Front. Earth Sci. 2020, 14(1): 209–220
https://doi.org/10.1007/s11707-019-0764-x

RESEARCH ARTICLE

Understanding the relationships between poverty alleviation and ecosystem conservation: empirical evidence from western China

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Abstract Despite growing interest in the use of Payments for Ecosystem Services (PES) for both social and ecological benefits, few studies have investigated the feedback and interaction between poverty alleviation and ecosystem protection outcomes. In this study, the poverty reduction effects of PES policies and their subsequent influence on environmental protection outcomes are investigated. To address these questions, 222 local rural households who were involved in PES programs from the Habahu National Nature Reserve in western China were interviewed. The results showed that the social and ecological outcomes of PES policies are neither two separate entities nor a trade-off. While rural households are the key participants in PES programs, the social and ecological outcomes of PES policies are closely related to each other. In addition, poverty reduction results could greatly influence ecosystem conservation effects. Livelihood assets, as well as the attitudes of rural households, play important roles in both of the outcomes. This research provides a new perspective that considers the social and ecological benefits of PES policies, and it also calls for an integrated consideration of social and ecological components in the design of PES policies to achieve enhanced results both for poverty alleviation and ecosystem conservation.

Keywords payments for ecosystem services (PES), ecosystem protection, poverty alleviation, livelihood assets

Received December 20, 2018; accepted April 29, 2019

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1 Introduction

Payments for Ecosystem Services (PES) is a policy mechanism that provides incentives for landholders to conserve ecosystems, and it is gaining worldwide recognition (Wunder, 2007; Persson and Alpízar, 2013). PES methods were designed primarily to complement top-down policy measures that deal with ecosystem degradation (Ferraro and Kiss, 2002; Wunder, 2005; Van Hecken and Bastiaensen, 2010). The success of PES in various countries has made them popular policy tools throughout the world (Ezzine-de-Blas et al., 2016; Börner et al., 2017; Costanza et al., 2017).

While the original aim of PES programs was to conserve or improve ecosystem services, the social benefits of PES have been widely explored in recent years (Adhikari and Agrawal, 2013; Ingram et al., 2014; Samii et al., 2014; Arriagada et al., 2015). In particular, a growing body of literature has developed that focuses on the potential effects of PES for poverty reduction (Landell-Mills and Porras, 2002; Grieg-Gran et al., 2005; Pagiola et al., 2005b; Wunder et al., 2008). This is primarily due to the fact that PES, as an economic policy instrument, has targeted areas that often geographically overlap with areas where poor people live (Bëtrisey et al., 2018). In many developing countries, PES has often been used as a dual-goal policy instrument to jointly improve ecosystem services and alleviate poverty (Pagiola et al., 2005a; Leimona and Lee, 2008; Pattanayak et al., 2010; Wendland et al., 2010).

Many studies that have investigated PES and poverty alleviation have primarily been evaluation studies. For example, many evaluations have demonstrated that local household income or livelihood asset changes are linked to the application of PES policies (Landell-Mills and Porras,

2002; Liu et al., 2010; Hegde and Bull, 2011). Other researchers have investigated the non-material benefits that poor people gain from PES programs (Grieg-Gran et al., 2005; Arriagada et al., 2015), or have focused on policy designs with goals to reduce poverty (Pagiola et al., 2005a; Leimona and Lee, 2008). However, quantitative and empirical data for assessing how PES contributes to poverty alleviation and what factors play key roles remain limited (Samii et al., 2014; Suich et al., 2015).

Whether PES can be effectively utilized as a dual-goal policy instrument remains debatable. Some scholars have demonstrated that the utility of PES for supporting both ecosystem conservation and poverty reduction has often been deemed incompatible (Howe et al., 2014; Alix-Garcia et al., 2015). In addition, many scholars and practitioners have expressed concern in the trend to emphasize PES as a poverty reduction tool, which may weaken the overall efficacy of the mechanism (Pagiola et al., 2005b; Wunder, 2005). In contrast, many scholars have argued that the social and ecological components of PES and their interactions must be understood together, rather than in isolation (Chan et al., 2012; Miller et al., 2012; Milner-Gulland, 2012). These scholars believe that PES policies should be designed as hybrid schemes that integrate both ecosystem conservation and societal development (Leimona and Lee, 2008; Petheram and Campbell, 2010).

However, few studies have provided empirical evidence regarding both the social influences resulting from PES policies and the subsequent effects to reveal the links between poverty reduction and ecosystem conservation at less than a macro or aggregate level (Engel et al., 2008; Miller et al., 2012; Suich et al., 2015). Hence, it is particularly important to understand the influences and links to develop appropriate and effective policies that achieve both sustained ecosystem conservation and poverty reduction outcomes (Ash et al., 2010; Liebenow et al., 2012).

China has implemented several PES programs throughout the country (Wang et al., 2016; Shang et al., 2018). The Chinese government has given great attention to PES mechanisms since the late 1990s (Ouyang et al., 2013). In the year 2017 alone, the national government invested more than one hundred billion CNY into PES schemes, including the Transfer Payment of National Key Ecological Function Areas program, the Sloping Land Conversion Program (SLCP), and others. (MOF, 2016). The PES policies in China also highlight the significance of alleviating poverty (CPCCC and SC, 2011; SC, 2016). However, even with large tracks of land that have been enrolled in PES schemes, the payments have normally not been sufficient to cover the economic losses and opportunity costs of landholders (Xu, 2013). The impacts of PES schemes on different households and the subsequent influences on ecosystem conservation outcomes remain unknown.

Therefore, the aim of this study is to provide empirical evidence regarding the poverty alleviation outcomes of PES programs in China in terms of their influence on different local households. Moreover, this study aims to examine the relationships between poverty alleviation and ecosystem protection, specifically feedback from poverty reduction outcomes on sustained ecosystem conservation. By providing empirical data on the regional level, this research aims to depict a clearer framework of the interactions and feedback between the social and ecological components within PES schemes to contribute to effective PES policy designs.

Section 2 will give a brief introduction of the study area located in western China. A conceptual framework will then be introduced to characterize the different local households. The methods used to collect and analyze the data for this research will also be explained in this section. Section 3 will present detailed research results on the poverty alleviation outcomes of PES programs, as well as provide feedback on sustained ecosystem protection. Discussions and conclusions will be presented in Section 4.

2 Materials and methods

2.1 Study area

This study focuses on the Habahu National Nature Reserve, located in the Middle North part of Yanchi County of the Ningxia Hui Autonomous Region in western China (Fig. 1). The land area of the Habahu National Nature Reserve is 840 km^2, with altitudes ranging from 1300 to 1622 m (HNNRMB, 2018). It consists of transitional zones from semi-arid to arid areas, dry steppe to desert steppe, and agricultural to pastoral land. Diverse ecosystems of shrubs, grasslands, meadows, deserts, wetlands, and sandy lands intertwine in this region (Xie et al., 2016).

There are 368 species of wild vascular plants, as well as 25 orders, 50 families, 141 species, and 44 subspecies of vertebrates living in the natural reserve. These species include 4 species of national first level protected animals and 21 species of national second-level protected animals (HNNRMB, 2018). The Habahu National Nature Reserve is also defined as part of the Key Ecological Function Area of the Loess Plateau in the National Main Function Area Planning document (SC, 2010). Located in the upper reaches of the Yellow River, this region provides the fundamental ecosystem services of soil and water conservation, as well as biodiversity conservation, for the nation. In addition, the study area is highly ecologically fragile, and water loss and soil erosion have long been outstanding problems (MEP, 2015).

This region typifies much of western China, with serious short-term conflicts between conservation and the livelihood activities of the poor. Yanchi County, where the reserve is located, is designated as one of the state's

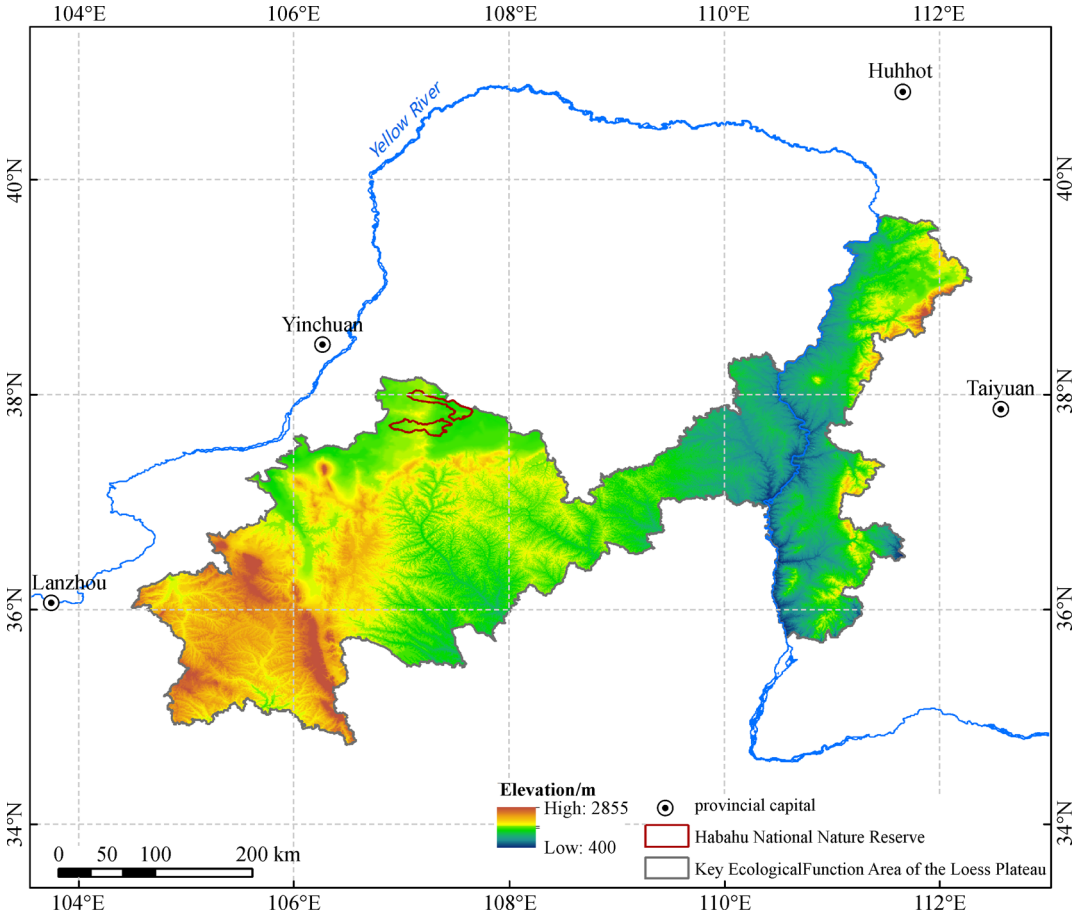

Fig. 1 Habahu National Nature Reserve in the Key Ecological Function Area of the Loess Plateau.

poverty counties (YCPG, 2017). In 2016, the per capita disposable income of rural residents in Yanchi County was one-third of the national per capita disposable income (SBNHAR, 2017; NBS, 2018). Livelihoods of rural households living in the Habahu National Nature Reserve heavily rely on farming and grazing. However, excessive land reclamation and over exploitation of grassland have caused forest losses and severe degradation of the grassland ecosystem, leading to soil erosion and desertification. This further threatens the ecological security of this region, as well as the middle and lower reaches of the Yellow River.

Due to the ecological importance of the reserve, as well as the long-existing conflicts between ecosystem conservation and livelihood activities, many PES programs have been conducted in this region with the joint aim to conserve ecosystems and alleviate poverty. These programs include the SLCP, Compensation for Public Welfare Forest, Grassland Ecological Compensation, and others (MOF and SFA, 2004; SFAIO, 2006; Xu, 2013)[1)].

2.2 Sustainable livelihoods framework

This study introduces the sustainable livelihoods framework developed by the UK Department for International Development (DFID) to more thoroughly characterize the different rural households involved in this research (DFID, 1999). The framework views people as operating in a context of vulnerability, facing an outside transforming environment and having to adjust their livelihood strategies based on livelihood assets to achieve livelihood outcomes. The framework also provides a holistic and realistic assessment of the living conditions and resources of poor people, which agrees with the aim of this research (Krantz, 2001). Therefore, this framework can assist in understanding how PES programs influence rural households differently, and how these families view ecosystem protection.

According to this framework, the resources that rural households use for their livelihood strategies are described

1) The SLCP requires farmers to turn their cultivated land into forest land. The Grassland Ecological Compensation program rewards herdsmen who no longer graze on grassland or who graze in an environmentally friendly manner. The Compensation for Public Welfare Forest program compensates owners or managers of existing important forests, and it does not require farmers to change their livelihood strategies.

as livelihood assets. The livelihood assets of households include their human capital (H), social capital (S), natural capital (N), physical capital (P), and financial capital (F) (Fig. 2). These five types of capital together make up the total livelihood assets of rural households (DFID, 1999).

Human capital represents the amount and quality of laborers within a household. Social capital in the context of the sustainable livelihoods framework means the social resources people use to pursue their livelihood objectives, including their networks and their connectedness to those networks. Natural capital refers to natural resource stocks from which useful livelihood resources are derived, for example the land and forests managed by households. Physical capital comprises the basic infrastructure or equipment used for supporting livelihoods. Financial capital denotes both monetary and liquid assets, such as livestock that people use to undertake their livelihood strategies. Livelihood assets are the basic capital that rural households are able to utilize to pursue their intended livelihood outcomes.

To better apply the framework to describe rural livelihood assets and strategies, the framework was translated from a conceptual model into a set of quantifiable indicators. The indicators for livelihood assets were then linked with each of the five dimensions or first-tier variables (human capital, social capital, natural capital, physical capital, and financial capital). The lower-tier variable selection process was driven by the current knowledge of the sustainable livelihoods framework, the condition of rural households living in the reserve, and the PES schemes that have been instituted in the region. In addition, the scholarly literature was reviewed for reference (Soini, 2005; Petheram and Campbell, 2010; Zhao et al., 2013; Zhao et al., 2016; Cao et al., 2017; Li et al., 2017; Li et al., 2018; Wu and Jin, 2018).

The Delphi method was applied to determine the weight of each indicator. The number of available laborers and the educational degree of householder were considered to be equally important to the human capital of households in this region. This weight assignment was similar to the research results of Zhao et al. (2016), Cao et al. (2017), Wu and Jin (2018) who conducted their research in similar geographical regions and determined the various weights either using entropy or the Delphi method. The natural capital for households in this region consisted of cultivated land, forest land, and grassland. Equal weights were assigned to the three different kinds of natural capital because they have a similar potential to bring benefits to households. The number of houses, farm machinery, and vehicles were considered as similarly important physical capital items that support the livelihoods of households. The monetary assets (annual income) were considered more important than liquid assets (livestock) for the financial capital of households according to their different liquidities.

While social capital is defined as networks and connectedness to the networks, the operation of social capital are still subjective and uncertain. Interpretations of social capital vary significantly from study to study. Cao et al. (2017) used ‘family members as village cadres’ as the key indicator, while Wu and Jin (2018) regarded ‘participating in social organizations’ as the main index. Li et al. (2017) considered the ‘evaluation of village organization’ as an important indicator, while the ‘betrothal expenditure’ was used as a key index by Zhao et al. (2016). Due to the fact that the villagers all knew each

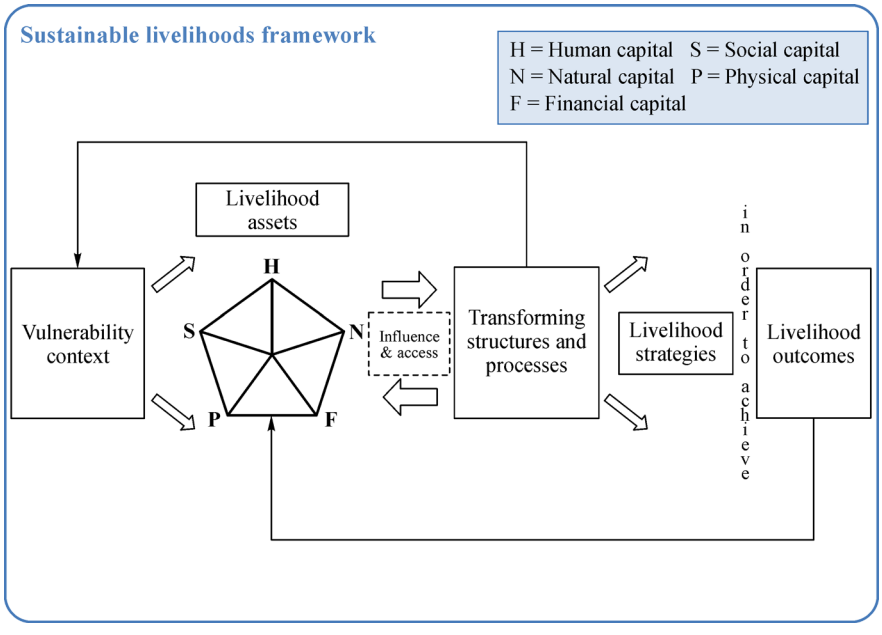

Fig. 2 Sustainable livelihoods framework.

other well and there were few village cadre positions or community organizations in the study area, the social capital for rural households living in the study area were considered to be similar. Therefore, the characterization of social capital was excluded from this research. Hence, there were a total of 10 lower-tier variables (Table 1).

Table 1 Sustainable livelihood asset variables of rural households

Asset type	Variable	Weight
1. Human capital /h	1.1 Number of available laborers	0.50
	1.2 Educational degree of householder	0.50
2. Social capital /s	—	—
3. Natural capital /n	3.3 Cultivated land	0.33
	3.4 Forest land	0.33
	3.5 Grass land	0.33
4. Physical capital /p	4.6 Number of houses	0.33
	4.7 Farm machinery	0.33
	4.8 Vehicles	0.33
5. Financial capital /f	5.9 Annual income	0.80
	5.10 Livestock	0.20

Note: Weight refers to the weight given to each lower-tier variable and is used to calculate the first-tier variables.

2.3 Data collection and analysis

The data used in this study came from a rural household survey conducted in the Habahu National Nature Reserve in 2015. The rural household survey was based on face-to-face questionnaires. The questionnaire was designed to collect qualitative data that described self-reported income changes of local households after involvement in PES programs. A second area of inquiry was local household livelihood assets, including human, natural, physical, and financial capital. The indicators for livelihood assets included the number of available laborers, the educational degree of householder, the annual income, and other variables developed from the sustainable livelihoods framework. A third area of inquiry focused on the attitudes of local households toward ecosystem protection. Their attitudes were studied by evaluating their satisfaction and preference to continue being enrolled in PES programs. Both open-ended and close-ended questions were used to collect this information. In addition, the head of the households (hereafter referred to as the householder) or a family member over 18 years old was asked to complete the questionnaire. Valid surveys were conducted in N = 222 rural households, including 119 conducted in the town of Huamachi, 48 in Wanglejin village, 41 in Qingshan village, and 14 in the town of Gaoshawo (53.6%, 21.6%, 18.5%, and 6.3%, respectively).

The primary data used to develop the indicators of livelihood assets were all quantitative, either measured as a ratio (e.g., the number of available laborers) or as an ordinal scale (e.g., the educational degree of householder). Importantly, all of the variables for livelihood assets were normalized into a scale of 0–1. Hence, the variables could be combined and compared. The qualitative data used to develop the income change of households and their attitudes toward ecosystem protection were translated into quantitative data.

This study used logistic regression to test the correlations between the income changes and livelihood assets of rural households. The 10 indicators of livelihood assets, including 'the number of available laborers', 'educational degree of householder', 'annual income', and other indicators were used as the independent variables. The income changes were used as the dependent variables. These included 'increased income', 'decreased income', and 'unchanged income'. When analyzing the correlations between 'increased income' and the livelihood assets of rural households, 'increased income' was assigned the value 1, while the other two types of income change were assigned the value 0. This was also done for the regression model of the other two types of income changes. The authors then further tested the correlations between the income change of local households and their attitudes toward ecosystem protection. Before analysis, the primary data and the calculated variables were plotted to investigate their fit to statistical assumptions such as normality.

3 Results

3.1 Basic characteristics of the households

Basic characteristics of the households included the age and educational background of the householder, the number of family members, and the number of income earners in the family (Fig. 3). Householders with ages from 40 to 49 made up the largest group, which was 31.13%. Householders younger than 30 years were the smallest segment. Householders with ages from 30 to 60 were the majority. These demographics are similar to the general situation in all of rural China.

The educational background of householders varied significantly. The majority of householders had only an elementary school education, which was 41.0%. The percentage of householders decreased, with higher educational level. Only 1.3% of householders had an educational level higher than high school. This situation mirrors the educational level of the poverty population in many parts of western China.

Most families included in this study (34.2%) consisted of four members, and 56.8% had two income earners. The household size also showed a decreasing trend, mirroring China's development due to lower fertility rates, aging populations, and other factors (Liu et al., 2003). This includes the population of older adults left behind in their rural villages (Wu et al., 2016).

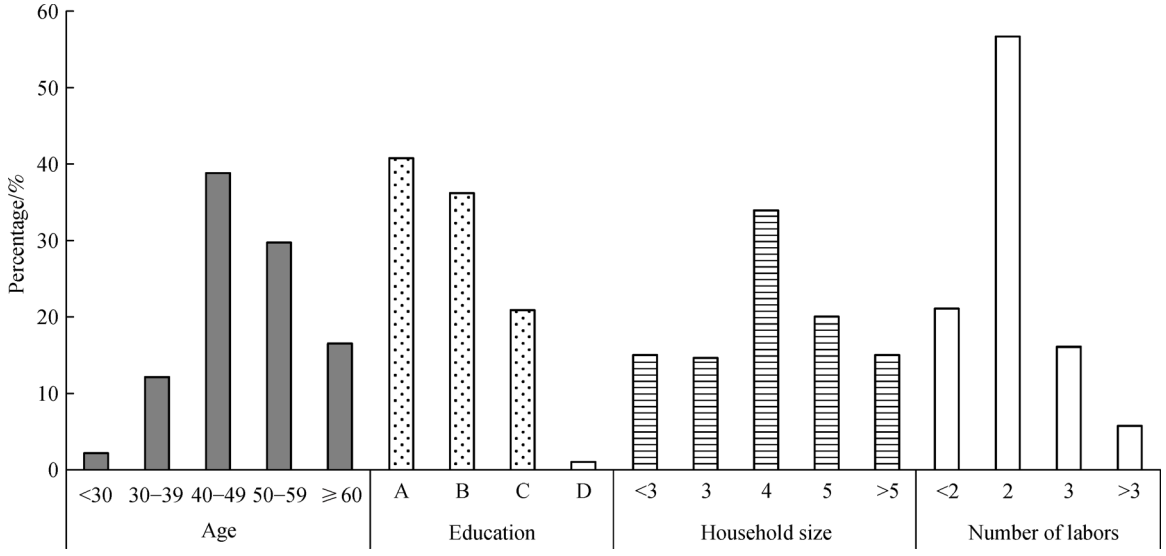

Fig. 3 Basic characteristics of the investigated householders.

Note: The A, B, C, D values of education refer to primary school or lower than primary school, junior high, senior high, and junior college or higher, respectively.

3.2 Livelihood assets of the respondents

Respondent livelihood assets at the household level were assigned the following values. Values assigned for the educational status of individuals were 0 for no educational background, 0.25 for primary school or lower than primary school, 0.5 for junior high, 0.75 for senior high, and 1 for junior college or higher. Values assigned for house numbers were 0 for no self-owned house, 0.5 for an adobe house, and 1 for a brick house. Farm machinery values were 0 for no farm machinery, 0.5 for three-wheeler machinery, and 1 for four-wheeler machinery. Values for vehicles were 0 for no vehicle, 0.33 for a manpower tricycle, 0.66 for an electro mobile or motorcycle, and 1 for a car. The number of available laborers, cultivated land acreage, forest land acreage, grass land acreage, annual income, and number of livestock were continuous variables. Table 2 shows the statistical results of each variable's mean, standard deviation, minimum, and maximum values.

The average available laborers of the respondents was 2.05, even though the average educational degree of the householder was 0.40, meaning their average educational level did not reach junior high school. For cultivated, forest, and grassland, the average acreages were 31.04, 94.78, and 216.13 mu, respectively. The data indicated that households in this region on average managed more grassland than any other type of natural capital. However, the acreage of grassland the households managed varied significantly.

Households in the investigated villages owned many houses, and the average reached 4.31. However, the average values for farm machinery and vehicles were 0.42 and 0.61, respectively. Significant differences existed in household annual income, with the highest being 499100 yuan and the lowest being 700 yuan. The average was 36445.92 yuan. Many households raised livestock and had an average number of 57.95 yuan.

3.3 The influence of PES policies on household incomes

The participating households self-reported their income changes after their involvement in PES programs. The majority of households reported an increase in their income, which constituted 44.1% of all of the respondents. This result reflected that the political intention to alleviate poverty by implementing PES policies was, to some extent, successful. A total of 28.3% of households reported that their income had been little influenced by PES policies. Yet, there was a group of households that claimed that their income decreased due to the PES projects. This group accounted for 27.5% of the total. This result showed that PES policies implemented in this area did not only have positive impacts on the poor, but would also cause adverse effects on many rural households.

3.4 Regression analysis of the impacts of household livelihood assets on income changes

Livelihood assets are defined in the DFID sustainable livelihoods framework as the resources and corresponding strategies that households could utilize for their livelihood, thus supporting households under changing conditions (DFID, 1999). When involved in PES programs, different households are able to utilize their livelihood assets to respond to the outside conditions differently. Therefore,

Table 2 Variables of respondent livelihood assets and their descriptive statistics

Variables	Definition and value	Mean	Std. d	Max	Min
Number of available laborers	continuous variable	2.05	0.85	6.00	0.00
Educational degree of Householder	0–no education background; 0.25–primary school or lower than ps; 0.5–junior high; 0.75–senior high; 1–junior college or higher	0.40	0.27	1.00	0.00
Cultivated land /mu	continuous variable	31.04	23.72	230.00	0.00
Forest land /mu	continuous variable	94.78	91.88	714.00	0.00
Grass land /mu	continuous variable	216.13	304.83	4000.00	8.00
Number of houses	0–no house; 0.5–adobe house; 1–brick house	4.31	2.05	12.00	0.00
Farm machinery	0–no farm machinery; 0.5–three-wheeler machinery; 1–four-wheeler machinery	0.42	0.40	1.00	0.00
Vehicles	0–no vehicle; 0.33–manpower tricycle; 0.66–electromobile or motorcycle; 1–car	0.61	0.34	1.00	0.00
Annual income	continuous variable	36445.92	47258.78	499100.00	700.00
Livestock	continuous variable	57.95	65.44	300.00	0.00

Note: 1 mu = 0.067 ha.

livelihood assets are an important factor to examine when analyzing the influences of PES programs on household incomes. In this study, a regression analysis of household livelihood assets and their impact on income was also performed using the logit model.

Figure 4 shows that nature capital has strong relationship with income changes in households involved in PES programs. When nature capital increases, household incomes are more likely to be influenced by PES policies, either in a positive or negative fashion. In contrast, the possession of less natural capital would decrease the likelihood of household incomes to be influence by PES programs.

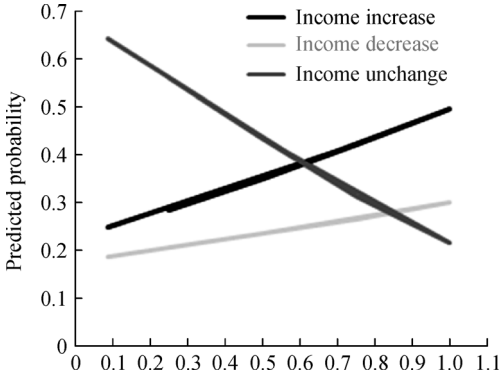

Fig. 4 The predicted probability curve of income changes under increasing natural capital.

Table 3 provides further insights into the role that different types of natural capital play in the effect of PES programs on household income, especially forest and cultivated lands. Abundant forest land would significantly raise the household incomes, while managing more cultivated land would significantly reduce household incomes. In addition, households who manage less cultivated and forest land were less likely to be influenced by PES policies.

In addition to natural capital, financial capital could also significantly influence local incomes. The more annual income households earn, the less they were likely to be influenced by PES programs. While the less annual income, the more likely they were to be negatively influenced by PES policies. However, when the amount of livestock increased, household incomes were likely to decrease. Breeding less livestock could prevent household incomes from being influenced by PES policies.

An increased amount of farm machinery lowered the potential for households to be influenced by PES policies. Human capital, including the number of available laborers and the educational degree of householder, as well as grassland, number of houses, and vehicles did not have a close relationship with income changes in households under PES programs. With the exception of forest land, the remaining household livelihood assets did not have a significant relationship with an increase in household incomes.

3.5 Regression analysis of the impacts of household income changes on sustained ecosystem protection

The essence of the PES mechanism is to provide incentives for rural households to conserve ecosystems (Wunder, 2007; Persson and Alpízar, 2013). Therefore, the continued participation of rural households in PES programs as ecosystem services providers is one of the main determinants for sustained ecosystem protection. To understand the impacts of household income changes on sustained ecosystem protection, this study examined the attitudes of local households toward PES policies. This included an examination of their satisfaction with PES

Table 3 Logistic regression of the impact of livelihood assets on household incomes

Livelihood assets	Increased income		Decreased income		Unchanged income	
	b	sig.	b	sig.	b	sig.
Human capital						
Number of available laborers	–0.821	ns	1.486	ns	–0.618	ns
Educational degree of householder	0.149	ns	–0.885	ns	0.740	ns
Natural capital						
Cultivated land	0.787	ns	3.940	**	–7.365	***
Forest land	2.124	*	0.418	ns	–5.124	**
Grass land	–2.604	ns	2.768	ns	–0.011	ns
Physical capital						
Number of houses	–0.442	ns	–0.321	ns	0.825	ns
Farm machinery	–0.402	ns	0.059	ns	0.736	*
Vehicles	0.118	ns	0.499	ns	–0.594	ns
Financial capital						
Annual income	–0.320	ns	–1.624	***	1.943	***
Livestock	0.202	ns	0.861	*	–1.037	**

Note: *, **, and *** denote significance at $p < 0.1$, $p < 0.05$, $p < 0.01$ levels, respectively.

policies and their willingness to continue participating in PES programs.

Figure 5 shows that the attitudes of households vary according to differences in their income changes. The investigated households whose income decreased were most unsatisfied with PES policies (80.33%) and were unwilling to continue participating in PES programs (67.21%). Table 4 shows that the influence of decreased income on the attitudes of households is significant. In contrast, households whose income increased were least unsatisfied (20.41%) with PES policies and were also least unwilling (21.43%) to continue with the programs. The influence was also significant according to the regression analysis. The income increase effectively lifted the enthusiasm of households to participate in PES programs. The attitudes of households whose incomes were little influenced by PES programs were in between these two results.

3.6 Regression analysis of the impacts of livelihood assets on the attitudes of households toward ecosystem protection

This study further investigated the impacts of household livelihood assets on sustained ecosystem protection to understand the role of livelihood assets in influencing the attitudes of households toward PES programs. Table 5 shows that while income changes were the main influential factor of household attitudes, their attitudes could also be influenced by livelihood assets.

Annual income played a negative role in the willingness of households to continue participating in PES programs, especially for those whose income decreased. The amount of cultivated land also played negative role in decreasing the satisfaction of households toward the PES programs, especially for households whose income increased.

Conversely, the number of vehicles played a positive role in reducing the dissatisfaction of households with PES policies. For households whose income increased, vehicles also played positive roles in increasing their satisfaction with PES policies.

The rest of the livelihood asset variables, including educational degree of householder, number of available laborers, forest land, grassland, number of houses, farm machinery, and livestock, did not significantly influence household attitudes toward PES polices.

4 Discussion and conclusions

As long as participation in PES programs is voluntary,

Table 4 Logistic regression of the impact of household income changes on sustained ecosystem protection

Income changes	Unsatisfied with pes programs		Unwilling to continue with pes programs	
	b	sig.	b	sig.
Increased income	–1.753	***	–1.170	***
Decreased income	2.354	***	1.892	***
Little influence	–0.190	ns	–0.580	ns

Note: *** denotes significance at $p < 0.001$ level.

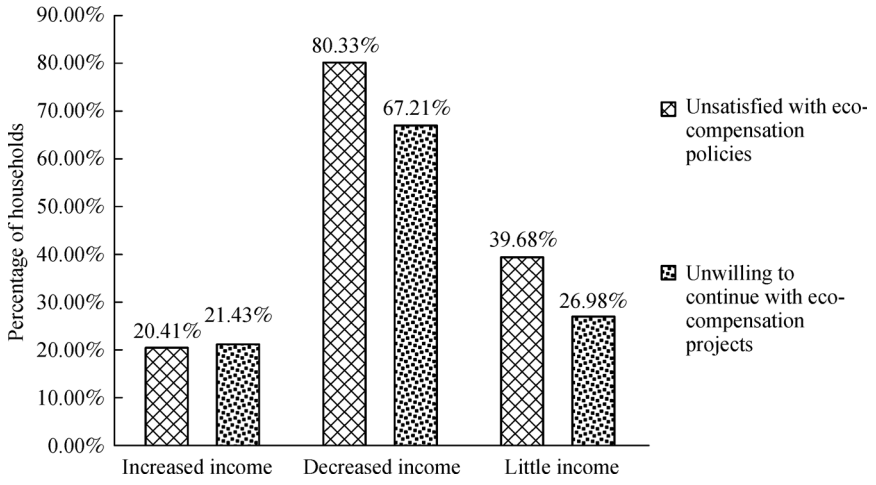

Fig. 5 The attitudes of local households toward PES policies.

Table 5 Logistic regression of the impact of household income changes and livelihood assets on sustained ecosystem protection

Index	Unsatisfied with PES programs		Unwilling to continue with PES programs	
	Income increased	Income decreased	Income increased	Income decreased
Human capital				
Number of available laborers	–0.925	–1.291	–0.235	–0.799
Educational degree of householder	–0.310	0.068	–0.435	–0.245
Natural capital				
Cultivated land	3.950*	1.540	3.366	1.530
Forest land	0.100	–1.231	2.442	1.886
Grass land	0.394	0.255	–6.832	–7.680
Physical capital				
Number of houses	–0.153	0.277	0.730	1.143
Farm machinery	–0.380	–0.210	0.241	0.367
Vehicles	–0.991*	–1.335**	–0.008	–0.268
Financial capital				
Annual income	–0.784	0.173	0.386	1.297*
Livestock	0.810	0.292	0.134	–0.337
Income change	–1.988***	2.530***	–1.299***	2.236***

Note: *, **, and *** denote significance at $p < 0.05$, $p < 0.01$, $p < 0.001$ levels, respectively.

there is premise assumption that PES will make their participants better off. In particular, PES could be an important addition to the income of the poor. However, this will not happen automatically. The results of this study demonstrated that PES policies do not always benefit households. In fact, many households were negatively influenced by involvement in PES policies, and the effects were greatly determined by household livelihood assets. Nature capital was one of the main factors that influenced household income. While cultivated land led to deceased income, more forest land contributed to increased income. This may result from different PES program designs and requirements. Farmers who managed cultivated land were primarily involved in SLCP, which requires farmers to change their livelihood strategies. However, households who manage forest land may be involved in the Compensation for Public Welfare Forest plan, which does not require changes in livelihood strategies as the premise for payments.

Financial and physical capital are other important factors that influence household income. Households with more annual income and farm machinery are less likely to be negatively influenced by PES policies. Financial abundance as well as physical capital may help farmers deal with changing environments and assist them in developing effective livelihood strategies. Households may either

develop new strategies relying on their physical capital or switch strategies supported by their financial capital. Abundant physical and financial capital may also contribute to the flexibility of local farmers to develop new livelihood strategies when facing outside socio-economic-political environmental changes, thus improving their ability to maintain stable incomes.

Some practical suggestions can be drawn from these research results that can assist policy makers in decision making. First, managers should pay more attention to rural households with cultivated land when these households are involved in PES programs, because this group is more likely to be negatively influenced by PES policies. In addition to payments for ecosystem services in cash, additional policies should be formulated to guide these households to smoothly switch their livelihood strategies by getting technical training and job opportunities, so as to stabilize their livelihood outcomes or achieve a better income. Policy makers should also rapidly lift the financial and physical capital of these households using interest-free loans, lending policies, and other financial incentives. These measures would support rural households in maintaining and raising their financial and physical capital. When involved in PES programs, participants could rely on these sources of capital to develop new livelihood strategies or switch strategies. Such policies could improve the ability of locals to maintain stable incomes.

In this study, local households were not only viewed as a group that was influenced by PES programs, but rather locals were the ecosystem services providers. Therefore, the attitudes of local households toward PES policies can determine ecosystem protection effects. According to this view, the impact of poverty alleviation outcomes on environmental protection were also analyzed. The findings suggested that poverty alleviation factors significantly influence the original objective of PES programs to sustainably protect ecosystems. When PES programs help increase the income of the poor, participants will be much more satisfied with PES policies and be willing to continue their involvement in the programs. However, adverse effects on the incomes of the poor would lead to their dissatisfaction with PES policies and unwillingness to continue enrolling in the programs. This is similar to the finding of Fan et al. (2005) that stated households would shift back to their previous livelihood strategies when their contracts end if their incomes had been adversely affected. Other scholars also found that leakage would occur, and that rural households would transfer exploitation to areas not covered by PES policies when their incomes were restricted (Angelsen and Wertz-Kanounnikoff, 2008; Baylis et al., 2013).

Interestingly, this study also found impacts from household livelihood assets on the attitudes of households toward PES programs. The number of vehicles played a positive role in increasing the satisfaction of households with PES policies. This may be due to the flexibility households gained to change their livelihood strategies due to the possession of more vehicles. However, annual income and cultivated land played negative roles in the willingness and satisfaction of households toward PES programs. Households with more annual income and cultivated land were more easily influenced by PES programs, and thus more likely to hold negative views toward PES policies.

For policy makers, it is important to understand the role of rural households not only as the objects of payments, but more importantly the providers of ecosystem services. Therefore, it is vital to consider the effects of poverty alleviation and ecological outcomes as a whole in PES policy designs due to the great impact of rural household attitudes on environmental protection outcomes. Social benefits should be used as the basis for ecological benefits in PES policies to achieve a win-win situation. The results also revealed interesting evidence that assisting PES participants with their vehicles could contribute to positive effects on the final ecosystem protection results. Additionally, PES participants with more annual income and cultivated income were the group that required special attention to raise their positive attitudes toward PES programs for a better ecological conservation outcome.

This empirical evidence from western China provides important insights to encourage a close interaction between the social and ecological components of the PES mechanism, rather than examining the trade-offs between them (Howe et al., 2014; Alix-Garcia et al., 2015). The results of this study indicate that poverty alleviation outcomes of PES programs are an important basis for achieving sustainable ecosystem protection results. This study also emphasizes that using PES as a poverty reduction tool would not weaken the overall efficacy of PES policies, as some may claim (Pagiola et al., 2005a; Wunder, 2005), but it would rather improve the participation and sustainability of ecological outcomes in the long-term. Livelihood assets are also important factors that influence household attitudes and ecosystem outcomes. As Leimona and Lee (2008) and Petheram and Campbell (2010) have also argued, PES policies should consider both conservation and development in their design to achieve both social and ecological benefits.

In conclusion, by presenting the impacts of PES on local incomes and the subsequent influences on sustained ecosystem protection, this research showed how PES influences households very differently. The results also showed the close interactions between poverty alleviation and environmental outcomes within PES programs. These results emphasize the importance of PES policies to consider livelihood assets to achieve enhanced poverty alleviation and ecosystem protection results. Furthermore, this research also demonstrated the importance of considering social components to attain both social and ecological goals. Thus, this research provides important evidence for understanding the relationship between the

social and ecological components of the PES mechanism and for more effective PES policy design.

Acknowledgements This work was financially supported by the National Natural Science Foundation of China (Grant Nos. 41471092, 41501095 and 4170011561). The view expressed in this document does not reflect the official opinions of donors. Experiments performed in this research comply with the current laws of China.

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