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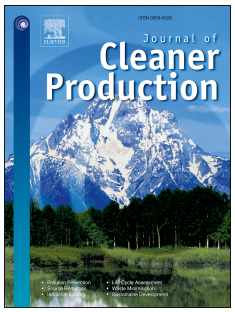

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How Eco-compensation contribute to poverty reduction: a perspective from different income group of rural households in Guizhou, China

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Abstract

In recent years, eco-compensation in China, or more internationally termed as the payments for ecosystem services (PES) has emerged as an important policy instrument for not only environment management, but also poverty reduction. In the individual eco-compensation programs, there are usually some additional objectives other than ecosystem protection, among which poverty alleviation is the most important. In the policies on poverty alleviation, the central government of China lists eco-compensation as one of the five major approaches to alleviate poverty. However, there is little empirical evidence of the effectiveness of eco-compensation programs on poverty alleviation. This paper uses the field survey data of rural households in three poverty-stricken counties in Guizhou Province, China to evaluate the poverty alleviation effect of different eco-compensation programs on different income group of rural households. Research indicates that: for the eco-compensation programs with direct cash payment, the Sloping Land Conversion Program has a significantly positive impact on high-to-medium income group. The project of Ecological Forest Compensation Program has no significant impact on all income groups. The Ecological Job Offer Program has a great positive impact on the income of low-income households. Our research highlights that i) different eco-compensation programs might have different impacts on the same income group of households; ii) a specific eco-compensation might have different income impacts on different income groups of households; and iii) eco-compensation does not necessarily contribute to poverty reduction unless the eco-compensation scheme is purposely designed for it.

Key words

Payments for ecosystem services
Eco-Compensation
PES
Poverty reduction
Household income

1. Introduction

Ecological compensation or eco-compensation which is more often used in China, is similar to the more internationally popular term of payment for ecosystem services (PES).

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Eco-compensation refers to the incentive based institutional arrangement of reasonable compensation for conservation by means of financial transfer payment or market transaction in comprehensive consideration of ecological protection costs, development opportunity costs and ecological service value. Compared with the international definition of PES, which emphasizes ensuring the efficiency of environmental protection through voluntary and market mechanism, China's ecological compensation includes two forms, i.e. government-led and market-based mechanisms. In recent years, eco-compensation in China and the payments for ecosystem services (PES), as a new environmental policy tool, is gradually used to coordinate the conflict between ecological environment protection and economic and social development, and attract much attentions. At the same time, there are often some other sub-goals in the practice of eco-compensation programs, among which the most common and important is to alleviate poverty, which has become the focus of attention of researchers and policy makers.

In China, there is a high degree of overlap in geography between ecologically fragile areas and impoverished areas. According to the *National Program for the Protection of Ecologically Fragile Areas* issued by the Ministry of Environmental Protection in 2008, over 80% of the national poverty-stricken counties and 95% of the absolute poverty-stricken people in China live in poor and remote areas with extremely fragile ecological environment. National poverty-stricken county refers to an administrative county with lower average income level determined by the state with average annual net income level of a certain resident as the standard. Besides, most of the poverty-stricken areas are located in key ecological function areas. Key ecological function area refers to an important ecological area designated by the Chinese government, with fragile ecosystem or important ecological functions and low carrying capacity of resources environment, which should be restricted for large-scale development. Among the various main function areas in poverty-stricken areas, key ecological function areas are most widely distributed, accounting for 76.52% of the total poverty-stricken areas. To protect the ecological environment, these areas have lost many development opportunities and have sufferred huge opportunity costs. In these regions, poverty is not only the consequence of the fragile ecological environment, but it also further aggravates the fragility of ecological environment, and the two fall into a vicious cycle of mutual cause and effect. Thus, the coordination of sustainable development among poverty, resources and environment is needed in poverty-stricken areas.

As an effective tool that solves ecological and environmental problems through economic means, eco-compensation promotes the environmental protection behavior through giving direct or indirect economic compensation to the environmental protectors, and at the same time, enables the recipients to acquire resources that can be used for development, in order to reach poverty alleviation. Thus, eco-compensation is also regarded as an effective tool to solve the problem of poverty in ecologically fragile areas, and the dual objectives of poverty reduction and income increase in rural areas and ecological environment protection should be coordinated. The "Five Batches" Project proposed by the central government in 2015 and the "Ecological Poverty

Alleviation Program" issued by National Development and Reform Commission and six departments in January 2018 designated the eco-compensation as one of the five major approaches to poverty alleviation, demonstrating that eco-compensation and poverty alleviation have become a focus of the central government to promote poverty alleviation.

Under this circumstance, it is necessary to explore the relationship between eco-compensation and poverty alleviation and further study the impacts of eco-compensation on poverty alleviation in poverty-stricken areas, both from the actual demands of the high coincidence between the poverty-stricken areas and the ecologically fragile areas and from the new requirements of the central government for eco-compensation.

At present, many researchers have come to a consensus that paying for ecological protection can promote the alleviation of poverty to a certain extent. Michael Richard (1997) argues that ecosystem services markets offer greater opportunities than product markets for poorer and remote areas, contributing to regional economic development and poverty alleviation. Pagiola et al. (2004) concluded that paying poor natural resource managers can reduce poverty through analyzing relevant literature data from Latin America. They also pointed out that although the payment for ecosystem services wasn't primarily used for poverty reduction, the two objectives of ecological protection and poverty eradication could be achieved synergistically if sound design was carried out in accordance with specific circumstances. Using economic models, Wang et al. (2017) concluded that the payment for ecosystem services could not only have ecological and economic benefits, but also promote social progress and narrow the wealth gap. In this way, economically wealthy people will make more contributions to the payment mechanism for ecosystem services, while poorer people will reap more benefits from it, so it is beneficial to alleviate poverty.

Several practical cases at home and abroad have also demonstrated that the eco-compensation project has achieved some results in poverty reduction, such as the eco-compensation project in Costa Rica's Osa Peninsula, the forest hydrological service compensation project in Mexico and the Sloping Land Conversion Program (SLCP) in China. The income of most of the poor eco-service providers who are involved in the project has increased. Taking the SLCP in China as an example, the income of farmers can be improved through SLCP, resulting mainly from two aspects: direct compensation for returning farmland and non-farm income. According to the report of the Socio-economic Benefit Assessment Group of the State Forestry Key Projects of the State Forestry Administration of China in 2014, the accumulated subsidy of the farmers that returned farmland accounted for 14.36% of the average per capita net income of farmers and the incidence of poverty in the returned farmland decreased from 36.14% in 1998 to 6.65% in 2011. The conversion of farmland to forests also reduces the income gap in the project area. The livelihood transformation and alternative livelihood increase the income of all the farmers who return farmland to forests, imposing a significantly positive impact on the low-income farmers. Time series data analysis of those farmers showed that their income increased by 2.5 times with non-agricultural income as the main source of growth (Yin et al., 2014). However, it is uncertain

whether this positive impact can last for a long time, for example, Wang et al. (2012) in a case study of Dunhua County found that 58% of the farmers thought their income decreased after returning farmland, and 16% planned second ploughing if there was no compensation.

However, some researchers pointed out that there are some barriers for poor families to participate in eco-compensation projects, which need to meet three conditions: (1) eligibility to participate, that is, only land owners have the opportunity to participate in eco-compensation projects since the supply of ecological services is generated by specific land use patterns and there is no land for extreme poverty families; (2) willingness to participate, that is, poor families participating in eco-compensation should get more compensation than the opportunity cost. Under a certain compensation rate, poor families with low opportunity costs are willing to participate in eco-compensation project and poor families with high opportunity costs are not willing to participate in eco-compensation projects; (3) the ability to participate, that is, poor families may not be able to participate in eco-compensation projects because of unclear land property rights, investment costs, technical constraints and other factors (Pagiola et al., 2005). Mills et al. (2004) argued that the land area of poor farmers is small and the transaction cost of them to participate in policies is higher. An eco-compensation may widen the income gap and adversely affect poor farmers.

According to the voluntary requirements of eco-compensation, farmers will compare the compensation rate of eco-compensation and their opportunity costs. If the situation of participating in eco-compensation projects is worse than that of not participating in them, poor farmers will choose not to participate in them. But Wunder (2008) pointed out that eco-compensation has a positive effect on poverty alleviation can’t be deduced from the voluntary nature of the project, since the voluntary nature of many eco-compensation projects is not obvious and many poor farmers may be forced to participate in eco-compensation projects and their compensation can’t fully cover the cost, such as the SLCP in China and the forest ecology in Vietnam, and their income level is reduced. Therefore, the mechanism design of eco-compensation needs to overcome the barriers for poor families to participate, enabling the economically affluent people to make more contributions to the payment mechanism of ecosystem services and the poorer people gain more benefits, which is really conducive to poverty alleviation.

In conclusion, many studies have indicated that eco-compensation could contribute to poverty alleviation. However, most of the related studies are qualitative analysis at the theoretical level, and there is very few empirical research on the relationship between ecological compensation policy and farmer household income in China, especially the research on the actual impact of ecological compensation on different income groups. In order to achieve more accurate and sustainable poverty alleviation effects, we need to design eco-compensation mechanism carefully based on the different characteristics of rich and poor farmers, and adopt different compensation policies for different groups and only in this way can the poor households really benefits from it. Most of the existing studies focus on the overall impacts of a certain

compensation policy on the household groups. Empirical studies on the relationship between eco-compensation policy and household income based on the heterogeneity of rural households are still lacking. Therefore, this paper will study the different impacts of different compensation methods on different income farmers in order to improve the matching of poverty alleviation policies to different income groups.

2. Theoretical discussion

To investigate the impact of eco-compensation policies on the income of farmers, it is theoretically necessary to clarify how the eco-compensation policy affects the income of farmers, that is, the specific path of impact. The impact of eco-compensation on farmers' income mainly includes the following two categories: The first category is the direct impact of eco-compensation on farmers' income, which mainly depends on the type and the strength of eco-compensation. Some related research (Shang Haiyang et al., 2012; Du Hongyan et al., 2016) pointed out that different types of eco-compensation policies have different effects on farmers' income levels through different methods. For example, the compensation program for directly giving farmers cash increases the household's cash income, and the compensation program for providing ecological protection jobs for participating farmers allows farmers to obtain wage income by providing labor, which means that after the farmers participate in the policy, the family's cash income level can be improved, and the income channel is expanded, thus increasing of the overall income of the farmers' families. In addition, the strength of the compensation will determine the direction and size of the impact, and whether the compensation rate setting is reasonable is an important factor affecting the policy effect. When the compensation amount is greater than the cost of the farmer giving up the original agricultural activities, the household income level of the farmer can be increased, and vice versa.

The second category is the indirect impact of eco-compensation policies on their income based on the characteristics of farmers. Some studies (Pagiola et al., 2005; Fairhead et al., 2012; Osborne, 2013) point out that farmers with more land (forest land) resources are more likely to participate in eco-compensation policies, and large land (forest land) households are more likely to benefit from participation policies, so the more natural resource endowments a farmer has, the more compensation they can receive, and the higher the income level. At the meantime, due to the improvement of the ecological environment after the implementation of the eco-compensation policy, the soil erosion in the region can be reduced, the soil fertility can be improved, and the overall agricultural production conditions can be improved, which is conducive to the increase of crop yields and the reduction of agricultural input costs, thus increasing the agricultural production income of farmers. This is an indirect impact of eco-compensation policies based on the characteristics of natural resources entitled by farmers. The implementation of the eco-compensation policy will significantly change the farmers' original agricultural production methods and livelihood strategy choices. For example, the SLCP reduces the land resources

available to farmers, the demand for labor in agricultural production is greatly reduced, and the surplus labor after returning farmland will choose to work in the towns or use the compensation funds obtained to carry out the business activities of the secondary and tertiary industries. Compared with a single agricultural production income, diversified livelihood strategy choices will increase household income channels and thus increase household income levels. Therefore, the impact of eco-compensation on household human capital will also indirectly affect household income levels.

In addition, the difference in the income level of farmers themselves will affect the income of participating farmers in different degrees. Low-income farmers have little chance in choosing ways for making livings, whose household income is mainly obtained through agricultural production. High-income farmers will have more choices in livelihoods because they have more resources. The implementation of the eco-compensation policy may further reduce the income channels of low-income farmers, thus widening the income gap of different income farmers, so the impact of eco-compensation policies on different income groups is inconsistent.

Based on this, this paper hypothesizes that the implementation of the eco-compensation policy is conducive to raising the income level of the households, but the impact is related to the characteristics of the farmers' own families. Based on the above analysis and the actual situation of the eco-compensation policy of the surveyed area, this paper proposes the following four hypotheses: Hypothesis 1: The SLCP has a positive impact on the income level of farmers. Hypothesis 2: The public welfare forest ecological benefit compensation project has a positive impact on the income level of farmers. Hypothesis 3: Ecological public welfare positions have a positive impact on the income level of farmers. Hypothesis 4: The impact of different policies on different income groups is inconsistent.

3. Methodology

3.1. Study area

China’s Guizhou province has a high level of poverty. By 2015, the province had a total of 4.93 million poor population ranking first in the country, while Guizhou enjoys an excellent ecological environment, ranking among the top in terms of urban air quality, forest coverage rate and surface water quality, and provides a large number of ecological products but with very backward economic development, intertwining ecological and poverty problems. Eco-compensation and poverty alleviation is an effective means to promote the smooth progress of poverty alleviation in Guizhou. Therefore, this paper takes Guizhou province as the sample for research. Governments at all levels in Guizhou Province are currently vigorously promoting eco-compensation and poverty alleviation work, mainly relying on ecological protection compensation funds to lean toward poverty-stricken areas and tilting to the poverty-stricken population. As a result, for the poor people with working ability, they can take the government

purchased service-oriented ecological public welfare jobs and engage in the eco-compensation-type industry. Certain results have already achieved. Among them, cash-type direct compensation and public service-type indirect compensation are the eco-compensation and poverty alleviation measures involving the largest number of farmers and covering a wide range of areas.

This paper takes these two compensation methods as the main content of the research. The research area mainly implements the direct cash compensation to the farmers to compensate for the return of farmland to forests and the ecological benefits of the public welfare forests. The compensation rate for the SLCP is that the first round of SLCP will compensate 119.5 yuan per mu per year, and the new round of SLCP (implemented in 2015) will compensate 240 yuan per mu per year. The compensation rates for ecological benefits of public welfare forests are as follows: (1) Compensation for collective and individual state-level public welfare forests is 15 yuan per mu per year. (2) Compensation for local-level public welfare forests is 8 yuan per mu per year. Post-type indirect compensation is mainly for the wages obtained by participating in ecological protection projects as relevant ecological protection posts, including forest guards who work for SLCP, public welfare forests, and Tianbao project. The salary of the post is between CNY600 - 800 per month, including temporary posts in the fire season and permanent fixed posts. Temporary posts involved working for about 3 months per year, and fixed posts for 12 months each year.

3.2. Data collection and analysis

The data used in this paper comes from the field investigation conducted in July and August 2016 in Huangping County, Southeast Guizhou Province, Guizhou Province (26° 43`46" N to 27° 14`30"N, 107° 35`40"E to 108° 12`48"E), Weining County, Bijie City (26° 30`35" N to 27° 25`45"N and 103° 36`14"E to 104° 45`48"E) and Dafang County (26° 50`02" N to 27° 36`04"N and 105° 15`47"E to 106° 08`04"E). The three counties selected by the survey are all state-level key poverty alleviation counties, and are also the key ecological function zones where the state's fiscal transfer payments are allocated. The incidence of poverty in the region is high, the ecological environment is fragile, poverty problems and ecological problems are intertwined, and innovative ecological poverty alleviation methods are urgently needed. This survey is based on questionnaire surveys at the farmer level. Data acquisition is conducted through questionnaires conducted by researchers and farmers. In addition, the research team also conducted village-level interviews with the village heads or party branch secretaries of each village to fully understand the relevant situation of the village. Besides, we also held meetings with relevant administrative departments involved in the formulation and implementation of eco-compensation policies to understand the basic condition of local agricultural production, farmers' living, and the implementation of local eco-compensation policies.

3.2.1. Research on farmers

The research team applied stratified random sampling to select 24 sample villages in 12 townships (towns) for random sampling questionnaire survey. Each village randomly surveyed 28-32 households. Totally 445 questionnaires were issued, and 432 valid questionnaires were obtained, including 99 in Huangping County, 117 in Weining County, and 216 in Dafang County. The questionnaire efficiency was 97.08%. Among the surveyed households, the proportion of males is relatively high. Their age is mainly concentrated above 45 yrs old. The surveyed households are 91.43% of the junior high school and below, and the family size is 3-5 persons. Table 1 shows the basic characteristics of the farmers surveyed.

Table 1
Basic characteristics of interviewed farmers

		Respondents	Proportion (%)
Gender	Male	364	84.26
	Female	68	15.74
Age	Under 35 years old	43	9.95
	35 to 45 years old (including 35 years old)	121	28.01
	46 to 60 years old	170	39.35
	Above 60 years old	98	22.69
Family size	2 people and below	66	15.28
	3-5 people	248	57.41
	6 or more people	118	27.31
Education level	Below primary school	95	21.99
	Primary school	165	38.19
	Junior high school	135	31.25
	High school or technical secondary school	26	6.02
	High school education or above	11	2.55
Policy participation	The first round of SLCP	142	34.55
	New round of SLCP	87	21.17
	Public welfare forest compensation for ecological benefits	74	18.00
	No policy	108	26.28

3.2.2. Government

The research team has visited and interviewed officials of relevant administrative departments involved in the formulation and implementation of eco-compensation policies, such as the provincial government and the development and reform committees of the three counties,

the forestry bureau, the finance bureau, the agriculture bureau, and the water conservancy bureau, understands the basic situation of local agricultural production, farmers' life, and the implementation of local eco-compensation policies, and obtains a large amount of research data.

3.3. Data analysis

In order to gain a deeper understanding of the basic situation of farmers at different income levels, based on the per capita income level of farmers, the sample is divided into five groups from high to low, which are relatively rich, not too poor, generally poor, comparatively poor and very poor, with 86 data per group. Table 2 is a descriptive statistic of the survey data.

Table 2
Descriptive statistics of the basic characteristics of the surveyed farmers

	Very poor	Comparatively poor	Generally poor	Not too poor	Relatively wealthy
Household per capita annual income (ten thousand yuan)	0.14	0.34	0.61	0.99	2.63
Family size (person)	4.6	4.7	4.5	4.5	4.6
Number of labor (person/household)	1.8	2.2	2.3	2.6	3.1
Number of migrant workers (person/household)	0.1	0.4	0.7	1.1	1.2
Number of children in the family (person/household)	2.6	2.3	2.0	2.1	2.2
Family health	1.0	1.0	1.2	1.1	0.5
Cultivated land area (mu)	2.76	4.00	3.84	4.81	9.46
Forest area (mu)	10.53	19.06	16.61	19.67	16.64
Average education level (years)	5.2	5.9	6.5	5.6	7.7
Average age (years)	49	50	48	53	49
Family situation serving as ecological forest guards (person)	0.1	0.1	0.1	0	0.2
Cash compensation amount for obtaining eco-compensation (thousand yuan)	0.64	0.81	0.89	0.90	0.92

Note: The amount of eco-compensation received by the family refers to the total amount of compensation received by farmers in the policy of SLCP, ecological public welfare forests, and the new round of SLCP in 2015.

It can be seen from the table that the per capita annual income of the relatively wealthy farmers in the survey is 26,300 yuan, and the per capita annual income of the very poor households is 14,000 yuan, and the difference between the two is about 18.8 times. The number of

household laborers is positively correlated with the household income level. The average number of household laborers in very poor households is 1.8, and the average number of household laborers in relatively wealthy households is 3.1, and the difference between the two is about 1.7 times. Similarly, the number of out-of-home workers is also positively correlated with income levels. The average number of migrant workers in very poor households is 0.1, and the average number of migrant workers in relatively wealthy households is 1.2, and the difference between the two is about 12 times. The number of children in the family, the health status of the family, and the average level of education and family income are reversed. Although there is no absolute trend change, it can be seen that compared with very poor farmers, relatively wealthy farmers have fewer children, are more healthy, and have longer years of education. There was no significant trend change in the total number of households, arable land, woodland area, and average age between groups.

From the perspective of participating in the eco-compensation policy, the relatively affluent group is slightly higher than the very poor households, regardless of the number of employees engaged in ecological forest guards and the average amount of cash compensation from eco-compensation. Figure 1 shows the participation of different income groups in the eco-compensation policy.

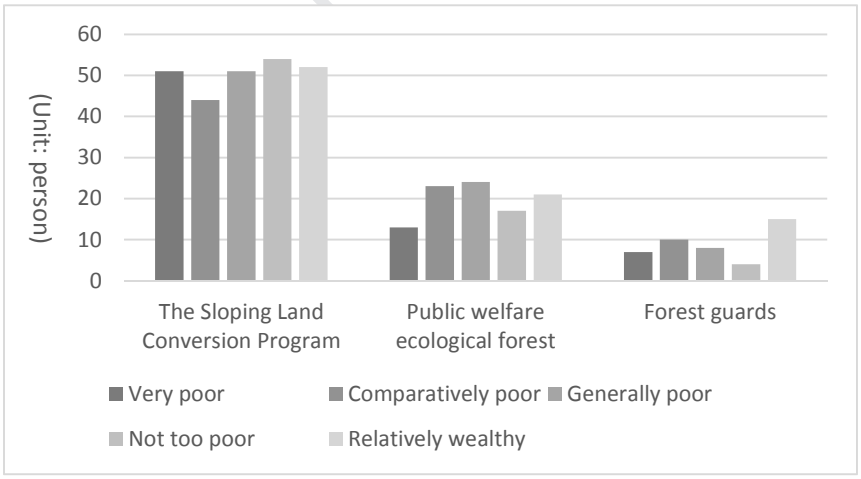

Fig. 1. The situation of the surveyed households participating in the eco-compensation policy

As can be seen in the figure, the cash compensation type eco-compensation policy is evenly distributed among different groups, which may be related to the wide distribution of forestry resources in the survey area and the participation of most farmers' families in forestry eco-compensation projects. Among the ecological forest guards, there are more wealthy households, which may be because the more capable farmers have the opportunity to serve as forest rangers, and the income is correspondingly improved. Based on the descriptive statistical characteristics of the survey data, wealthy farmers are more likely to benefit from participating in

eco-compensation policies than poor households. Whether it is consistent with the actual situation, further empirical research is needed.

3.4. Empirical Analysis

Based on the correlation analysis of the influence path of ecological compensation on farmer household income, the literature on the research findings of the influencing factors of farmer household income, and the descriptive statistical characteristics of survey data, this study sets the income model as:

$$\ln Y_i = \beta_0 + \beta_1 fsize_i + \beta_2 o\_farmer_i + \beta_3 all\_labor_i + \beta_4 health_i + \beta_5 chinum_i + \beta_6 land\_farm_i + \beta_7 land\_forest_i + \beta_8 age_i + \beta_9 edu_i + \beta_{10} county_i + \beta_{11} town_i + \beta_{12} village_i + \beta_{13} pes1\_area_i + \beta_{14} pes2\_area_i + \beta_{15} pes\_job_i + \varepsilon_i \quad (1)$$

In model (1), $\ln Y_i$ is the natural logarithm of the i^{th} farmer's household income; the total family member, number of labor force, physical condition, number of offspring, average age and average education level indicate a family's human capital; the number of migrant workers reflects a family's members engaged in non-agricultural activities; the farmland area and woodland area represent a family's natural capital. There are three different counties of various conditions for economic development and resource environment involved in this survey, thus adding the control variables of county, town and village with the number of variables set to N-1. To investigate the different effects of cash compensation and public service compensation on farmer household income, three independent variables of pes1_area, pes2_area and pes_job were added into the model, among which pes1_area and pes2_area depict the impact of cash compensation, while pes_job describes the impact of public service compensation. Since there is a multi-collinearity problem between the compensation amount directly used as the independent variable and other independent variables, the woodland area specified in the family participation policy is seen as the independent variable, pes1_area is the farmer-owned woodland area involved in the policy of returning farmland to forests, pes2_area is the farmer-owned woodland area involved in the policy of ecological public welfare forests; pes_job is whether the farmer is engaged in the ecological public service job, 0 means no, 1 means yes. Table 3 shows a description of all variables and corresponding characteristics.

Table 3

Variable settings and related characteristics

Variable	Description	Mean	Standard deviation	Min	Max
lnY	logarithm of household income	10.06	1.19	6.42	15.20
pes1_area	area involved in conversion of farmland to forests	4.16	5.95	0	40
pes2_area	area involved in ecological public welfare forests	8.83	26.16	0	216
pes_job	ecological public service job	0.10	0.30	0	1

fsize	total family members	4.58	1.90	1	11
o_farmer	number of migrant workers	0.71	0.87	0	6
all_labor	number of labor force	2.40	1.22	0	8
health	health condition	0.94	1.36	0	11
chinum	number of offspring	2.23	1.53	0	7
land_farm	farmland area (mu)	5.45	15.30	0	300
land_forest	woodland area (mu)	16.47	26.59	0	216
age	average age	50.04	12.36	20	80
edu	average level of education	6.23	3.93	0	16
county	county control variables	2.27	0.81	1	3
town	town control variables	7.09	3.62	1	12
village	village control variables	13.65	7.30	1	24

Combined with the research content, it is necessary to investigate the influence degree of each variable on farmers with different income levels, this paper therefore chooses OLS mean regression and quantile regression to carry out regression analysis.

4. Results

This paper explains the impact of different factors on the household income of farmers by establishing a household income model, and focuses on the impact of different eco-compensation policies on farmers' income, and analyzes inherent causes. The logarithmic farm household income in Table 3 was used as the dependent variable, and the remaining 15 variables were used as independent variables for OLS regression and quantile regression. Among them, the OLS regression results can reflect the average impact of each independent variable on the household income, and the quantile regression results can reflect the degree of influence of each variable on different income level groups, thus revealing the reason for the difference in household income. The estimated results of the two regressions are shown in Table 4.

Table 4

OLS Regression and quantile regression results affecting household income of farmers

Explanatory variables	OLS	10-digit quantile	20-digit quantile	30-digit quantile	40-digit quantile	50-digit quantile	60-digit quantile	70-digit quantile	80-digit quantile	90-digit quantile
Constant	9.0701***	8.0421***	8.1400***	8.5786***	9.1892***	9.3850***	9.3664***	9.6984***	9.6009***	9.7882***
term (cons)	（0.3657）	（0.7981）	（0.5590）	（0.4364）	（0.3455）	（0.3372）	（0.3704）	（0.3403）	（0.5153）	（0.7816）
pes1_area	0.0135	0.0045	0.0041	0.0079	0.0136	0.0209**	0.0209*	0.0248***	0.0192*	0.0056
	（0.0088）	（0.0192）	（0.0135）	（0.0105）	（0.0083）	（0.0081）	（0.0089）	（0.0082）	（0.0124）	（0.0188）
pes2_area	−0.0021	−0.0053	−0.0013	−0.0025	−0.0016	0.0027	0.0012	0.0009	−0.0001	−0.0006
	（0.0035）	（0.0077）	（0.0054）	（0.0042）	（0.0033）	（0.0032）	（0.0036）	（0.0033）	（0.0050）	（0.0075）
pes_job	0.0589	0.6394*	0.3642	0.1252	−0.0327	−0.1362	0.0831	0.0733	0.0520	0.1567
	（0.1580）	（0.3449）	（0.2415）	（0.1886）	（0.1493）	（0.1457）	（0.1600）	（0.1470）	（0.2227）	（0.3377）
fsize	0.0582	-0.0334	0.0193	0.0804*	0.0704*	0.0757**	0.0647	0.0614*	0.1040**	0.1534**

	（0.0343）	（0.0748）	（0.0524）	（0.0409）	（0.0324）	（0.0316）	（0.0347）	（0.0319）	（0.0483）	（0.0732）
o_farmer	0.4900***	0.7518***	0.6470***	0.6257***	0.5950***	0.5820***	0.5539***	0.4471***	0.3740***	0.1548
	（0.0660）	（0.1441）	（0.1009）	（0.0788）	（0.0624）	（0.0609）	（0.0669）	（0.0614）	（0.0930）	（0.1411）
all_labor	0.1510**	0.1534	0.2176*	0.1453*	0.1247**	0.1188**	0.1542**	0.1679***	0.1585**	0.1621**
	（0.0494）	（0.1078 ）	（0.0755 ）	（0.0589）	（0.0467）	（0.0455）	（0.0500）	（0.0459）	（0.0696）	（0.1055）
health	-0.0379	-0.0105	2.75e-15	-0.0298	0.0102	-0.0235	-0.0181	-0.0497	-0.0682*	-0.0087
	（0.0349）	（0.0763）	（0.0534）	（0.0417）	（0.0330）	（0.0322）	（0.0354）	（0.0325）	（0.0492）	（0.0747）
chinum	0.0399	0.0148	-0.0095	-0.0232	-0.0170	0.0036	0.0262	0.0328	0.0150	-0.0129
	（0.0357）	（0.0779）	（0.0545）	（0.0426）	（0.0337）	（0.0329）	（0.0361）	（0.0332）	（0.0503）	（0.0762）
land_farm	0.0103***	0.0086***	0.0062**	0.0052***	0.0051***	0.0047***	0.0118***	0.0148***	0.0111***	0.0204***
	（0.0030）	（0.0066）	（0.0046）	（0.0036）	（0.0029）	（0.0028）	（0.0031）	（0.0028）	（0.0043）	（0.0065）
land_forest	0.0054	0.0087*	0.0058	0.0057*	0.0039	0.0016	0.0012	0.0011	0.0013	0.0009
	（0.0034）	（0.0074）	（0.0052）	（0.0040）	（0.0032）	（0.0031）	（0.0034）	（0.0031）	（0.0048）	（0.0072）
age	-0.0063	-0.0006	-0.0021	-0.0049	-0.0065	-0.0085**	-0.0077	-0.0057	-0.0025	-0.0037
	（0.0043）	（0.0093）	（0.0065）	（0.0051）	（0.0040）	（0.0039）	（0.0043）	（0.0040）	（0.0060）	（0.0091）
edu	0.0619***	0.0280	0.0417	0.0543***	0.0472***	0.0472***	0.0457***	0.0408***	0.0434**	0.0591**
	（0.0125）	（0.0274）	（0.0192）	（0.0150）	（0.0118）	（0.0116）	（0.0127）	（0.0117）	（0.0177）	（0.0268）
county	-0.0461	−0. 1568	0. 0949	−0. 0887	-0.2161	-0.1681	-0.2470	-0.3460*	-0.1790	0.1174
	（0.1728）	（0. 3771）	（0.2641）	（0.2062）	（0.1633）	（0.1593）	（0.1750）	（0.1608）	（0.2435）	（0.3693）
town	0. 0882	0. 3681	0. 1510	0. 2000	0. 0593	0. 0117	0. 2070	0. 0809	−0. 0229	−0. 0726
	（0.1909）	（0. 4165）	（0.2917）	（0.2277）	（0.1803）	（0.1760）	（0.1933）	（0.1776）	（0.2689）	（0.4079）
village	−0. 0596	−0. 1791	−0. 101	−0. 102	−0. 0230	−0. 0063	−0. 0879	−0. 0177	0. 0155	0. 0003
	（0. 0915）	（0. 1996）	（0.1398）	（0.1091）	（0.0864）	（0.0843）	（0.0926）	（0.0851）	（0.1289）	（0.1954）
R^2	0. 3900	0. 2787	0. 2944	0. 2999	0. 2969	0. 2827	0. 2687	0. 2648	0. 2382	0. 2107
Sample capacity （obs）	432									

Note: ***, **, and * represent significant levels at 1%, 5%, and 10% respectively. What exists in parentheses is the standard error corresponding to the estimated coefficient.

As shown in the table, in the impact of the eco-compensation project on the household income of the farmer and the OLS regression results, the impact of the two eco-compensation policies on income is not significant. In the quantile regression, after dividing the households with different incomes into groups, it is found that the SLCP has a significant positive impact on the middle and high income groups, and its coefficient is significantly positive in the 50 to 80 quantiles, and the coefficient is “inverted U-shaped”, which has no significant impact on the household income of extremely poor farmers.

The compensation received by poor farmers participating in the policy cannot cover their opportunity costs, resulting in slow income growth. The public welfare forest ecological benefit compensation project has no significant impact on different income groups, indicating that for all farmers participating in the policy, the gap between the compensation standard for public forest ecological benefits and the actual opportunity cost of farmers is greater. That is to say, if the

farmer chooses to participate in the compensation for the ecological benefits of the public forest, he will lose more income, such as not being able to cut down the timber for sale. The public welfare post-type eco-compensation project has a great impact on the income of extremely poor rural households, and its coefficient is about 30 times the compensation coefficient of SLCP, indicating that it can effectively help the families of extremely poor farmers to raise their income.

For the 90-digit wealthy farmers, both cash-type compensation and public service-type compensation cannot affect their household income levels, indicating that rich household income is mainly dependent on non-agricultural labor. Whether it is compensation funds or public welfare jobs, the proportion of total wages is very low. On the whole, the SLCP and public welfare post-type compensation have positively affected the income level of farmers, confirming hypothesis 1 and hypothesis 2 in the research hypothesis. However, the empirical regression results of compensation for ecological benefits of forests in public welfare forests do not significantly indicate that they have a positive impact on farmers' income, so hypothesis 3 is falsified, which also reflects whether the eco-compensation proposed in the theoretical framework is conducive to raising the income level depends not only on the type of compensation, but also the strength of compensation. In addition, the empirical results show that the SLCP and public service-type compensation have different effects on different income groups, so hypothesis 4 is verified.

The coefficient of family size is significantly positive in the 30-50-digit and 70-90-digit quantiles, indicating that in non-extremely poor households, the larger the family size, the more the family income channels, and the higher the overall household income, and this positive effect is more obvious in relatively wealthy households. The mean regression results of the number of migrant workers are very significant, indicating that on average, the number of migrant workers has a large positive impact on the household income of farmers. In the quantile regression, the coefficient of the number of migrant workers is the largest in the 10-digit quantile, the smallest in the 80-digit quantile, and the maximum value is twice the minimum value, indicating that for poor households with limited income channels, abandoning the original agricultural production labor and engaging in non-agricultural labor are ways to quickly increase household income. The OLS mean regression of the household labor quantity coefficient is significant and significantly positive in the 20-90 quantile in the quantile regression, indicating that the labor force has a significant impact on household income, and this effect is more prominent in low-income groups.

The coefficient of cultivated land area is significantly positive in both the OLS mean regression and the quantile regression, indicating that agricultural productive income is still the main part of the income of most farmers, which has a great impact on household income. In the quantile regression, as the quantile increases, its coefficient has an upward trend, which may be because rich households have more cultivated land than poor households, so their pulling effect on income will be greater. The coefficient of forest land area is only significant in the 10- and 30-digit quantile, indicating that for poor farmers, the development of forestry economy has a

pulling effect on income, and poverty alleviation should be considered to help poor households develop forestry industry. The average age coefficient is significantly negative in the 50-digit quantile, indicating that in the middle-income group, the overall income of the family decreases as the average age of the family increases.

The average number of years of education for family members is very significant in the 30-90-digit quantile, and the coefficient is positive, indicating that educational factors have a greater impact on the income of non-extremely poor households, and the higher the average level of education of the family, the higher the income. Among the county, town, and village control variables, only the coefficient of the county variable is significant in the 70-digit quantile, indicating that the geographical features of the surveyed places are similar, and the administrative divisions do not have a large impact on the household income of the farmers. The coefficient of the number of family children is not significant in all quantiles.

5. Discussion

Poverty includes both regional poverty and poverty for specific populations. Direct cash compensation for eco-compensation can be more effective in addressing regional poverty problems, and the targeting effect is limited. In the survey, it was found that the poverty-stricken areas in the eco-compensation project area have a high degree of coincidence with the environmentally vulnerable areas, but the poor households do not match the resources very well. Relatively wealthy households have 1.5 times more land area than the extremely poor households, so rich households receive a lot of compensation funds, and poor households have few land resources and therefore less compensation. Similar problems exist in eco-compensation in other areas of China. For example, in the grassland eco-compensation, the compensation standard is 7.5 yuan for the grazing prohibition of one mu of land. Cash compensation can be obtained as long as the farmer is not overgrazing. However, relevant research has found that it is impossible to carry out overgrazing due to the limitation of the number of household laborers. Therefore, the big herdsmen are generally not overgrazing, and they can get the corresponding compensation funds. At the same time, the big herdsmen have a lot of grassland. Based on the compensation according to the area, about 75% of the grassland eco-compensation funds are taken by 24% of the big herdsmen. As a result, the poor groups receive little compensation. Related studies have reached similar conclusions. Wang et al. (2017) assessed the combined and dynamic livelihood impact of PES on participants and non-participants by using survey data of rural families in Changting County, Southeast China, and found that PES project had a positive and negative impact on participants and non-participants, respectively.

This paper finds that among the existing eco-compensation policies, the direct cash compensation for SLCP and public welfare post-type compensation have certain complementarities in alleviating poverty, the SLCP has a significant positive impact on middle- and high-income groups, and the public welfare post-indirect compensation project has a greater

impact on the income of low-income farmers.

In the design of eco-compensation mechanism, the synergy between the two should be exerted more, and the inclusiveness of cash-type compensation and the poverty alleviation of post-type compensation should be highlighted. Based on the heterogeneity of farmers, cash compensation is used to motivate wealthy groups to provide more ecological services. In the context of the current targeted poverty alleviation activities, based on the accurately identified poverty groups, giving them more opportunities to serve as ecological public welfare jobs will achieve the effect of alleviating poverty to a certain extent.

However, it is worth noting that, according to the selection requirements of the forest guards, forest guards should be between 18 and 60 years old, in good health, can be qualified for field patrol work, and complete the work of stopping the destruction of forest resources, as well as fighting forest fires in the protection area. The main purpose of setting up a forester's post is to protect forest resources and prevent the destruction of the ecological environment. It is not purely for the purpose of poverty alleviation. The general poor have a variety of causes for poverty. Whether they are capable of being competent for the work as a forester, it shall be deliberated in specific practice.

6. Conclusions

Based on the field research data of poverty-stricken counties in Guizhou Province, the empirical analysis of the factors affecting the household income of farmers through OLS regression and quantile regression leads to the following conclusions: First, in the OLS regression, the impact of the three eco-compensation policies on the household income of all farmers has not passed the significance test, and the results cannot explain the impact of eco-compensation on the household income of farmers. Second, in the quantile regression, the direct cash compensation for SLCP has a significant positive impact on the middle and high income groups, and the ecological public welfare forest project has no significant impact on different income groups, the public welfare post-indirect compensation project has a greater impact on the income of low-income farmers, and compensation for SLCP and compensation for public service posts have certain complementarities. The findings of this study coincide with the existing relevant conclusions that participants with resources can reap more economic benefits, whereas those who do not have resources have no or less access to the benefits, indicating that poverty reduction is not effective.

Based on the above findings, we found that: (1) For poor households, the compensation rate for existing eco-compensation policies is low, the compensation rate is lower than the actual opportunity cost of farmers, and the cash compensation method has little effect on their income level and the effect of poverty alleviation is not obvious, and it may also put them in a poverty trap. In the design of eco-compensation mechanism, more synergies between cash-based direct compensation and public service-type indirect compensation should be exerted, highlighting the inclusiveness of cash-type compensation and the poverty alleviation of post-type compensation.

Based on the heterogeneity of farmers, cash compensation is used to encourage wealthy groups to provide more ecological services, and post-type compensation can help poor groups to raise household income, which can better achieve the two goals of ecological protection and poverty alleviation. (2) Rational treatment of eco-compensation and poverty alleviation is needed. Eco-compensation and poverty alleviation is a method of poverty alleviation. However, this method is also limited. The primary goal of eco-compensation is targeted at ecosystem, and is not necessarily to solve the bread-and-butter issue for farmers. The eco-compensation policies aimed at poverty alleviation require special design to achieve the two goals of ecological protection and poverty alleviation.

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Title: How Eco-compensation contribute to poverty reduction: a perspective from different income group of rural households in Guizhou, China

Abstract

In recent years, eco-compensation in China, or termed more internationally the payments for ecosystem services (PES) has emerged as an important policy instrument for not only environment management, but also poverty reduction . In the individual eco-compensation programs, there are usually some other sub-goals, among which poverty alleviation is the most important. In the policy on poverty alleviation, the central government of China lists eco-compensation as one of the five major approaches to alleviate poverty. However, there is little empirical evidence of the effectiveness of eco-compensation on poverty alleviation. This paper uses the field survey data of rural households in three poverty-stricken counties in Guizhou Province, China to evaluate the poverty alleviation effect of different eco-compensation programs on different income group of rural households. Research indicates that: for the eco-compensation programs with direct cash payment, the Sloping Land Conversion Program has a significantly positive impact on high-to-medium income group; the project of Ecological Forest Compensation Program has no significant impact on all income groups; the Ecological Job Offer Program has a great impact on the income of low-income households. Our research highlights that i) different eco-compensation programs might have different income impacts on the same income group of households; ii) a specific eco-compensation might have different income impacts on different income groups of households; iii) eco-compensation does not necessarily contribute to poverty reduction unless the eco-compensation scheme is purposely designed for it.

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