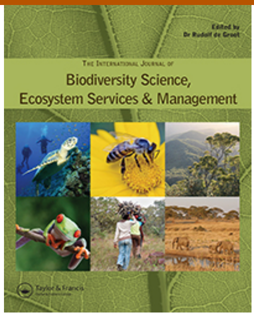

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RESEARCH

How socioeconomic and institutional conditions at the household level shape the environmental effectiveness of governmental payments for ecosystem services program

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ABSTRACT

As the world's largest payments for ecosystem services (PES) program, China's Sloping Land Conversion Program (SLCP) is designed to combat soil erosion and land degradation by converting cropland on steep slopes into forests. Operating through an incentive-based approach, the SLCP involved 32 million rural households as core agents. This paper aims to fill a research gap regarding how socioeconomic and institutional conditions influence rural households to reach the primary environmental goals. Using fuzzy-set qualitative comparative analysis (fsQCA), we conclude that at the household level, the different pathways to environmental success or failure have been shaped by socioeconomic and institutional conditions in a combinatory manner rather than single conditions alone. Specifically, the combination of household involvement and effective monitoring plays a fundamental role in capacity-building between government and households. We found that financial incentives have a trade-off effect, as they could not only create a positive interaction but also trigger failure in situations with different conditions. Finally, the potential and limits of QCA were discussed, and we call for a more serious reflection on the added value of QCA as an alternative or complementary method to conventional approaches in environmental governance research.

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1. Introduction

Payments for ecosystem services (PES) has been a popular approach to address environmental degradation in recent years. The principle of PES is to use an economic incentive to motivate voluntary local actors to protect and restore valuable ecosystem services (Engel et al. 2008). As PES is not a panacea, how to make PES the right tool has attracted considerable attention. Notably, by summarizing 70 PES programs worldwide, Wunder et al. (2018) argue that four theoretical preconditions and three desirable design features should enable PES to achieve success. However, based on a review of PES design features, Engel (2016) claimed that the evidence on the effectiveness of PES is still scarce and rather mixed.

The Chinese Sloping Land Conversion Program (SLCP), initiated in 1999, is considered one of the largest governmental PES programs in the world due to its broad geographic cover, wide participation and tremendous investment (Zhen and Zhang 2011). This program aimed to reduce soil erosion and support rural economic development by reforesting approximately 14.67 million hectares of cropland countrywide (State Forest Administration 2003). With an explicit emphasis on voluntary participation and local autonomy in the policy's design, the SLCP directly engaged over 32 million households as core agents of program implementation (State Forest Administration 2007). Although embracing innovative PES elements, similarly to other governmental schemes, the SLCP contains components from the traditional command-and-control approach, such as top-down structure, inflexible contract design and campaign-style mobilization (Kolinjivadi and Sunderland 2012). Thus, an open question remains concerning whether the SLCP is an institutional innovation or just 'business as usual' (Bennett 2008).

The success of economic incentive instruments depends on the capacity to target the self-interest of the final agents – the households (Liang et al. 2012; Li et al. 2017). Various socioeconomic and institutional conditions, including household attitude, trust, household involvement, household livelihood, property rights clarification, off-farm labor allocation, and regular monitoring, were considered important factors to create the incentive and shape the behavior (Uchida et al. 2005; Bennett 2008; Cao et al., 2009a). Their influence on rural households' willingness to participate in SLCP was intensively studied (Démurger and Pelletier 2015; Li et al. 2017; Liu et al. 2019). Many studies had linked those factors with program implementation, poverty alleviation, cost-

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Supplemental data for the article can be accessed here.

effectiveness and long-term sustainability (Uchida et al. 2009; Gauvin et al. 2010; König, Podhora et al. 2015). Many studies had extensively investigated the various impacts of the SLCP on the participating households, such as their household income (Lin and Yao 2014), livelihood diversification (Liu and Lan 2015), agricultural production activities (Yao and Li 2010; Liu and Henningsen 2016), labor transfer (Yao et al. 2010) and productivity (Liu and Lan 2018). The studies shed light on the factors that affect the program implementation and rural household livelihood. While many longitudinal household databases had provided comprehensive analysis of the livelihood impact of the SLCP, the dependency of the primary environmental goal on socioeconomic and institutional conditions at the household level has rarely been explored. In particular, what determinants influenced the final environmental effectiveness and efficiency at the household level has until now been unclear.

The environmental effectiveness of SLCP is mixed. Environmental effectiveness at the household level refers to the quantity and quality of forest in SLCP-enrolled plots (The State Council 2002). Officially, the most important indicators used to evaluate the outcomes are tree survival rate and canopy coverage[1]. While the governmental national evaluation result shows 93% acceptance after inspection (State Forest Administration 2007), many filed studies cast doubt upon the accuracy and reliability of that assessment (Bennett 2008; Trac et al. 2013; He and Sikor 2015). In contrast, several studies found great forest cover improvement in extensive SLCP-enrolled regions by using remote sensing (Zhou et al. 2009; Zhang et al. 2017). Nevertheless, SLCP could not take all the credit, as private commercial afforestation increasingly dominates the expansion of tree cover (Frayer et al. 2014). Additionally, the aggregated regional result may neglect significant differences by individual household and locale (Bennett et al. 2014). Therefore, scientific field observation of the official indicator is important to justify the SLCP-induced environmental outcome at the individual household level. However, due to the difficulty in collecting the filed data in the remote mountainous area, the criticisms of the environmental effectiveness of SLCP primarily relied on secondary data, such as household self-reported information and governmental inspection results (Bennett 2008; Bennett et al. 2014; He and Sikor 2015). Only a handful of filed observations are available, but they are not up to date (Cao 2008; Cao et al. 2009b). To offer direct and detailed evidence, further local case studies and field-based data collection have been called for (Trac et al. 2007).

While there have been several studies devoted to addressing the link between socioeconomic and institutional conditions with the environmental effects of the SLCP (Bennett 2008; Yin and Zhao 2012; He et al. 2014; Zhang et al. 2017), they have not explicitly clarified the interactions between socioeconomic and institutional conditions and environmental outcomes at the same household level. To fill this research gap, the objective of our paper is to analyze the relation between relevant socioeconomic and institutional conditions and environmental effectiveness at the household level. We target the following research questions:

- What are the necessary and sufficient[2] socioeconomic and institutional conditions at the household level for environmental effectiveness?[3]
- What are the necessary and sufficient socioeconomic and institutional conditions at the household level for environmental effectiveness and environmental noneffectiveness[4]?

2. Analytic framework

Our research is structured using a combination of methods. After selecting the case study, we selected and defined the conditions based on the literature and local interviews. Then, we collected data by a second household interview and field observation. After calibration of the data, we employed a fuzzy-set qualitative comparative analysis (fsQCA) to determine the different pathways to success and failure in terms of environmental effectiveness among varied condition arrangements. Figure 1 gives an overview of how we proceeded with our analysis.

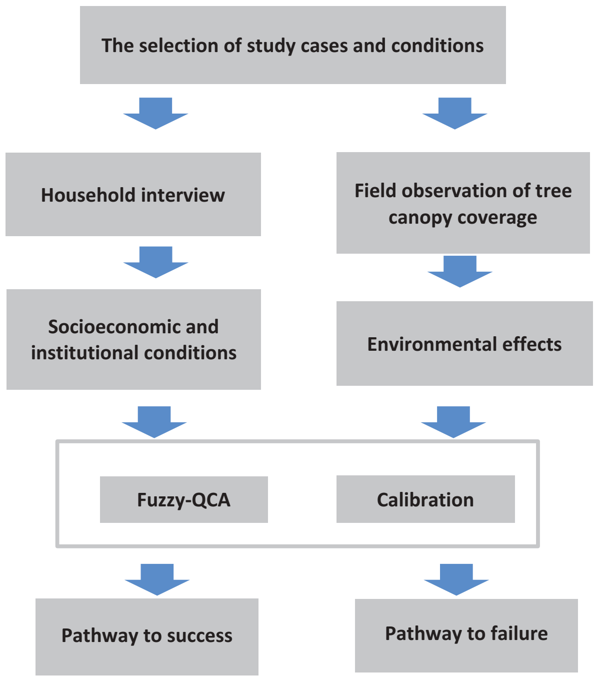

Figure 1. Analytical framework.

3. Selection of case study area and conditions

3.1. Selection of study cases

As a typical target region of the SLCP, Jingyuan County from the Guyuan Region in the Ningxia Hui Autonomous Region (Figure 2) was selected as the study region. Located at the southern tip of the Loess Plateau, Jingyuan County is in a remote, environmentally fragile mountainous frontier region. The county is defined as a national key ecological function zone and is one of the most undeveloped areas in China. Shengli village and Miaowan village were purposely selected because both villages implemented two rounds of the SLCP, with significant tree plantations and extensive involvement of the local households since 2000. To answer our research question, individual households in both villages were selected as our study cases, and their environmental effectiveness for SLCP-enrolled land was defined as the outcome.

Another reason for us to select these two villages is the similarity of their environmental settings. In general, environmental conditions (e.g. soil, precipitation, and temperature) are important determinants of environmental outcomes. Of course, for an individual plot, the micro-environmental conditions are different, especially considering the variation under climate change. However, the land areas in the two villages are categorized into three classes according to biophysical conditions (e.g. slope, soil, access to water and plot size) and traffic conditions (e.g. distance to home). To make the overall quality of land allocated to each household nearly equal, one household normally has 3–6 plots that include all three classes. Due to the targeting strategy, SLCP-enrolled plots are mostly in the worst class, with the worst biophysical and traffic conditions. By selecting the SLCP-enrolled plots in the two villages, we consider that our sample has been naturally controlled for the environmental aspect. This assumption was also confirmed by the local forest experts. Our first field trip in 2014 observed that one frequently sees two neighboring plots with similar environmental conditions but completely different results due to different management strategies. We therefore believe that for our study cases, environmental conditions may play only a limited role in determining different environmental outcomes across different households.

3.2. Selection of relevant conditions

Consistent with the PES theory and international experience, the environmental success of SLCP depends on a variety of conditions. As only a limited number of conditions can be considered for valid inferences by QCA, we assumed that some key conditions are most relevant for the program's environmental effectiveness. To avoid subjectivity, we selected the most relevant ones through three steps. Step 1 listed the potential conditions through a broad search based on studies. The literature study began with socioeconomic, institutional and environmental aspects that are generally assumed to be important within the SLCP literature. The review, conducted by the first author (Chen et al. 2015) in 2015, includes 164 international scientific articles; additional studies were updated in 2017. As

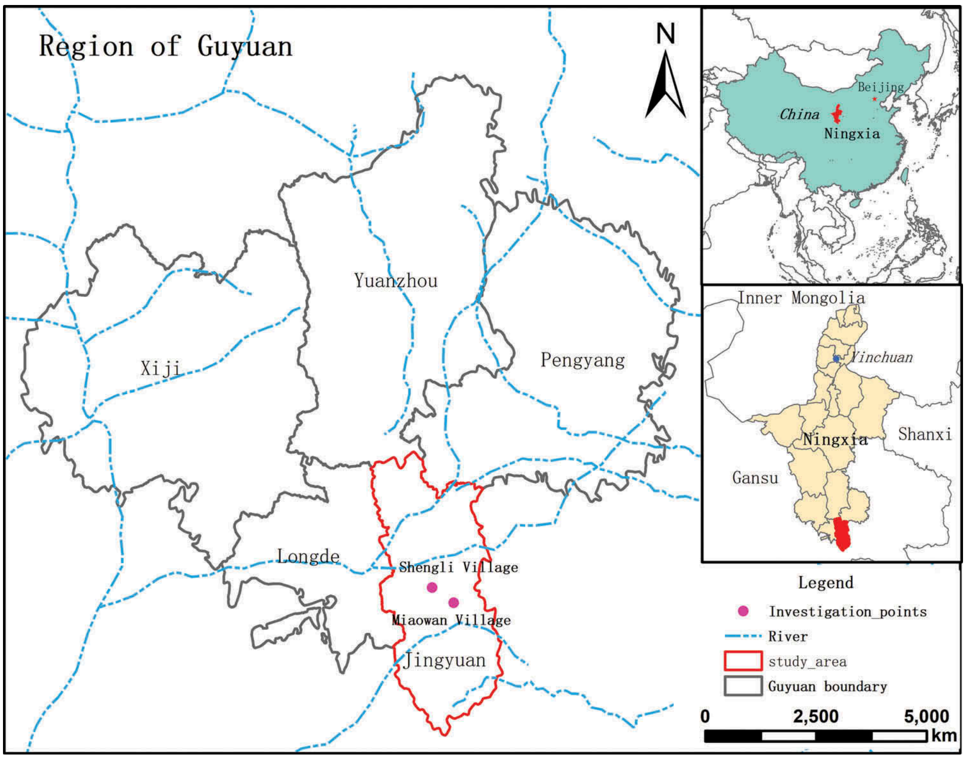

Figure 2. Location map of Jingyuan County in Guyuan region, Ningxia Hui Autonomous Region.

a result, 20 relevant conditions were found. Step 2 shortened the list by merging similar conditions into more-general conditions based on local household interviews. Finally, Step 3 selected the most relevant conditions according to a local expert workshop. Detailed information about this process can be found in A1, the condition selection protocol, in the supplementary material. The final selected socioeconomic and institutional conditions are summarized in Table 1.

3.2.1. Household involvement

The SLCP claimed to be decentralized, and voluntary households were to be free to choose their site to retire and choose tree species to plant (The State Council 2002). However, during implementation, household participation was not entirely voluntary and was observed in a passive manner (Li et al. 2017). When a region was targeted by the governmental general plan, individual households can hardly have a say in the enrollment decision (Démurger and Pelletier 2015). Therefore, we viewed the participation by using the broader term, 'involvement.' By our definition, household involvement included being part of the general planning, site selection and tree species selection and of the satisfaction of the decision results.

3.2.2. Financial incentives

For SLCP households, behavioral changes are highly conditional on the governmental payment. Economists viewed the financial incentive based on the opportunity costs (Uchida et al. 2005). However, it is important to consider household resources when analyzing real behavioral changes. Furthermore, the payment amount varied according to the enrolled land size and environmental outcome. Therefore, we define the financial incentive based on the household's comparison between the cost required by the SLCP (farmland loss, replanting responsibility and obligation to be monitored) and payment received.

3.2.3. Off-farm labor allocation

A household's position within agriculture and off-farm labor markets has a complicated impact on the program implementation (Uchida et al. 2009). The effect of off-farm labor allocation has been studied intensively but remains unclear. Many scholars have argued that the shifting from on-farm activities to off-farm employment can offer the household better economic opportunities (Yao et al. 2010; He et al. 2014). Therefore, this transition was considered key to ensuring the converted land is not returned to cropland (Groom et al. 2010). However, other evidence shows that off-farm households do worse at keeping their planted trees alive (Bennett et al. 2011). The percentage of land-related income (farming, gardening and livestock breeding) that accounts for total income is chosen as the measure for off-farm labor allocation.

3.2.4. Property rights

Demsetz (1967) noted that different patterns of property rights could lead to different patterns of behavior, and Tu et al. (2011) found that property rights are generally considered to influence SLCP household behavior regarding resource use and environmental management. Moreover, secure property rights played an important role when payments were terminated by encouraging households to pursue off-farm employment (Grosjean and Kontoleon 2009; Yin and Zhao 2012). However, there are increasing concerns about the uncertainty over the lack of property rights in rural China due to the separation of land property rights and use rights[5] (Uchida et al. 2005). Since we are interested in the incentive for households to provide environmental effects, the measure of property rights focuses on household perception about trees and land rather than the legal property status.

3.2.5. Effective monitoring

Effective and lasting monitoring, particularly internal monitoring and enforcement, has been understood as a major component of SLCP implementation (Yin et al. 2013). While monitoring was widely accepted as the core of PES design, how to implement monitoring cost-effectively remains unclear (Ezzine-de-Blas et al. 2016). As we consider the monitoring from the perspective of households, household awareness of the checking standard and the appearance of monitoring officials are used as measures.

4. Data and methods

4.1. Data collection – socioeconomic and institutional conditions

Data collection was done during our second field trip in 2015. Thirty households in Shengli village and 29 households in Miaowan village were onsite sampled, totaling approximately 10% of the households in both villages. The survey targeted the household head as the

Table 1. Definition of the five conditions.

Condition	Code	Category	Definition
Household Involvement	'invo'	Institutional	Household is involved in decision making in program implementation
Off-farm labor allocation	'off'	Socioeconomic	A majority of income comes from off-farm employment
Financial incentive	'fina'	Socioeconomic	Household feels the payment is attractive compared to the required input
Property rights	'prop'	Institutional	Household recognizes property rights for trees and land
Effective monitoring	'moni'	Institutional	Household is aware of the checking standard and has been effectively monitored

person viewed as knowing the most about his/her household. Apart from basic household characteristics, the interview focused on the five conditions and their measures. In addition, interviews with the village head and local forest officials helped to verify the results from the households.

The subjective impacts from the interviews, such as strategic answers, influence of the interviewer and misinterpretation were seriously considered and carefully addressed. The interviews were conducted face-to-face by a team led by the first author. Since 2014, this team has worked in Jingyuan County, particularly in the two study villages. The team included three PhD students from a research group at the Institute of Geographic Sciences and Natural Resources Research (IGSNRR), Chinese Academy of Sciences. All team members were trained on relevant conditions and corresponding measures. The existing mutual trust and well-prepared knowledge enabled the interviews to be conducted with minimum communication difficulty.

4.2. Data collection – measurement of environmental effects

Tree survival rate was used as the most explicit indicator for evaluation for pragmatic reasons (Bennett 2008). However, it is often criticized by household and local forest officials because survival rate counts the quantity of the trees rather than the quality of the forest. To equally consider the quantitative and qualitative performance, we therefore evaluated environmental effectiveness at the household level by using the Braun-Blanquet method to scale the tree canopy coverage. The Braun-Blanquet cover-abundance scale is a widely used method for ecological studies (Braun-Blanquet 1932) that provides sufficiently accurate baseline data to allow environmental impact assessment in terms of species, estimation of relative abundance, estimation of foliar coverage and density measurement (Wikum and Shanholtzer 1978).

Due to land fragmentation and lacking information, applying remote sensing and GIS to measure the environmental effects for our sampled households is not suitable. The field work was very challenging but appeared to be the only option. We collected field-observed data from 128 SLCP-enrolled plots (Figure C1 and C2 in the supplementary material) owned by our 59 interviewed households. Each household was measured by at least two different located plots because of land fragmentation. We randomly placed a 100 m^2 quadrat with the steel tape within the plot during the middle of the growing season (August and September). In order to eliminate accidental in selection, the sample quadrat from the sample plot was checked by our local guide (local farmer specialized in forest management). Species diversity, species number, tree height and coverage were collected according to the Braun-Blanquet table (Braun-Blanquet 1932). The Braun-Blanquet cover-abundance scale was recorded by the authors' estimation in the quadrat. To make our estimation more accurate and objective, we confirmed the scale by counting the number of each tree species in the quadrat. Finally, we adapted the scale with the Chinese forest regulations (Table 2) (General Administration of Quality Supervision 2006). The environmental outcome was categorized 'forest', 'sparse forest', 'developing forest or grass' or 're-farm' (Figure C3 in the supplementary material). According to the Chinese forest regulations, the first two categories are considered forest, and the other two categories are not. Therefore, a coverage ratio of 10% is used as the threshold to distinguish environmental success and failure at the household level (Table 2). We acknowledge that we are not seeking to precisely quantify the environmental effects. Instead, we want to make an estimation of the relative abundance of forest for further outcome comparisons. Given the current availability of data and facility at the household level, the cover-abundance scale in a sample quadrat is an appropriate measure for examining the household-level environmental effectiveness.

As our study case is the individual household, the field observation data from 128 SLCP-enrolled plots need to be aggregated into 59 households. When one household's plots have the same result (45 of 59), they can be easily unified. When one household's plots had different results, a participatory process with the village head was carried out to make a decision based on the overall performance during the previous local inspection. If re-farm is observed in any of the plot, the outcome of the household is labeled as re-farm (9 of 59).

4.3. Data analysis by qualitative comparative analysis

To compare the 59 households, we employed qualitative comparative analysis (QCA) to determine the different pathways to environmental success and failure among varied condition arrangements. QCA, which is based on Boolean logic, allows comparison between cases and at

Table 2. Conversion of Braun-Blanquet cover abundance scale to SLCP scale.

Braun-Blanquet scale	Coverage ratio	SLCP scale	Coverage ratio
3–5	>25	Forest	20%-100%
2	10–25	Sparse forest	10%-20%
1	<10, numerous individuals	Developing forest	5%-10%
+	<10, few individuals	Grass	0–5
R	<10, no individuals	Re-farm	0, crop or nursery planting

the same time offers a detailed understanding of the complexity of each case, particularly in small or medium-sized samples (Ragin 2008). QCA is particularly powerful in analyzing multiple conjunctural and asymmetrical causation (Rihoux and Ragin 2009). Multiple conjunctural causation means that 1) not one factor but a combination of factors will lead to the outcome; 2) different combinations of factors can produce the same outcome; and 3) one condition can have different impacts on the outcome, depending on its combination with other factors and the context. The justification for considering QCA as an appropriate method for our study can be found in A2 in the supplementary material.

Hypotheses within QCA are implication hypotheses of the notions of necessity and sufficiency (Ragin 2008). A condition is necessary if, whenever the outcome is present, the condition is also present. A condition can be interpreted as sufficient, if always whenever the condition is present, the outcome is also present. The QCA analyses presented in this paper were conducted with fsQCA 2.0 software (Ragin 2008). The software used the truth table to sort the condition data into the different logically possible combinations. When applying the logical minimization procedure to the truth table rows, three solution terms are produced: the complex solution, the parsimonious solution and the intermediate solution. With no simplifying assumption, a complex solution avoids using any counterfactual cases (remainder). Parsimonious solutions, on the other hand, permit the use of any remainder that will yield the simplest recipes. An intermediate solution is something in between; it uses only the remainders that survive counterfactual analysis based on theoretical and substantive knowledge. The researcher is free to choose the solution for substantive interpretation depending on the balance between complexity and parsimony (Ragin 2008). Finally, to explain inconsistencies, contradiction analysis is used to explore why some of the cases covered by the sufficient condition exhibit the outcome and others do not.

The comparison of QCA and classical regression analysis (e.g. binary logistics) is by far a mixed result (each has merits and drawbacks). As this study does not intend to compare the methods, readers can find a detailed discussion in the works of Seawright (2005), Grofman and Schneider (2009) and Vis (2012). We acknowledged that this method is only briefly introduced in this section of this paper. Our recent publication explains how QCA could be applied in institutional analysis for PES and illustrates five basic steps for such application (Meyer et al. 2018). In Ragin (2008, 2014) and Schneider and Wagemann (2010, 2012) provide handbooks, user guides, explanations and standards of good practice regarding this method. Nevertheless, to facilitate the understanding of the results and discussion, we summarized the basic terminology in Table B2 in the supplementary material.

4.4. fsQCA and calibration

Crisp-set qualitative comparative analysis (csQCA), specifically, an early developed version with dichotomy, was first introduced by Charles Ragin in 1987 (Ragin 2008). As csQCA was criticized by using binary-value data, fuzzy-set QCA (fsQCA) allows the researcher to establish differences in degree through a fuzzy membership score (Schneider and Rohlfing 2013). The membership score is usually generated by calibration, and this crucial process should be transparent, open and replicable (Ragin 2006). The fuzzy membership score of our four conditions was a four-value scheme with '0', '0.33', '0.67", and '1.0' to indicate 'fully out,' 'more out than in,' 'more in than out,' and 'fully in', respectively. Since the household involvement is more complicated, the fuzzy membership scores of household involvement employed a six-value scheme, with values of '0', '0.2', '0.4', '0.6', '0.8' and '1.0'. Similarly, the fuzzy membership outcome scores were categorized with a four-value scheme to indicate 'forest', 'sparse forest', 'developing forest or grass' and 're-farm'.

Theoretical knowledge and empirical insight were used to generate the fuzzy membership scores of each condition by using a measure. The selection of the measure followed the structural calibration procedure suggested by Basurto and Speer (2012). Each condition was explained by a measure, and each measure corresponds to a survey question (Table 3). The full dataset can be found in table B1, and details of the calibration process are summarized in table B3 in the supplementary material.

Table 3. Measure of condition.

Condition	Measure	Survey question
Household Involvement	Involvement in general planning	Were you involved in the program general plan in the village?
	Involvement in tree selection	Were you involved in the tree species selection for your own enrolled land?
	Involvement in site selection	Were you involved in the site selection for your own enrolled land?
	Satisfaction	Were you satisfied with the tree and spot selected for your SLCP enrolled land?
Property rights	Tree ownership	Do you think you own the tree under the payment?
	Tree disposition	Do you think you own the tree after the payment?
	Land ownership	Do you think you own the enrolled land?
Off-farm labor allocation	Income structure	How much is your land-related income?
		How much is your total income?
Effective monitoring	Checking standard	Do you understand the checking standard?
	Monitoring	Have you been regularly monitored by a local official?
	Inspection	Did the provincial or national official inspect your SLCP enrolled land?
Financial incentive	Recognition of attractiveness	Do you feel the payment is attractive compared to the input that is required?

5. Results

5.1. Monitoring of environmental effects

In Jingyuan, ecological planting (species that provide ecological services, compared to fruits and nuts) has been fully implemented due to longer payment, as the local government promoted. Local forest experts told us that ecological trees grow better on SLCP-enrolled land in Jingyuan, which has poor soil fertility. Inappropriate choices of tree species were made in the first few years, given the study region's low water availability and harsh winter (König et al. 2014), and replanting was conducted every year to fill the gaps left by dead trees. Thus, local governments, on behalf of the program, asked the households or hired local laborers to participate in replanting. Years later, due to many rounds of replanting, a mixed plantation of many indigenous species was established by the households. However, many households complained that the payment was greatly reduced due to the replanting.

A majority of trees on the ground are less than 3 meters tall, with low coverage (Table 4) and low density (Table 5). Most of our observation plots are at the early stage of forest development. The average self-reported tree survival rate is 65.4%, while the field-checked tree survival rate[5] is 40.46% (Table 5). Both figures are much lower than the official 85% standard, implying that there may be a serious problem with tree management. Sixteen of 59 households had delivery of a qualified 'ecological forest', and they will be entitled to annual compensation by categorizing their forest into a national public forest. Forty-three households had not achieved the expecting environmental outcome, and 9 households had reconverted their SLCP-enrolled land back to agricultural use.

5.2. Pathway to success

We assumed that the presence of household involvement, property rights, off-farm labor allocation, effective monitoring and sufficient financial incentive is relevant for environmental success.

5.2.1. Necessary conditions

For this study, we used a consistency score of 0.90 as a threshold for accepting a condition as being necessary, as suggested by Schneider and Wagemann (2010). The analysis showed that all consistency scores are below the threshold with an exception that the condition of effective monitoring (0.897683) is very close to 0.9, indicating that effective monitoring is likely the necessary condition for success.

Table 4. Coverage of 128 SLCP-enrolled 100 m^2 quadrat.

SLCP scale	Coverage ratio	Number of plots	Percentage
Forest	20%-100%	23	18%
Sparse-forest	10%-20%	16	12.5%
Developing-forest	5%-10%	27	21.1%
Grassland	0–5	49	38.3%
Re-farm	0	13	10.2%

Table 5. Descriptive statistics of tree number and survival rate of 128 SLCP-enrolled 100 m^2 quadrat.

	Number of trees	Survival rate
Mean	13.75	40.46%
Standard Deviation	10.27	0.26
Minimum	0	0
Maximum	78	1
Count	128	128

5.2.2. Sufficient conditions

By performing a sufficiency analysis, we sought to determine which individual conditions or combination of conditions would be sufficient for achieving the outcome. All 59 cases were used to build the crisp-set truth table, with 24 rows (figure C4 in the supplementary material). The outcome value of each row was determined. We found a clear gap between the outcome consistencies of 0.82 and 0.79 (marked as red in figure C4); therefore, we used the natural break of 0.8 as the threshold. QCA is a case-oriented method and is very sensitive to case. To avoid over-interpretation, we set the frequency at 2. Thus, five rows were considered successful and 19 rows unsuccessful (figure C4). We identified two solution terms for sufficient conditions for success (Table 6). The verification of the QCA solutions for inconsistencies and noncoverage can be found in A3 in the supplementary material.

Accordingly, the results of our sufficiency analysis are graphically displayed through an XY plot (Figure 3) that can be used to visualize how consistent a given combination of conditions is with the statement of being a sufficient condition. The axes show the fuzzy-set membership scores of the cases in the set of condition X and the outcome Y. For sufficiency, each case's fuzzy-set membership score in X must be equal to or less than its fuzzy-set membership in Y. In other words, almost all cases falling above the main diagonal would indicate a sufficient relation. In this figure, most cases are above or on the bisecting line.

5.3 Pathway to failure

Similar to our analysis of environmental success, we assumed that the absence of household involvement, property rights, effective monitoring or financial incentive is relevant for environmental failure. However, the effect of off-farm labor allocation is not clear in the literature. Therefore, we retained both on-farm labor allocation and off-farm labor allocation in the assumption. The condition code was marked with a tilde (~), indicating the status of absent.

Table 6. Sufficient conditions for success: complex solution.

Term	Solution	Raw coverage	Unique coverage	Consistency	Covered household number
1	invo*moni*fina	0.708494	0.411583	0.851113	3, 4, 8, 13, 15, 19, 23, 24,29, 33, 35, 39, 43, 44, 52, 55, 56, 57
2	invo*moni*prop*off	0.335135	0.038224	0.843538	4, 8, 16, 17, 39, 52

Model: out = f(part, prop, off, moni, fina)
Solution coverage: 0.746718, Solution consistency: 0.823329
Frequency cutoff: 2.000000, Consistency cutoff: 0.824345

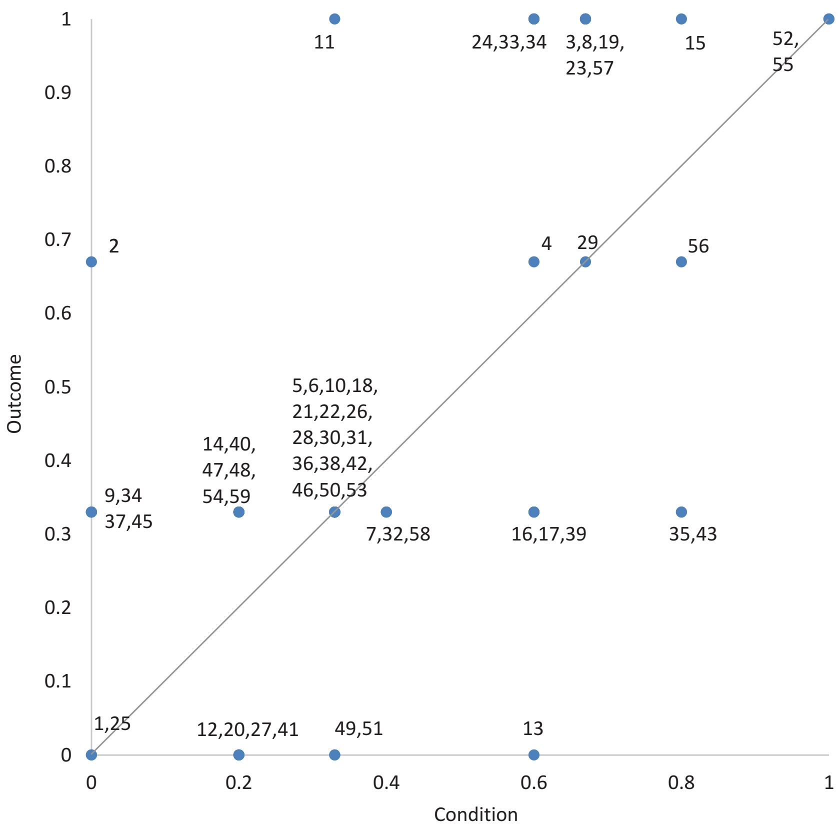

Figure 3. XY plot of solution for sufficient condition invo*moni*fina + invo*moni*prop*off.

5.3.1. *Necessary conditions*

The analysis of necessary conditions of environmental failure indicated that none of the five conditions was necessary for the outcome.

5.3.2. *Sufficient conditions*

We use the intermediate solution as a result because it balances parsimony and complexity via the injection of additional theoretical knowledge into the analysis. Again, we set 0.8 as the threshold according to the natural break (marked as red in figure C5 in the supplementary material) and set the frequency at 2. Thus, we identified three solution terms for sufficient conditions for failure (Table 7). The verification of the QCA solutions for inconsistencies and noncoverage can be found in A4 in the supplementary material.

6. Discussion

6.1 *Conditions for environmental effectiveness*

According to the necessary condition analysis, consistency of effective monitoring is very close to the threshold, indicating that monitoring is practically the only necessary condition for an environmental success at the household level. The results of our sufficient condition analysis indicate that the combination of certain conditions rather than a single condition alone is crucial for environmental effectiveness. The results reveal one main path and one complementary path, which include both socioeconomic and institutional conditions. The two different paths can independently lead to environmental effectiveness (multiple conjunctural causation).

Each path contains the combination of household involvement and effective monitoring, illuminating them as a fundamental combination. This combination can create platforms for negotiation and capacity-building between stakeholders. Both social systems and ecosystems are nonstatic, and the governmental PES needs to cope with abrupt change. Specifically, a reforestation program such as the SLCP requires closely cooperating stakeholders who deal with general planning, location and tree species selection, and problem solving. The initiation of SLCP includes choosing saplings, planting at the right time, digging a good-sized

Table 7. Sufficient condition intermediate solution. Assumptions: ~fina (absent) ~moni (absent) ~prop (absent) ~part (absent).

Term	Solution	Raw coverage	Unique coverage	Consistency	Covered household number
1	~off*~invo	0.511783	0.172508	0.870504	6,12,20,21,26,27,28,32,37,38,41,45,47,48,49,51,53,54,58
2	~prop*~invo	0.434441	0.048640	0.892613	5,6,7,14,26,27,28,37,40,41,49,51,59
3	fina*~moni*~prop	0.322054	0.073112	0.889816	5,6,9,28,36,37,41,46,50,59

Model: out = f(~part, ~ prop, ~ off, ~ moni, ~ fina)
Solution coverage: 0.680061, Solution consistency: 0.873836
Frequency cutoff: 2.000000, Consistency cutoff: 0.816568

hole and keeping the soil moist. Failure of any of these factors can lead to extensive tree death, poor growth, or a decline after planting. The fundamental combination urges the households to manage their saplings at an early stage, establishing a strong resistance to later environmental challenges such as open livestock grazing, drought, cold and rodent damage. For example, 2007 saw the coldest winter in Jingyuan in the last decade, and massive damage to trees occurred. Therefore, long-lasting household involvement and effective monitoring are needed for both initiation and follow-up replanting. Our results confirm the hypothesis that PES schemes that are serious about involvement and monitoring will also tend to perform better with respect to their environmental outcomes (Ezzine-de-Blas et al. 2016). Nevertheless, environmental success can only be expected from the occurrence of a fundamental combination with either 1) a financial incentive or 2) both property rights and off-farm labor allocation.

6.1.1. Path 1: the combination of household involvement, effective monitoring and financial incentives

Due to the high coverage (14 of 16 successful households), path 1 is the main path to environmental success. It shows that the fundamental combination has to be consistent with financial incentives. As primary incentive, payment is important for the properly initiated households to maintain their efforts. In contrast, payment to those who failed to pass the checking standard can be largely deducted and use to contribute to replanting costs. This path can focus the households' incentive away from one-time behavior and towards long-lasting efforts by creating a positive feedback loop.

Notably, clear property rights and off-farm labor allocation are missing in the combination, which has challenged many studies (Uchida et al. 2009; Tu et al. 2011) by showing that clear property rights and off-farm labor allocation are irrelevant for the main path to environmental success. In Jingyuan County, local employment opportunities are limited and unstable. Most off-farm employment is physical work in the construction and service sector. This kind of employment often has no contract and is excluded from the social security system. The households covered by this path showed varied recognition of property rights. Only 3 of 14 successful households could explicitly recognize a property right. Therefore, we argue that the instability of off-farm work in poor areas and the vagueness of property rights in rural villages may undermine the two important conditions for environmental effectiveness.

6.1.2. Path 2: the combination of household involvement, effective monitoring, clear property rights and off-farm labor allocation

The second path shows that environmental effectiveness can also be expected in the presence of a fundamental combination together with clear property rights and off-farm labor allocation. Complementary to the main path, this path describes how to reach environmental success for a special group of off-farm households. Although a majority of the income came from off-farm employment and their dependency on the land was increasingly weak, the three successful households covered by path 2 (household numbers 4, 8, and 52) hold strong concerns about the risk of unemployment. Therefore, they wanted to strengthen their ownership of the trees and the land as a safeguard.

The financial incentive is not a component of the path for off-farm households, although three successful households had two '0.67' and one '1' in the value scheme of the financial incentive. Due to the inconsistent cases (household numbers 16, 17, and 39), the logic minimization procedure treated financial incentive as an irrelevant condition. While the payment was important at the early initiation stage, three successful households told us that this importance was increasingly weak as time passed. As off-farm employment has recently dominated total income, the payment of SLCP was only viewed as 'icing on the cake'. Therefore, we argue that it is not necessary to add a financial incentive to the combination.

6.2 Conditions for the failure of environmental effectiveness

Similar to the conditions for environmental effectiveness, failure can occur from a combination of certain conditions rather than single conditions alone. Additionally, asymmetrical causation was also observed. Conversely, the presence of certain conditions linking with environmental effectiveness does not imply that their absence links with failure.

In the absence of certain conditions, the SLCP may become either business as usual or a form of welfare entitlement. In particular, household noninvolvement occurred in paths 1 and 2, showing that when program implementation was informed rather than discussed with households, their environmental effectiveness may be harmed at the household level. As Bennett (2008) found, incomplete involvement may place some households in an unfair situation in terms of resource distribution. Indeed, some households complained that the saplings they received were bad quality compared with those households who kept a close relationship with local forest officials. Corresponding to section 6.1, household involvement plays a large role in determining both success and failure of environmental effectiveness.

A negative effect of off-farm labor allocation was not found in any of the three paths, which challenges the argument that off-farm labor allocation may endanger tree management due to time conflict or geographic mismatch between city-based off-farm employment and village-based forests (Bennett et al. 2011; Li et al. 2017). In Jingyuan County, most off-farm laborers commute between the construction sites and the villages by motorcycle. The short distance does not place the on-farm and off-farm work in contradiction. Thus, off-farm labor allocation may not play a role in the failure of environmental effectiveness.

6.2.1. Path 1: the combination of household noninvolvement and on-farm labor allocation

Households covered by this path have continued their dependence on farming and lost the chance to diversify their income. Many scholars assumed that it is more likely that the on-farm labor allocating households and relatively poor households will reconvert some of the SLCP forest back to farming when the program ends (Grosjean and Kontoleon 2009). The households covered by this path confirmed this assumption; five households had already reconverted some of the SLCP forest back to sapling nursery or forage (alfalfa) planting. Our results reflect the assumption of Barbier (2010) of a 'poverty-environment trap' in developing countries, where the relationship between poverty and natural resource degradation is affected by the people's access to outside employment. Households covered by this path may be resistant to both sapling initiation and repeated replanting because they distrust the implementation process and they simply need the land for agricultural use. Therefore, we argue that an environmental failure can be expected in the presence of household noninvolvement and on-farm labor allocation, where distrust, initiation failure, poor replanting and farm dependency are all mutually reinforcing.

6.2.2. Path 2: the combination of poor property rights and household noninvolvement

The combination of household noninvolvement and poor property rights can also lead to failure. While half of the covered households of the second path overlapped with the first path due to the presence of household noninvolvement, it is interesting to notice the appearance of poor property rights. To date, forest tenure reform allocated forestland to households but caused more ambiguity about forest ownership (He et al. 2014). Households covered by this path have doubts about their property rights and hardly consider the enrolled land their property, discouraging them from managing the forest appropriately in the long term. Similarly, in Vietnam (Kolinjivadi and Sunderland 2012), Cambodia (Clements et al. 2010), and Indonesia (Fauzi and Anna 2013), the implementation of governmental PES has been challenged by the lack of well-defined property rights, raising a question about the suitability of PES as a suitable tool in some developing countries.

6.2.3. Path 3: the combination of financial incentive, weak monitoring and poor property rights

This path may be viewed by households as a form of welfare entitlement or a profitable cheating strategy. Particularly when the payment is attractive, monitoring is not in place and property rights are not clear, households consider the SLCP compensation instead of conditional payment. Our results are supported by the study of Ezzine-de-Blas et al. (2016), who found that governmental PES schemes that are perceived to be ill-monitored will often eventually lead to widespread noncompliance.

The trade-off effect of financial incentives is worth mentioning, since it is a component of a successful path and a failed path. It may be considered an inconsistency by the regression analysis, but it is absolutely normal in the QCA analysis. The multiple conjunctural causation of QCA allows one condition to have different impacts on the outcome, depending on its combination with other conditions. Therefore, when combining with different conditions, financial incentives can trigger not only success but also failure.

6.3 Policy implications

Our study could be a reference to improve the governmental PES programs. Governmental PES has great potential to create significant economies of scale and cost efficiencies when compared to other types of PES (Engel et al. 2008). However, the tremendous investment from the state does not necessarily guarantee the expected environmental outcome. Attention should be given to understanding the combined effect of conditions on PES program goals. Several studies have presented certain design features and synthesized some common conditions for PES (Sattler and Matzdorf 2013). However, most existing studies consider the various conditions individually and independently.

Notably, Meyer et al. (2015) first showed that combinations of certain design rules influenced the success of a governmental payment scheme in Germany. Similarly, our SLCP study shows that the combination effect of certain conditions rather than single conditions alone should be considered. In particular, for a successful reforestation program, household involvement, effective monitoring and financial incentives should be present in a combination. While reforestation requires continuous management with a trustable reward system, this combination can foster a positive feedback loop by building long-lasting cooperation between households and government. The present of both socioeconomic and institutional conditions shows that interaction of socioeconomic and institutional conditions may have a direct impact on the environmental outcome. However, the interactions discussed in this paper are by no means an exhaustive description of the complex set of interrelationships between socioeconomic, institutional and environmental dimensions. We therefore call for more attention to combination effects when designing a PES scheme.

Our study provided new empirical evidence that is relevant for SLCP policymakers. First, our field observation was in agreement with the claim that environmental effectiveness decreased to thresholds below those stipulated for payment. Second, the effect of labor allocation is clear in our results. On the one hand, off-farm labor allocation is the key component of the complementary path to success. On the other hand, households who continued their dependence on farming may be trapped in poverty. Third, the income structure change does not make those off-farm households relax their property right claims to their SLCP land and trees. Therefore, the strength of property rights is needed in future policies, especially for those off-farm households who successfully developed the trees. In late 2016, the central government decided to terminate the payment (State Forest Administration 2016). From 2017 onward, the successfully established 'ecological forest' could be categorized as a national public forest, which is entitled to annual compensation. The successfully established 'economic forest' can be developed with the under-forest economy (agroforestry) and even allowed to be cut down if permitted by a local authority (State Forest Administration 2016). However, the termination did not offer a solution to those households who failed to meet the evaluation standard. Therefore, timely policies should be made to address these 'excluded' households by guiding them from previously failed paths to successful paths. In particular, the combination effect of household involvement and governmental monitoring can help households break down institutional constraints.

6.4 Methodological discussion

The Braun-Blanquet method was used to evaluate the canopy coverage of SLCP-enrolled plots as an indicator of environmental outcomes. Similar to other ecological study methods for vegetation analysis, the result depends on the time of the field visit. For instance, deciduous trees may have different coverage in different seasons. Moreover, the difference in tree species can influence the result. For example, broadleaf trees (e.g. black locust and Elm) in general have larger coverage than do coniferous trees (e.g. dahurian larch and pine). In our study region, both broadleaf trees and coniferous trees were mixed planted, and trees were qualitatively different due to different planting times. Therefore, we consider that the Braun-Blanquet method is a better tool to compare survival rates.

Our results confirm that QCA has the advantage in the identification of necessary and sufficient conditions and multiple conjunctural causation. However, disadvantages of QCA, including reduced case numbers, limited causal conditions (Rihoux and Lobe 2009), subjective condition selection and imperfect calibration (Basurto and Speer 2012), have also been observed. Similar to other case-oriented studies, fsQCA faces the same challenge that only a limited number of cases and conditions can be considered if one wants to draw valid inferences. High numbers of conditions might be dysfunctional for QCA, just as in garbage can statistical models, where too many independent variables 'destroy' the results (Schneider and Wagemann 2010). As is always true in QCA, the number of cases is equal to 2^k, where K is the number of conditions included in the study. Our number of cases is 59, and our number of conditions is 5, which are suitable for the QCA application. Moreover, the selection of conditions has a strong impact on the research result; therefore, strong arguments are required to avoid subjectivity (Sehring et al, 2013). In our SLCP study, the conditions were selected and defined based on theoretical knowledge and an extensive participatory process. However, several important conditions (e.g. trust and norm) were excluded from our final five conditions. Authors must constantly justify their choices and make them transparent (Table B1). As a key part of fsQCA, calibration is essential to the reliability and replicability of the result. Therefore, it needs to be done carefully and documented clearly and in detail. We kept the selection and calibration of conditions transparent (Table B3) and open to criticism. We thus believe that this openness has helped to balance the subjectivity inevitably involved in any qualitative research.

As a 'middle road' between quantitative and qualitative strategies (Rihoux 2003), QCA may go beyond them by making systematic comparisons while still taking into account the single case (Meyer et al. 2018). Despite being a well-established tool for policy research, the application of QCA in the field of environmental governance is rare. As the potentials and limits of QCA were reflected by our SLCP study case, the added value of QCA as an alternative or complementary method to conventional research approaches might be discovered. The advantages of QCA may be especially relevant in terms of research on PES, which requires a better integration of relations between institutional, socioeconomic and environmental issues (Meyer et al. 2018).

7. Conclusions

In this study, we examined two major aspects. First, the paths of socioeconomic and institutional conditions to environmental effectiveness of the SLCP at the household level were revealed. Specifically, the linkage between two interrelated datasets of socioeconomic and institutional conditions and field-observed environmental outcomes were directly explored. Second, our study is the pioneering work to use fsQCA in environmental governance research for PES, and the added value of QCA might be discovered. By correctly reflecting its potentials and limits through empirical application, we call for a more serious reflection on the added value of QCA as an alternative or complementary method to conventional research approaches.

Our field observation data from 128 SLCP-enrolled plots are arguably one of the few datasets thus far available for SLCP field-observed evaluation. We show that 16 of 59 households had successfully implemented the SLCP and that 9 households had reconverted their SLCP-enrolled land back to agricultural use. The success and failure in terms of environmental effectiveness can be expected based on the combination of certain conditions rather than single conditions alone. Our results revealed one main path and one complementary path, either of which can independently lead to environmental success. As replanting was annually conducted to replace the dead trees in some areas, long-lasting incentives in situations with effective monitoring appear to be critical for the environmental outcome. The pathways to failure in environmental effectiveness were more complicated. The first and second paths were considered business as usual, and the third path was viewed as a form of welfare entitlement or a profitable cheating strategy. We found that financial incentives have a trade-off effect, as they can not only create a positive interaction but also trigger failure in situations with different conditions.

Notes

1. At the household level, environmental effects were measured by the tree survival rate (counting the trunks 3–5 years after the saplings are planted), tree species and canopy coverage. At the regional and national levels, environmental effects were measured by the increase in forest area and forest cover.
2. Necessary and sufficient conditions refer to QCA terminology; please see section 3.3 and Table B2.
3. The outcome and the negation of the outcome should always be analyzed in two separate QCA analyses.
4. In the early 1980s, through forest tenure reform, most collective forests in rural China came under the management of individual households.
5. We checked the survival rate according to the official standard, which uses number of survived trees divided by number of planted seeds or seeding (666.67 m^2 = 220 seeds/seeding) after a 3 to 5-year period from time of planting. The first planting was in 2000, but the re-planting was annually repeated until 2013. The survival rate was measured in 2015, which is three years after the latest re-planting and close to the end of the program.

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