0.02
	Training	The measurement of skill train-ing: Have you received training in employment skills, planting and breeding technology, wa-ter-saving irrigation, forestry management, etc.? 0=no, 1=yes	0.742 (0.439)	0.643 (0.483)	0.099	0.487 (0.501)	0.224 (0.418)	0.263***
	Skill	The measurement of non-agricultural labor skills: Do you have non-farm labor skills that generate economic income? 0=no, 1=yes	0.126 (0.333)	0.125 (0.334)	0.001	0.12 (0.326)	0.133 (0.341)	-0.013
Household resource endowment	labor	Labor force size	2.579 (1.507)	2.554 (1.235)	0.025	2.407 (1.306)	2.294 (1.547)	0.113
	migrant	Population size of migrant workers	0.811 (1.254)	1.232 (1.027)	-0.421**	0.787 (0.945)	1.049 (1.445)	-0.262*
	land	Cultivated land area: actual household contracted cultivated land area (0.067ha)	5.224 (4.999)	4.139 (3.996)	1.085	3.989 (3.059)	4.039 (3.965)	-0.05
	forest	Forest Land area: actual house-hold contracted forest land area (0.067ha)	20.196 (28.015)	20.378 (36.359)	-0.182	47.945 (96.438)	17.865 (23.951)	30.08***
	Social	Social connections: How much did your family spend on social connections last year? (10000 CNY/a)	2084.667 (2299.606)	1375.926 (1229.501)	708.741**	2452.365 (2969.484)	2163.986 (2549.602)	288.379
	Material	Material capital: a standardized score obtained based on the household housing situation and fixed assets	0.779 (0.132)	0.721 (0.164)	0.058***	0.611 (0.149)	0.604 (0.128)	0.007
Mediator	FDM	Farmer's development motiva-tion	2.237 (0.060)	1.604 (0.106)	0.633***	2.361 (0.069)	1.408 (0.055)	0.953***
Moderator	FST	The frequency of skill training	2.516 (0.146)	1.482 (0.209)	1.034***	1.533 (0.153)	0.531 (0.105)	1.002***

Note: SE in parentheses, and ***, **, * are significant at 1%, 5%, 10% levels, respectively.

3.3.4 Mediator

This study defined the capacity corresponding to functional activities related to the quality of life-improvement and production efficiency increase as FDM. It used the question, "If you get a ¥20,000 grant, what would you spend it on first?"

to measure FDM. Referring to Shi et al. (2022), if farmers choose "Savings", "Expenditure on food and clothing", and "Children education", which are still the primary objectives to safeguard or improve daily basic living, and are assigned a value of 1. "Learning a new craft" is assigned a value of 2 because although it does not directly generate income, farmers improve their ability to earn money by upgrading their skill and labor literacy. However, "Learning a new craft" is still essentially an exchange of labor and time for income, while investment can have a comprehensive capital effect. According to research on total factor productivity in Chinese agriculture (Li et al., 2009; Zhu et al., 2011), the capital elasticity is significantly higher than the labor elasticity. Therefore, "Investment in agriculture (purchase of farm machinery, expansion of cropping or husbandry scale)" and "Investment in non-agriculture (do a bit of business, etc.)" are assigned a value of 3.

3.3.5 Moderator

The frequency of farmers participating in the skill training was set as a moderator. The relevant question was, "Have you obtained training in employment skills, farming techniques, water conservation and irrigation, forestry management, etc.? How many times have they participated? What are the specifics?"

4 Quantitative Analysis

4.1 Propensity score matching estimation

4.1.1 Matching quality

This study examined the quality of matching through the common support condition and the balancing hypothesis. From the kernel density distribution of propensity scores before and after matching (Fig.6 and Fig.7)[8], two groups of samples after matching had large overlapping areas in the propensity score density distribution, indicating that the propensity value matching satisfies the common support domain condition better. The balanced hypothesis test results[9] showed that before matching, most of the covariates had relatively large deviations. After matching, the deviations of the variables were all reduced to less than 17.3%, which was below the 20% criterion. The reduction ranged from 20.2% to 97.4%, and all deviations were insignificant. Pseudo R^2 was significantly reduced to almost zero, and MeanBias and MedBias both decreased significantly, with both B values less than 25%. It can be seen that PSM significantly reduced the difference between the treatment and control groups and better controlled the endogeneity error, which indicated that the use of PSM model was consistent with the conditional independence assumption that the two groups of samples were essentially similar in each characteristic dimension after matching.

[8] Due to space limitations, k-nearest neighbor matching was used as an example.
[9] The results of Rosenbaum's boundary estimates were not demonstrated due to the limitation of the length of the article, and interested readers can ask the authors for them.

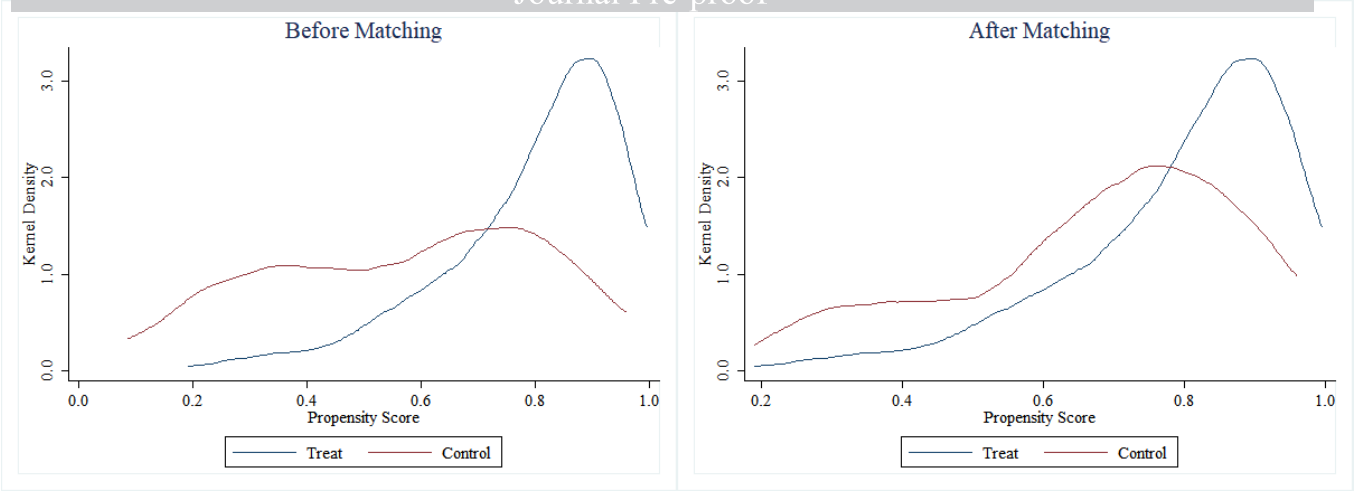

Fig. 6. Kernel density distribution of propensity values before and after sample matching in Jiangxi Province.

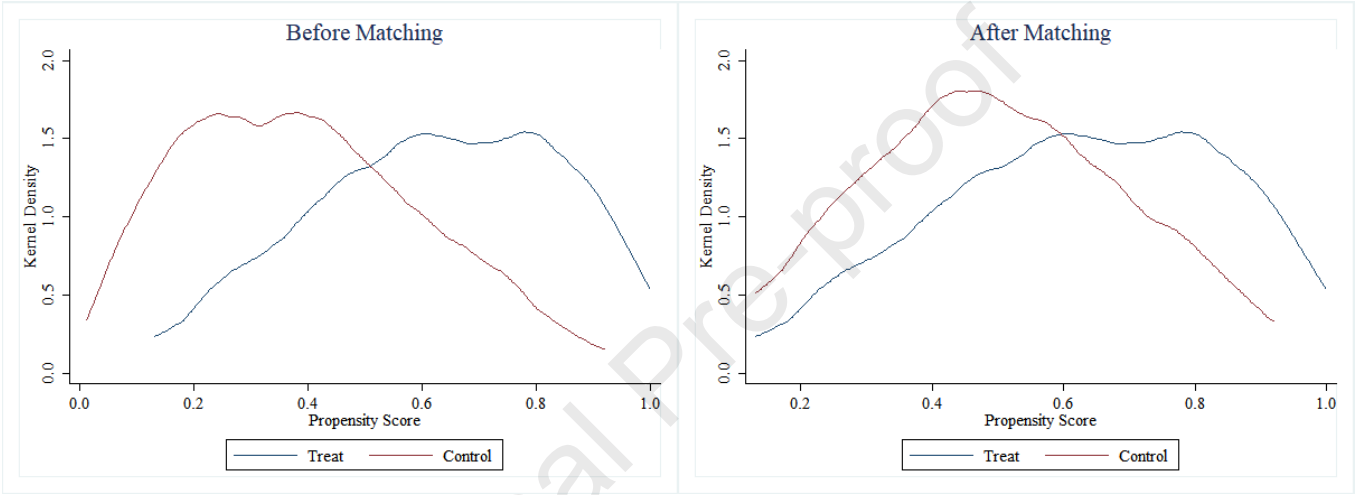

Fig. 7. Kernel density distribution of propensity values before and after sample matching in Hubei Province.

4.1.2 Average treatment effects analysis on the treated

To ensure the robustness of the matching results, k-nearest neighbor matching, caliper matching, and kernel matching were performed, respectively (Table 3 and Table 4). Generally, the results of the three matches were consistent. The study found that PEPWP led to a shift from single agricultural production to concurrent business. In addition to the significant increase in wage income, planting income in Jiangxi Province and husbandry income in Hubei Province also increased. Ganzhou City has unique climatic and resource advantages in navel orange production, which is one of the pillar industries of agriculture. However, husbandry is limited by the ecological red line policy. In contrast, most farmers in Shiyan City grow lower profitable crops such as wheat and corn, but husbandry income accounts for a large proportion of household income. In addition to the necessary training for ecological custodians, ecological protection stations also provide training on vegetables, rice planting technology, husbandry, and poultry breeding technology, which can indirectly increase the breeding income of farmers to a certain extent. However, PEPWP promoted farmers' income increase relying more on wages. Compared with the differences between the two regions, ecological protection stations should combine the local resource advantages, respect the farmers' willingness to learn, and select training programs according to local conditions.

Table 3 Treatment effects on farmers' household income (Jiangxi Province).

Matching method	y_{total}	y_{plant}	y_{forest}	y_{husb}	y_{wage}	y_{off}	y_{local}	y_{oper}

No matched	0.480***	2.206***	0.106	-0.778	7.676***	-0.575	0.773	-0.178
	(0.086)	(0.659)	(0.131)	(0.594)	(0.267)	(0.614)	(0.742)	(0.369)
K-nearest neighbor matching	0.427***	1.862*	0.112	-1.233	7.458***	-0.364	-0.761	-0.160
	(0.141)	(1.129)	(0.079)	(0.965)	(0.861)	(1.128)	(1.179)	(0.565)
Caliper matching	0.439***	1.873**	0.112	-1.033	7.710***	-0.085	0.239	-0.361
	(0.098)	(0.726)	(0.097)	(0.713)	(0.512)	(0.676)	(0.841)	(0.448)
Kernel matching	0.472***	1.668*	0.112	-1.028	7.490***	-0.123	-0.603	-0.136
	(0.125)	(1.100)	(0.085)	(0.931)	(0.761)	(1.037)	(1.102)	(0.504)
Mean	0.446	1.801	0.112	-1.098	7.553	-0.191	-0.375	-0.219

Note: SE in parentheses, and ***, **, * are significant at 1%, 5%, 10% levels, respectively.

Table 4 Treatment effects on farmers' household income (Hubei Province).

Matching method	y_{total}	y_{plant}	y_{forest}	y_{husb}	y_{wage}	y_{off}	y_{local}	y_{oper}
No matched	0.525***	0.399	0.027	2.216***	7.762***	-0.361	1.127	-0.128
	(0.090)	(0.394)	(0.216)	(0.455)	(0.183)	(0.338)	(0.546)	(0.213)
K-nearest neighbor matching	0.584***	0.087	-0.133	1.700***	7.682***	0.027	-0.633	-0.159
	(0.150)	(0.684)	(0.545)	(0.765)	(0.371)	(0.713)	(0.893)	(0.501)
Caliper matching	0.528***	0.244	-0.042	2.245***	7.725***	-0.456	1.118	-0.136
	(0.100)	(0.407)	(0.236)	(0.499)	(0.204)	(0.366)	(0.567)	(0.233)
Kernel matching	0.497***	0.338	-0.259	1.931***	7.832***	-0.363	-0.192	-0.427
	(0.119)	(0.550)	(0.371)	(0.621)	(0.219)	(0.574)	(0.737)	(0.424)
Mean	0.536	0.223	-0.145	1.959	7.746	-0.264	0.098	-0.241

Note: SE in parentheses, and ***, **, * are significant at 1%, 5%, 10% levels, respectively.

4.1.3 Robustness test of PSM

(1) Replacement matching method

There are various matching methods for PSM, and to ensure the robustness of the estimation results, K-nearest neighbor matching, caliper matching, and kernel matching were used to estimate ATT. The estimation results are shown in Tables 3 and 4 and are consistent.

(2) Matching method for bias-correction

Since there is a certain bias in inexact matching, Abadie and Imbens (2011) proposed a bias-correction method to obtain the matching estimator. The test using this method shows that the estimation results are quite robust (Table 5).

Table 5 Bias-correction matching estimation results.

	Jiangxi Province			Hubei Province		
Bias-correction	y_{total}	y_{plant}	y_{wage}	y_{total}	y_{husb}	y_{wage}
Before	0.363***	1.869**	7.375***	0.479***	1.506**	7.764***
	(0.088)	(0.923)	(0.910)	(0.121)	(0.620)	(0.204)
After	0.379***	1.754*	7.893***	0.538***	1.675**	7.765***
	(0.088)	(0.923)	(0.910)	(0.121)	(0.620)	(0.204)

Note: SE in parentheses, and ***, **, * are significant at 1%, 5%, 10% levels, respectively.

(3) Transformation of the econometric model

The OLS model was used for the analysis, and the estimation results remain robust after transforming the econometric model, as seen in Table 6.

Table 6 OLS model estimation results.

	Jiangxi Province			Hubei Province		
	y_{total}	y_{plant}	y_{wage}	y_{total}	y_{husb}	y_{wage}
d	0.363***	1.800**	7.576***	0.398***	1.631***	7.754***
	(0.089)	(0.731)	(0.301)	(0.091)	(0.498)	(0.208)
Matching variables	-	-	-	-	-	-
R^2	0.306	0.130	0.816	0.302	0.165	0.870

Note: SE in parentheses, and ***, **, * are significant at 1%, 5%, 10% levels, respectively.

4.2 Conditional process analysis of the effect of PEPWP on income

From the PSM results, PEPWP significantly increased wage income and farmers' household agricultural income (as reflected in the increase in planting income in Jiangxi Province and husbandry income in Hubei Province). What is the internal mechanism of PEPWP on farmers' agricultural income? This study used conditional process analysis to investigate.

4.2.1 Common method bias test

The results of the common method bias test using Harman's single factor test (Podsakoff and Organ, 1986) indicated that the first factor explained 31.664% of the total variance, which was lower than the critical value (40%) suggested by previous research. It proved that there was no significant common method bias in this study.

4.2.2 Descriptive statistics and correlation matrix of the main variables

Descriptive statistics and correlation analysis results were in Table 7, which revealed a significant positive correlation among PEPWP, FDM, agricultural income[10] and FST.

Table 7 Correlation analysis of each variable.

	M	SD	1	2	3	4
1. PEPWP	0.608	0.489	1			
2. FDM	1.965	0.808	0.499**	1		
3. Agricultural income	5.384	4.204	0.268**	0.277**	1	
4. FST	1.553	1.840	0.329**	0.408**	0.301**	1

Note: ***, **, * are significant at 1%, 5%, 10% levels, respectively.

4.2.3 *Moderated mediation effect and robustness test*

First, Model 4 in PROCESS (Hayes, 2017) was used to test the mediating effect. The results showed that the total effect of PEPWP on agricultural income was 2.037. FDM partially mediated between PEPWP and agricultural income, with a mediating effect of 0.727, accounting for a total effect of 0.727/2.037=35.69%.

Sobel test and self-help method test were conducted to test the robustness of the mediating effect estimates, respectively. Sobel test resulted in a z-value equal to 3.064 and a p-value equal to 0.002, which indicated that the mediating effect passed the Sobel test. The results of Bootstrap test are shown in Table 8. The confidence intervals for both the indirect and direct effects corrected for bias didn't contain 0, which meant there was a transmission mechanism of PEPWP to income by FDM. Both tests demonstrated that the estimation results were robust.

[10] Agricultural income is measured by taking the natural logarithm of the sum of planting income, forestry income, and husbandry income

Table 8 Bootstrap test results of the mediating effects.

Bootstrap test	coefficient	SE	95%CI	Bias-corrected 95%CI
Indirect effect	0.727	0.241	[0.265,1.217]	[0.265,1.212]
Direct effect	1.31	0.483	[0.362,2.259]	[0.362,2.259]

Second, the moderating effect test was performed using Model 7 in PROCESS (Hayes, 2017). Results showed that PEPWP×FST was a significant predictor of FDM, β= 0.099, p < 0.05 (Table 9). The recommendations of Jeffrey et al. (2007) were used to test H3 (Table 10). The difference values of the two indirect paths were significant (β=0.298, p<0.001) in the case of low and high FST. When the Bootstrap method was repeated 5000 times, the 95%CI was [0.010,0.681], which indicated that higher FST, higher effects of PEPWP on agricultural income through FDM. Thus H3 was validated.

Table 9 Moderated mediation.

	Dependent Variable: FDM			Dependent Variable: agricultural income		
	β	SE	95%CI	β	SE	95%CI
control variable		controlled			controlled	
PEPWP	0.735***	0.077	[0.585,0.886]	1.310***	0.483	[0.362,2.259]
FST	0.108***	0.020	[0.068,0.148]			
PEPWP×FST	0.099**	0.043	[0.013,0.184]			
FDM				0.885***	0.276	[0.342,1.427]
R2		0.327			0.133	
F		29.097***			10.771***	

Note: ***, **, * are significant at 1%, 5%, 10% levels, respectively.

Table 10 Moderated mediation test.

	β	SE	BootLLCI	BootULCI
Low FST(M-1SD)	0.510	0.178	0.181	0.879
High FST(M+1SD)	0.808	0.280	0.287	1.384
Difference between high and low FST	0.298	0.170	0.010	0.681

To further explain the moderating effect of FST and test the robustness of the results, FST was divided into two groups, high and low, by mean plus or minus one standard deviation, and the slope test was conducted. The results showed (Fig. 8) that when at high FST (M+1SD), PEPWP had a significant positive predictive effect on FDM, β=0.914, t=7.518, p<0.001. As for low FST (M-1SD), the predictive effect of PEPWP on FDM was relatively small, β=0.577, t=6.342, p<0.001. The results indicated that FST moderated the mediating effect of PEPWP on income through FDM.

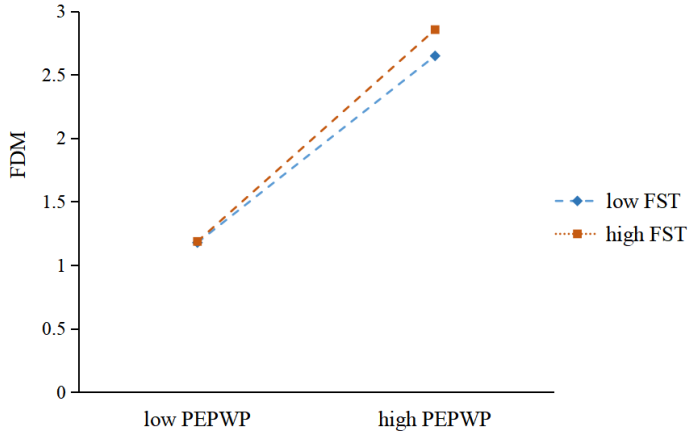

Fig. 8. The moderating effect of FST.

5 Discussion and Implications

Ecologically fragile regions frequently overlap highly with farmers' livelihood-vulnerable regions, and poverty and environmental issues are intertwined (Alvarado et al.; Lei et al., 2021). The ecosystem is significant livelihood capital, while the degradation leads to the emergence or worsening of poverty (Sen, 1982). Poverty is not only the result of ecological vulnerability but also in turn further exacerbate it (Barbier, 2012; Bird et al., 2002; Liu and Li, 2017; Zhou et al., 2020). The vicious cycle between poverty and eco-environmental degradation is one of the main reasons for the slow social-economic development in less developed areas. How to break this vicious circle and make families escape the "poverty trap" has always been a hot topic of widespread concern (Bird, 2010; Lei et al., 2021). As one of the most effective EPA programs, rationally designed PES programs are seen as a key to achieving synergistic development between poverty reduction and ecological conservation (Cao et al., 2017; Engel et al., 2008; Kinzig et al., 2011; Ola et al., 2019). EPWP policy has been widely and efficiently implemented, resulting in a steady growth in income in farmers' livelihood-vulnerable regions and a significant improvement in the regional environment, as well as a proactive role in enhancing FDM and rural administration.

Firstly, in farmers' livelihood-vulnerable regions, PEPWP progressively enhanced farmers' household income. Although the important role of PES plan in promoting the income increase of farmers has been discussed internationally (Pagiola et al., 2005; Pham et al., 2021; Sheng and Wang, 2022), researches on the income-enhancing effect of EPWP were relatively rare, and this study complemented it. As of 2019, China's national ecological forest covered 113 million ha, accounting for 11.8% of the national land area[11]. As forest resource is most frequently affected by human activities, it is necessary to patrol and protect them. According to survey data, the salary of ecological custodians was 69.6 CNY/ha. If the per capita salary reaches 8,000 CNY/year, the per capita protection area should be 114.94 ha. It can be estimated that a national ecological forest needs 983,100 ecological custodians, which will increase 7.87 billion yuan of regional transfer income, and the multiplier effect brought by transfer payments will drive regional economic development. This study discovered that PEPWP can reallocate labor time and human resources, resulting in increased personal wage income as well as household agricultural income, providing multiple opportunities to increase income and bringing the positive effect of "one person participates in ecological conservation, the entire family increases revenue."

Secondly, EPWP policy significantly improved regional ecological environment. As typical public resources, forests, grasslands, and wetlands do not have clear property rights characteristics. It may not be effective to rely only on high-cost government supervision, social donation, and moral awareness. How to establish a diversified and sustainable management and conservation mechanism? How to motivate farmers, community groups, conservation stations, and other organizations to participate in ecological conservation? These are critical issues in ecological construction. The area under ecological custodians patrol per capita in China must be at least 33.3 ha for ecological forest, 133.3 ha for wetlands and sandy regions,

[11] Department of Forest Resources Management, 2021 (http://www.forestry.gov.cn/slzy/1599/20210127/160840724923126.html)

and 200 ha for grasslands[12]. EPWP policy arranged for farmers to participate in ecological custodianship through the government's purchase of services, which raised farmers' environmental consciousness. More importantly, EPWP policy expanded the ecological protection teams at the grass-roots level, improved the level of regional ecosystem service supply, and tightened the protection network of natural resources in ecologically fragile regions. A series of spillovers from EPWP was consistent with the conclusion that other PES programs were proven to increase ecosystem services (Aganyira et al., 2020; Duan et al., 2015; Peskett et al., 2011)

Thirdly, this study also found that EPWP policy effectively stimulated FDM. Rural revitalization aims to strengthen farmers' development ability and willingness. Development motivation includes labor skills, management capacity, material conditions, and resource elements. EPWP policy has realized the transition from relief assistance to participatory assistance. Farmers have exercised their abilities and gained respect by participating in ecological management and protection. Furthermore, farmers' ability to survive and secure, develop their products, and earn income from their property has been further enhanced through skill training (Liu et al., 2021). In practice, there is a number of ecological custodians who lead the way to increase income. It further confirms the positive effect of EPWP on the development of farming households. In order to clarify the intrinsic effect mechanism of PEPWP on income, this study established the transmission mechanism of "participation environment - enhancement process - effect outcome", which verified the mediating and moderating effects of FDM and FST in the effect of PEPWP on income. This study is innovative as it breaks away from the limitations of previous research with a single pathway.

Furthermore, EPWP policy drives to improve rural governance in farmers' livelihood-vulnerable regions. Good rural governance is an essential component of the modernization of the national governance system and capacity (Koopmans et al., 2018). EPWP policy has built a "grid" management and protection mechanism to improve the level of rural governance in farmers' livelihood-vulnerable regions, which would, to a certain extent, contribute to rural revitalization. In promoting EPWP policy, the government gradually attaches great importance to the multi-functional role of ecological custodians. In addition to protection work, ecological custodians are also called to participate in rural governance. Luocheng County, Guangxi Province, China, has explored the "six-responsibilities" mechanism, and expanded and enriched the work responsibilities. Ecological custodians are guided to become guards of lucid waters and lush mountains, informers of rural governance, propagandists of national policies, supervisors of grassroots work, promoters of agricultural technology, and epidemic prevention coordinators, which could be taken into account in the future extension of EPWP policy. However, it is vital to concentrate on the balance between pay and workload.

It should be noticed that the primary purpose of setting up ecological custodians is to protect natural resources and prevent the damage to the ecological environment rather than assist low-income groups. The causes of livelihood vulnerability are diverse. The ability to be competent as ecological custodians should be considered in specific practice (Wu and Jin, 2020). According to the selection requirements, ecological custodians should be the ages of 18-60, healthy, competent

[12] National Forestry and Grassland Administration, 2021 (http://www.forestry.gov.cn/main/5501/20210918/094857480178062.html)

for field inspections, and can stop environmental damage. In addition, the number of ecological custodians should be reasonably controlled, and their assignment should be related to the size and difficulty of the patrol region, work performance, and other factors to avoid "setting positions due to poverty".

In conclusion, some insights are summarized. First, in response to PEPWP promoting farmers' household income that is more dependent on increased wage income, attention should be paid to diversifying farmers' income channels. Beware of returning to poverty due to large fluctuations in income after resigning from welfare positions. Second, the multi-functional role of ecological custodians should be emphasized. In addition to protection work, ecological custodians should participate in rural governance, and increase farmers' sense of social responsibility and participation. Furthermore, attention should be paid to the role of skill training by setting up training projects according to local conditions to activate the development power of farmers and effectively improve the effect of supporting policies.

Exploring the specific case of EPWP in China's PES program also has other significant implications for scholars and policymakers. First, the study not only confirmed that PEPWP affected household income composition, but also drew on psychological methods to explore the specific internal mechanism, which provided a new perspective and empirical evidence for related research fields. Second, the empirical approach of this study was largely generalizable and can be utilized to validate the income effects of other PES programs. In addition, the findings and insights may also be applied to other regions in China, as well as similar ecologically fragile regions around the globe.

6. Conclusions

The findings of this study are as follows. First, farmers participating in EPWP exhibited the characteristics of "self-selection", and after eliminating selective bias, PEPWP significantly increased the total household income of the farmers. In terms of sub-incomes, PEPWP significantly increased farmers' planting income in Jiangxi Province, husbandry income in Hubei Province, and wage income in both provinces, but the effects on other sub-incomes were insignificant. Overall, PEPWP promoted farmers' household income growth primarily by income diversification, which is in line with the development direction of the transformation to part-time farming advocated by the Chinese government. However, income from planting and husbandry had a smaller effect on farmers' household income than wage income. Second, there was a moderated mediating model between PEPWP and farmers' household agricultural income. FDM played a mediating effect between PEPWP and agricultural income, and this mediating effect accounted for 18.49% of the total effect. In addition, FST acted as a positive moderator of FDM's mediating role between PEPWP and agricultural income, specifically by moderating the anterior path of this mediation model. At a higher FST, the positive effect of PEPWP via FDM on agricultural income would amplify. Third, EPWP policy steadily enhanced farmers' household income in farmers' livelihood-vulnerable regions and significantly improved the regional ecological environment, as well as playing an active role in promoting FDM and rural governance.

There are still limitations in this study. First, this study adopted self-report measures. Farmers verbally responded to

our questions, which were highly subjective and susceptible to being impacted by the directionality and orientation of the performance evaluation. In the future researches could design more detailed and plausible methods to quantify these self-reports and employ more optimized survey methods to minimize the impact of subjective factors on the outcomes. Second, the analysis exclusively examined the revenue of farmers in 2019 only, ignoring the distortion created by temporal dynamics. Future tracking survey data can be utilized to investigate the evolution over time of the relationship between PEPWP, FDM, NST, and farmers' household income.

CRediT authorship contribution statement

Ke Xu: conceptualization, questionnaire development, methodology, data curation, software, formal analyses, writing original draft, visualization, writing review and editing, validation. **Changbin Yin:** supervision, writing original draft, resources, project administration, funding acquisition. **Boyang Shi:** data curation, writing-review and editing, validation. **Jie Pang:** data visualization, writing-review and editing.

Declaration of competing interest

We declare that no potential conflict of interest was reported by the authors.

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Reference

Abadie, A., Imbens, G.W., 2011. Bias-corrected matching estimators for average treatment effects. Journal of Business & Economic Statistics 29(1), 1-11.

Aganyira, K., Kabumbuli, R., Muwanika, V.B., Tabuti, J.R.S., Sheil, D., 2020. Determinants of participation in state and private PES projects in Uganda. Scientific African 8.

Agidew, A.A., Singh, K., 2018. Factors affecting farmers' participation in watershed management programs in the Northeastern highlands of Ethiopia: a case study in the Teleyayen sub-watershed. Ecological processes 7(1), 1-15.

Alvarado, Rafael, Toledo, Elisa, Environmental degradation and economic growth: evidence for a developing country.

Arriagada, R., Villaseñor, A., Rubiano, E., Cotacachi, D., Morrison, J., 2018. Analysing the impacts of PES programmes beyond economic rationale: Perceptions of ecosystem services provision associated to the Mexican case. Ecosystem Services 29, 116-127.

Barbier, E.B., 2012. Natural capital, ecological scarcity and rural poverty. World Bank Policy Research Working Paper(6232).

Begazo Curie, K., Mertens, K., Vranken, L., 2021. Tenure regimes and remoteness: When does forest income reduce poverty and inequality? A case study from the Peruvian Amazon. Forest Policy and Economics 128.

Bird, K., 2010. Isolation and poverty: the relationship between spatially differentiated access to goods and services and poverty.

Bird, K., Hulme, D., Shepherd, A., Moore, K., 2002. Chronic poverty and remote rural areas. Chronic Poverty Research Centre Working Paper(13).

Cao, S., Shang, D., Yue, H., Ma, H., 2017. A win-win strategy for ecological restoration and biodiversity conservation in Southern China. Environmental Research Letters 12(4), 044004.

Clarkson, G., Dorward, P., Poskitt, S., Stern, R.D., Nyirongo, D., Fara, K., Gathenya, J.M., Staub, C.G., Trotman, A., Nsengiyumva, G., Torgbor, F., Giraldo, D., 2022. Stimulating small-scale farmer innovation and adaptation with Participatory Integrated Climate Services for Agriculture (PICSA): Lessons from successful implementation in Africa, Latin America, the Caribbean and South Asia. Climate Services 26.

Dahl, T.E., 1990. Wetland losses in the United States:1780s to 1980s.

Dahl, T.W., 2011. Status and Trends of Wetlands in the Conterminous United States 2004 to 2009.

Department of Household Surveys National Bureau of Statistics of China, 2016. Poverty Monitoring Report of Rural China. China Statistics Press.

Duan, W., Lang, Z., Wen, Y., 2015. The Effects of the Sloping Land Conversion Program on Poverty Alleviation in the Wuling Mountainous Area of China. Small-scale Forestry 14(3), 331-350.

Engel, S., Pagiola, S., Wunder, S., 2008. Designing payments for environmental services in theory and practice: An overview of the issues. Ecological economics 65(4), 663-674.

Fan, J., Zhu, X., 2016. Cultivation Model of New Farmers under the Urban Rural Development: A Case Study of Guangdong Province. Journal of Landscape Research 8(2), 68.

Fisher, J.A., Patenaude, G., Giri, K., Lewis, K., Meir, P., Pinho, P., Rounsevell, M.D.A., Williams, M., 2014. Understanding the relationships between ecosystem services and poverty alleviation: A conceptual framework. Ecosystem Services 7, 34-45.

Gautam, S., Schreinemachers, P., Uddin, M.N., Srinivasan, R., 2017. Impact of training vegetable farmers in Bangladesh in integrated pest management (IPM). Crop Protection 102, 161-169.

Gonedelé Bi, S., Bitty, E.A., Yao, A.K., McGraw, W.S., 2019. Foot Patrols Enhance Conservation Efforts in Threatened Forest Reserves of Coastal Côte d'Ivoire. Tropical Conservation Science 12.

Handler, J.F., 2004. Social citizenship and workfare in the United States and Western Europe: The paradox of inclusion. Cambridge University Press.

Hayes, A.F., 2017. Introduction to mediation, moderation, and conditional process analysis: A regression-based approach. Guilford publications.

Heckman, J.J., Ichimura, H., Todd, P.E., 1997. Matching as an econometric evaluation estimator: Evidence from evaluating a job training programme. The review of economic studies 64(4), 605-654.

Jayachandran, S., De Laat, J., Lambin, E.F., Stanton, C.Y., Audy, R., Thomas, N.E., 2017. Cash for carbon: A randomized trial of payments for ecosystem services to reduce deforestation. Science 357(6348), 267-273.

Jeffrey, Edwards, Lisa, Schurer, Lambert, 2007. Methods for integrating moderation and mediation: a general analytical framework using moderated path analysis. Psychological Methods.

Kinzig, A.P., Perrings, C., Chapin Iii, F., Polasky, S., Smith, V.K., Tilman, D., Turner, B., 2011. Paying for ecosystem services—promise and peril. Science 334(6056), 603-604.

Koopmans, M.E., Rogge, E., Mettepenningen, E., Knickel, K., Šūmane, S., 2018. The role of multi-actor governance in aligning farm modernization and sustainable rural development. Journal of Rural Studies 59, 252-262.

Kumari, S., Khanduri, V., 2019. CAPACITY DEVELOPMENT FOR FARMERS AND THEIR SERVICE PROVIDERS, 9th International Micro Irrigation Conference (9IMIC) on Micro Irrigation for Modern Agriculture.

Lei, M., Yuan, X.-y., Yao, X.-y., 2021. Synthesize dual goals: A study on China's ecological poverty alleviation system. Journal of Integrative Agriculture 20(4), 1042-1059.

Li, G., Feng, Z., Fan, L., 2009. Is the Smal-l sized Rural Household More Efficient? The Empirical Evidence from Hubei Province. China Economic Quarterly(4), 30.

Li, W., Imura, H., 2007. Eco-compensation mechanisms and policies in China. Beijing: Science Press.

Li, X., Dong, Q., Rao, X., Zhao, L., 2007. Farmer's vulnerability analysis method and its localized application. Chinese Rural Economy(04), 32-39.

Liu, M., Rao, D., Yang, L., Min, Q., 2021. Subsidy, training or material supply? The impact path of eco-compensation method on farmers' livelihood assets. J Environ Manage 287, 112339.

Liu, Y., Li, Y., 2017. Revitalize the world's countryside. Nature 548(7667), 275-277.
Liu, Y., Ruiz-Menjivar, J., Zhang, L., Zhang, J., Swisher, M.E., 2019. Technical training and rice farmers' adoption of low-carbon management practices: The case of soil testing and formulated fertilization technologies in Hubei, China. Journal of Cleaner Production 226, 454-462.
Ma, B., Wen, Y., 2019. Community Participation and Preferences Regarding Conservation and Development Policies in China's Giant Panda Nature Reserves. Sustainability 11(18).
Mincer, J., 1991. Human capital, technology, and the wage structure: what do time series show? National Bureau of Economic Research Cambridge, Mass., USA.
Murillo, R., Kilian, B., Castro, R., 2012. Leveraging and sustainability of PES: lessons Learned in Costa Rica, Ecosystem Services from Agriculture and Agroforestry. Routledge, pp. 301-322.
O'Donnell, P., 2014. Environmental governance in Northern Thailand: the role of the district-level forest ranger.
Ola, O., Menapace, L., Benjamin, E., Lang, H., 2019. Determinants of the environmental conservation and poverty alleviation objectives of Payments for Ecosystem Services (PES) programs. Ecosystem services 35, 52-66.
Pagiola, S., Arcenas, A., Platais, G., 2005. Can Payments for Environmental Services Help Reduce Poverty? An Exploration of the Issues and the Evidence to Date from Latin America. World Development 33(2), 237-253.
Peskett, L., Schreckenberg, K., Brown, J., 2011. Institutional approaches for carbon financing in the forest sector: learning lessons for REDD+ from forest carbon projects in Uganda. Environmental Science & Policy 14(2), 216-229.
Pham, V.T., Roongtawanreongsri, S., Ho, T.Q., Tran, P.H.N., 2021. Can payments for forest environmental services help improve income and attitudes toward forest conservation? Household-level evaluation in the Central Highlands of Vietnam. Forest Policy and Economics 132.
Podsakoff, P.M., Organ, D.W., 1986. Self-Reports in Organizational Research: Problems and Prospects. Journal of Management 12(4), 531-544.
Sandhu, H., Sandhu, S., 2014. Linking ecosystem services with the constituents of human well-being for poverty alleviation in eastern Himalayas. Ecological Economics 107, 65-75.
Sen, A., 1982. Poverty and famines: an essay on entitlement and deprivation. Oxford university press.
Sen, A., 2000. Development as freedom. development in practice 10(2), 258-258.
Shen, J., Han, X., Hou, Y., Wu, J., Wen, Y., 2015. The Relationship between Marine Biodiversity Conservation and Poverty Alleviation in the Strategies of Rural Development in China. Journal of Coastal Research 73, 781-785.
Sheng, J., Wang, H., 2022. Participation, income growth and poverty alleviation in payments for ecosystem services: The case of China's Wolong Nature Reserve. Ecological Economics 196.
Shi, P., Wang, Q., Yu, J., 2022. The Impact of Ex Situ Poverty Alleviation Relocation on the Rural Households' Income: An Empirical Analysis Based on 1712 Households' Data in 8 Counties of 3 Municipalities in Southern Shaanxi Province. Economic Geography 42(2), 13.
Sun, F., Chen, Y., 2019. A Fuzzy Evaluation on the Development Level of Chinese Farmers. Journal of South China Agricultural University(Social Science Edition) 18(05), 45-58.
Thompson, B.S., Primavera, J.H., Friess, D.A., 2017. Governance and implementation challenges for mangrove forest Payments for Ecosystem Services (PES): Empirical evidence from the Philippines. Ecosystem services 23, 146-155.
Wang, P., Yan, J., Hua, X., Yang, L., 2019. Determinants of livelihood choice and implications for targeted poverty reduction policies: A case study in the YNL river region, Tibetan Plateau. Ecological Indicators 101, 1055-1063.
Wu, L., Jin, L., 2020. How eco-compensation contribute to poverty reduction: A perspective from different income group of rural households in Guizhou, China. Journal of Cleaner Production 275.
Zhang, H., Tang, Y., Ankrah Twumasi, M., Chandio, A.A., Guo, L., Wan, R., Pan, S., Shen, Y., Sargani, G.R., 2022. The Effects of Ecological Public Welfare Jobs on the Usage of Clean Energy by Farmers: Evidence from Tibet Areas—China. Agriculture 12(7), 900.
Zhou, Y., Li, Y., Liu, Y., 2020. The nexus between regional eco-environmental degradation and rural impoverishment in China. Habitat International 96, 102086.
Zhu, X., Shi, Q., Gai, Q., 2011. Misallocation and Total Factor Productivity in Rural China. Economic Research Journal(5), 13.

Zuo, T., Wang, L., Kuang, Z., 2018. Work for Welfare and Community Governance: Double Effcets of Public Job Program for Poverty Alleviation in Rural China - An Action Research Project in Qinba Mountain Area. Journal of Guizhou University of Finance and Economics 03, 85-92.

- Reveal the effect of ecological public welfare positions (EPWP) on farmers' income.
- EPWP can increase household income accompanying with sub-income diversification.
- The impact of EPWP on income is mediated by farmer's development motivation.
- Frequency of skill training moderates the internal mechanism of EPWP on income.
- The environmental-economic-social benefits of EPWP are discussed.

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: