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China's Sloping Land Conversion Program

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How socioeconomic and institutional conditions at the household level shape the environmental effectiveness of governmental PES: China's Sloping Land Conversion 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 ongoing land degradation by converting crop land on steep slopes into forests. Operating through an incentive-based approach, the SLCP involved 32 million rural households as the core agents for program implementation. In this paper, we aim to fill a research gap regarding the condition for environmental effectiveness at the household level. In particular, we analyzed how institutional and socio-economic conditions influence rural households to reach the primary environmental goals. Based on a broad literature review, we analyzed relevant conditions based on 59 interviews with SLCP participants at the household level to combine these data with field-observed evaluation of the environmental effects on enrolled plots. Using fuzzy-set Qualitative Comparative Analysis (fsQCA), our results show that the pathway to environmental success or failure at the household level has been shaped by local institutional and socio-economic conditions in a combinatory manner. As the key components of successful pathways, the combination of household involvement and effective monitoring plays a fundamental role. However, in the absence of certain conditions, the environmental effectiveness of SLCP may be in

danger. Based on our result, we discuss the potentials and shortcomings of using short-term governmental PES to realize long-term environmental effects.

Key words: Payments for Ecosystem Services (PES); SLCP; Financial incentive instruments; Qualitative comparative analysis (QCA); Reforestation; Ecological restoration

1. Introduction

Payment for Ecosystem Services (PES) is a popular approach to address environmental degradation in recent years (Muradian, Arsel et al. 2013). The principle of PES is to use an economic incentive to motivate voluntary local actors to protect and restore valuable ecosystem services (Engel, Pagiola et al. 2008). As PES is not a panacea, how to make PES the right tool has attracted considerable attentions. Notably, by summarizing 70 PES programs worldwide, Wunder (Wunder, Brouwer et al. 2018) argues that four theoretical preconditions and three desirable design features should enable PES in achieving success. However, by doing a review of PES design features, Engel (Engel 2016) claimed that the evidence on effectiveness of PES is still scarce and rather mixed.

Compared to the market-based PES, governmental PES is considered a type of hybrid PES program (Vatn 2010, Kolinjivadi and Sunderland 2012, Chen, König et al. 2015) where the government sets the rules, acts as the buyer and implements the scheme (Muradian and Rival 2012, Matzdorf, Sattler et al. 2013). Many governmental conservation programs in developed and developing countries are grouped under the governmental PES label, from Costa Rica, Mexico, the EU member states, the US and China (Schomers and Matzdorf 2013). While the government and its agencies lead in the design and implementation of the program, the effectiveness of the program are determined by the fitting of the local institutional and socio-economic setting and governance structures (Vatn 2010, Muradian and Rival 2012). The

In the past two decades, the Chinese government has launched a series of ecological restoration programs to restore degraded ecosystem services (ES) (Yin, Yin et al. 2010). Among these programs, the Sloping Land Conversion Program (SLCP), also known as the Grain for Green Program, was initiated in 1999. 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). SLCP is considered one of the largest PES programs in the world due to its broad geographic cover, wide participation and tremendous investment (Zhen and Zhang 2011, Liu and Yang 2013). With an explicit emphasis on voluntary participation and local autonomy in the policy's design, SLCP directly engaged over 32 million households as the core agents of program implementation (State Forest Administration 2007). Embracing innovative PES elements, however, similar to other governmental schemes, 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 as to whether the SLCP is an institutional innovation or just “business as usual” (Bennett 2008).

Households, as the land-users and key stakeholders, have significant importance in the implementation of SLCP (Liang, Li et al. 2012, Li, Bennett et al. 2017). They received payments in grain or cash for a maximum of 8 years for converting cropland on steep slopes to forest or grassland (The State Council 2002). The period of payment differed by the type of conversion, including “economic forest” (economic species, e.g., fruits and nuts), “ecological forest” (species that provide ecological services) or grassland (The State Council 2002). In 2005, the State Council extended the program period for another round but halved the payment (The State Council 2007). However, in late 2016, the central government decided to terminate the payment (State Forest Administration 2016), despite the call for extension by provincial governments and the scientific community. 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).

The large reforestation efforts at the regional and country level have been widely praised (Liu and Diamond 2005, Zhou, Van Rompaey et al. 2009, Lü, Fu et al. 2012). However, the environmental effectiveness at household level is a mixed result. The indicators in the official evaluation¹ are the tree survival rate, tree species and canopy coverage. By visiting the enrolled spot in the field, evaluators used these indicators to determine the payment and evaluate the program’s success (The State Council 2002). While governmental evaluation showed success in extensively regions, many studies casts doubt upon the accuracy and reliability (Bennett 2008, Trac, Schmidt et al. 2013, He and Sikor 2015). However, due to the difficulty of field-based data collection, the criticisms of environmental effectiveness of SLCP are primarily based on household self-reported information, governmental inspection result or small-scale ground observation (Bennett 2008, Cao 2008, Cao, Chen et al. 2011, Bennett, Xie et al. 2014), which can not offer a direct and detailed evidence.

Various institutional and socio-economic conditions, including household attitude (Cao, Xu et al. 2009), trust (Tu, Mol et al. 2011), household participation (Bennett 2008), household livelihood improvement (Liang, Li et al. 2012), property rights clarification (Bennett, Mehta et al. 2011), off-farm labor allocation (Uchida, Xu et al. 2005), regular monitoring (Yin and Yin 2010), local institutional

¹ While the second goal of SLCP is poverty alleviation and rural development, the official evaluation is mainly based on environmental effects. In household level, the 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. In regional and national level, the environmental effects were measured by the increasing of forest area and forest cover.

interaction (Yin and Yin 2010) and local economic development (Yin, Zhao et al. 2014) were considered as important factors for program implementation. At the household level, the program's impacts on livelihood change and off-farm labor allocation were intensively discussed and debated (Uchida, Xu et al. 2007, Uchida, Rozelle et al. 2009, Gauvin, Uchida et al. 2010). However, most studies aim to improve the program design, implementation, cost-effectiveness and long term sustainability. The dependency of primary environmental goal on institutional and socio-economic conditions at household level was rarely explored.

Understanding how institutional and socio-economic conditions shape the households to achieve the program's environmental effectiveness is essential for ensuring the provision of targeted forest ecosystem services and for improving the governmental PES. To date, there is no study directly addressing the link between institutional and socio-economic conditions and field-observed environmental effects. In order to fill this research gap, the objective of our paper is to analyze the relation of relevant institutional and socio-economic conditions and environmental effectiveness at household level². In order to understand why success happens in some sites while failure happens in others, we want to target the following research questions:

- What are necessary and sufficient³ institutional and socioeconomic conditions for the success in terms of environmental effectiveness at the household level?
- What are necessary and sufficient institutional and socioeconomic conditions for the failure in terms of environmental effectiveness at the household level?

2. Analytic framework

2.1 Overview

Our analytic framework is structured to answer our research questions by using a combination of methods (Figure 1). Following the selection of case and conditions, we collected data on conditions by household interview and data on outcomes by field observation. After careful 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. Finally, based on our results, we provided policy design recommendations for SLCP and for governmental PES programs in general.

² We acknowledge that the environmental effectiveness and environmental effects at household level refer to the quantity and quality forest in SLCP enrolled plot.

³ Necessary and sufficient conditions refer to QCA terminology, please see section 3.3 and Table A2

Figure 1 Analytical framework

2.2 literature study and experts interview

The literature study was started with institutional, socioeconomic and environmental aspects that are generally assumed to be important within the SLCP literature. The review conducted by Chen et al. (Chen, König et al. 2015) in 2015 includes 164 international scientific articles and additional literatures were updated in 2017. The literature study, on one hand, offers us a broader view about various institutional and socio-economic conditions (as mentioned in introduction) which could be relevant to the program's goal. On the other hand, some conditions which are particularly important at household level were identified. Because our study is based on local context, we interviewed local experts in Guyuan Region in the Ningxia Hui Autonomous Region during our first field trip in 2014 to verify and confirm our assumptions. A total of 34 interviews were completed, including 10 forest officials from province, prefecture, county and township level as well as 6 village head (current and previous) and 18 villagers.

2.3 The 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. It is defined as the national key ecological function zone and is one of the most undeveloped areas in China (Yang, Williams et al. 2010).

Shengli village and Miaowan village were purposely selected because both villages implemented two rounds of the SLCP with significant tree plantations and the extensive involvement of the local households since 2000. According to the local government, the implementation of the SLCP helped the local household, which traditionally depends on farming, to change their livelihood to off-farm employment. Therefore, to answer our research question, individual households in both villages were selected as our study cases and their environmental effectiveness in SLCP enrolled land were defined as the outcome.

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

Another reason for us to select these two villages from one small county is because that households are under very similar environmental setting. In general, environmental conditions (e.g., soil, precipitation, temperature) are important determinants of the environmental outcomes. Of course,

to individual parcel, the micro environmental conditions are different. However, land in the two villages is categorized into three classes according to environmental criteria (e.g., slop, soil and access to water) and biophysical conditions (e.g., distance to home and parcel size). To make the overall quality of each household nearly equal, each household normally has 3-6 parcels which include all the three classes. Due to the targeting strategy, SLCP enrolled parcel are mostly the worst class with worst environmental and biophysical condition. So by selecting the two villages, we consider our sample has been naturally controlled for environmental aspect. This assumption was also confirmed by the local forest experts during our first field trip in 2014. The local expert told us that it is very often to see two neighboring parcels with totally different results. We therefore believe that environmental conditions may only play a limited role in determining environmental effects.

2.4 The selection of relevant conditions

In line with the PES theory and international experiences, the success of SLCP depends on a variety of conditions. We assumed that some key conditions are relevant for program's environmental success. We selected and defined the conditions based on the literature (Chen, König et al. 2015) and local experts interview. The final conditions are as follows: 1) household involvement, 2) property rights, 3) off-farm labor allocation, 4) effective monitoring and 5) sufficient financial incentive. We defined these five conditions according to the PES theory and SLCP literature. Nevertheless, the measure of the condition is based on the local context, as we want to address the the relations at household level.

Household involvement

According to PES theory, engaging voluntary participants as the core agent for PES implementation is critical to program success (Wunder 2005). Studies also showed that permitting households the right to determine some dimensions of their participation in the program is conducive to program success (Bennett, Mehta et al. 2011). SLCP claimed to be decentralized, and voluntary households should be free to choose their site to retire and choose the 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, Bennett et al. 2017). When a region is targeted by the governmental general plan, individual households can hardly decide on the enrollment decision (Démurger and Pelletier 2015). Therefore, we viewed the participation by using the broader term of involvement. By our definition, household involvement included being part of the general planning, site selection and tree species selection, as well as the satisfaction of the decision results.

Property rights

Clearly defined property rights is a well-accepted precondition for PES design (Wunder 2015). Theoretically, the PES mechanism draws on Coasian principles (Coase 1960), which link well-defined

property rights and low transaction costs. Demsetz (Demsetz 1967) noted that different patterns of property rights could lead to different patterns of behavior, and Tu et al. (Tu, Mol et al. 2011) found that property rights are generally considered to influence household behavior regarding resource use and environmental management. Moreover, secure property rights play 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 rights⁴ (Uchida, Xu et al. 2005). Since we are interested in incentive of households to provide environmental effects, the measure of property right focuses on household perception about trees and land rather than the legal property status.

Off-farm labor allocation

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

Effective monitoring

Effective monitoring is a precondition for PES because it ensures that participants actually comply with their contracts by undertaking the specified land uses (Wunder 2005). Effective and lasting monitoring, particularly internal monitoring and enforcement, has been understood as a major component of SLCP implementation (Yin, Liu et al. 2013). While monitoring was widely accepted as the core of PES design, how to implement monitoring in a cost-effective way remains unclear (Ezzine-de-Blas, Wunder et al. 2016). Monitoring is a very subjective issue and the measure of effective

⁴ In China, land is owned by the state or by collectives. In the early 1980s, with the initiation of the household responsibility system, land tenure reform was started in the agricultural sector by allocating use rights of the collective land to individual households for periods up to 70 years. Similarly, through forest tenure reform, most collective forests in rural China had come under the management of individual households.

monitoring is difficult. So our measure focuses on the effect of monitoring on households' awareness and the checking pressure brought by monitoring officials.

Financial incentives

PES relies on financial incentives to induce behavioral changes in local actors to provide ES (Engel, Pagiola et al. 2008). For SLCP households, behavioral changes are highly conditional on the governmental payment. Economists viewed the financial incentive based on the opportunity costs (Uchida, Xu et al. 2005). However, it is important to consider household resources when analyzing real behavioral changes (Komarek, Shi et al. 2014). Furthermore, financial incentive is very subjective to individual households, and the payment amount varied according to the enrolled land size and environmental outcome. Therefore, we define the financial incentive based on the household's recognition of the financial attractiveness. However, the financial attractiveness is subjective and depends on certain context. Thus, we use the overall input that required by SLCP to compare with payment. The inputs includes lost of farmland, annual re-plantation responsibility and obligation to be monitored.

Table 1 The definition of five conditions

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

3. Methodology

3.1 Data collection - institutional and socio-economic conditions

Data collection was made by our second field trips in 2015. Thirty households in Shengli village and 29 households in Miaowan village were sampled. Apart from basic household characteristics, the interview focused on the householder's perception, livelihood, involvement in decision-making, sense of land security, trust in local institutions and post-SLCP decision. In addition, interviews with the village head and local forest officials helped to identify the overall achievements of the SLCP as well as the difficulties that they encountered in the local implementation process.

The subjective impact from interview, such as strategic answer, influence of the interviewer and misinterpretation, was seriously considered and carefully addressed. The interview was conducted face-to-face by a team led by the first author. This team has worked in Jingyuan County, and particularly in the two case study villages, since 2014. The team has three PhD students from a research group in Institute of Geographic Sciences and Natural Resources Research (IGSNRR), Chinese Academy of Sciences, which has long history in cooperation in this region. All team members are well-trained with relevant conditions and corresponding measures. The existing mutual trust with local villagers enable the interview to be conducted with minimum communication difficulty.

3.2 Data collection - measurement of environmental effects

The existing studies mostly used second-hand data such as household self-reports (Bennett 2008, Cao, Chen et al. 2009, Bennett, Xie et al. 2014) or local governmental reports (He, Lang et al. 2014) to reflect the local 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 the environmental effectiveness at 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).

The field work was very challenging. Except walking, there is no transportation option in the remote mountain region. Furthermore, the scattered land distribution created more difficulty for each site visiting. Nevertheless, we collected field observed data from 128 SLCP-enrolled plots (Figure A1 and A2) owned by our 59 interviewed households. Each household was measured by a minimum of two different located plots because household land holdings are fragmented. We randomly placed a 100 m² quadrat within the plot and collected data, including species diversity, species number, tree height and coverage, 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", "spare forest", "developing forest or grass" and "re-farm" (Figure A3). We acknowledge that we are not seeking to precisely quantify the value of ES but make an estimation of the relative

abundance of forest for further outcome comparison. 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 outcome.

As our study case is individual household, the field observation data from 128 SLCP-enrolled plots need to be aggregated into 59 households. When the plots have the same results with one household (45 out of 59), it can be easily unified. When the plots have different results, a participatory process with the village head was carried to make a decision based on the overall performance in local inspection. In line with the standard of local evaluation, any of the spot has been observed for re-farm, the outcome of the household is labeled as re-farm (9 out of 59).

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	Spare 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

3.3 Data analysis by Qualitative Comparative Analysis

To compare the 59 cases (households), we employed Qualitative Comparative Analysis (QCA) to determine the different pathways to environmental success and failure among varied condition arrangements. As a case study method and a set-theoretic method (Ragin 2008), QCA is considered as an appropriate method for our study for three following reasons:

Firstly, QCA is particularly powerful to analyzing multiple conjunctural causation (Rihoux and Ragin 2009). QCA is grounded in the analysis of set relations, not correlations. while statistical regression analysis treats different variable as competitive and the one with higher significance is presented as the most probable determining factor, QCA assumes that different conditions are complementary and often interdependent. As a result, the identified causal relation is usually not one condition but a combination of given and absent conditions. In QCA terminology, 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 (Rihoux 2009).

Secondly, QCA offers a strong support for the institutional analysis. Traditionally, to capture the complexity and detail among different institutional settings, institutional analysis relies on the

qualitative information from theoretical knowledge and empirical in-depth understanding. QCA inherited this advantage from qualitative method and in the same time strengthen it by offering the generalization (Rihoux and Ragin 2009). From an institutional perspective, QCA enable us to work with the qualitative and detailed information from interviews with local experts and 59 households.

Thirdly, QCA can be usefully applied to research designs involving small and intermediate-size N. In the range between 5-100, there are often too many cases for qualitative case research to keep all the case knowledge but too few cases for most statistical analysis (Rihoux and Ragin 2009). Our case number is 59. To further increase the N was very difficult because both household interview and field observation were very time-consuming. Therefore, QCA appears to be a suitable option for our size of N.

Hypotheses within QCA are implication hypotheses of the notions of necessity and sufficiency (Ragin 2008). A condition is necessary, if always when the outcome is present, the condition is also present. A condition can be interpreted as sufficient, if always when 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). It 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. Without any 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, which 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 the inconsistency, 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 is not intending to compare the methods, readers can find detailed discussion in the work of Seawright (Seawright 2005), Grofman and Schneider (Grofman and Schneider 2009) and Vis (Vis 2012). We acknowledged that this terminology is only briefly introduced in this section of this paper. Ragin (Ragin 2008, Ragin 2014) and Schneider and Wagemann (Schneider and Wagemann 2010, Schneider and Wagemann 2012) provide handbooks, user's guides, explanation and standards of good practice regarding this terminology. Nevertheless, in order to facilitate the understanding of the result and discussion, we summarized the basic terminology in Table A2.

3.4 FsQCA and calibration

Crisp-set Qualitative Comparative Analysis (csQCA), as 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 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 were a six-value-scheme, with “0”, “0.2”, “0.4”, “0.6”, “0.8” and “1.0”. Similarly, the fuzzy membership scores of outcome were categorized with a four-value-scheme to indicate “forest”, “spare forest”, “developing forest or grass” and “re-farm”.

Theoretical knowledge, as well as empirical insight, was used to generate fuzzy membership scores of each condition by using measure. The selection of measure followed the structural calibration procedure suggested by Basurto and Speer (Basurto and Speer 2012). Each condition was explained by measure and each measure corresponds to a survey question (Table 3). The details of calibration are summarized in table A3.

Table 3 The 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 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 comparing to input that required?

4. Results

4.1 Effects of SLCP implementation

In Jingyuan, ecological planting has been fully implemented due to longer payment. Local forest experts told us 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, Zhen et al. 2014), and re-plantation 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 labors to participate in re-plantation. Years later, due to many rounds of re-plantation, 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 re-plantation.

The majority of trees on the ground are less than 3 meters high with low density and low coverage. Most of our observation spots are at the early stage of forest development. The dominant tree species is black locust (*Robinia pseudoacacia*), but a mixed plantation contains elm (*Carolus linnaenus*), dahurian larch (*Larix gmelinii*), plum (*Prunus armeniaca*) and eight other species.

In general, households have retired a large portion of their cropland and feel that the SLCP has improved the local environment. The income structure of many households has greatly changed by allocating their free labor to off-farm employment. However, the average self-reported tree survival rate is 65.4%, while the field-checked tree survival rate is 40.4%. Both figures are much lower than the official 85% standard, implying that there may be a serious problem with tree management. Sixteen out 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 re-converted their SLCP-enrolled land back to agricultural use. The result of the environmental outcome and five condition can be found in Figure 3 and figure 4

Figure 3 The frequency of condition in four-value-scheme

Figure 4 The frequency of condition in six-value-scheme

4.2 The analysis of success in terms of environmental effectiveness

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

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 (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.

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 (for condition combinations, figure A4). The outcome value of each row was determined. We found a clear gap between the outcome consistencies of 0.82 and 0.79; 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 found to be successful and 19 rows unsuccessful (figure A4). We identified two solution terms for sufficient conditions for success (Table 4).

Table 4 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

The first term covered 14 successful households. For this term, high levels of household involvement, effective monitoring and combining with financial incentive led to an environmental success. In general, households covered by this term felt they jointly made important decisions with the village head and local forest bureau officials. Some of them told us that the village head can stand for them and they wanted to follow the technical advice from the forest bureau officials. They paid attention to the checking standard and were often monitored. Households covered by this term received the full or nearly full payment.

The second term covered three successful households and three unsuccessful households. For this term, high levels of household involvement, effective monitoring, clear property rights and off-farm labor allocation led to the same outcome. Although all of the successful households in the second path overlapped with the first path, the second path is worth noting due to the presence of property rights and off-farm labor allocation. The three successful households covered by this path are the influential people in the village who were considered as wealthy and successful models. Unlike other villagers, they express no intent of re-farming the SLCP land but have a strong concern about property rights.

By using contradiction analysis, the first term covered four unsuccessful households (13, 35, 39 and 43). Two of them are the previous village head. The third one is the current Miaowan village head and the last one is the Akhoond (also called Imam, an Islamic leadership position who may lead Islamic

worship services, serve as community leaders, and provide religious guidance) in the village mosque. The second term covered three unsuccessful households (16, 17 and 39). The first one is the village head of Shenli village and the second one is his brother.

Accordingly, the results of our sufficiency analysis are graphically displayed through an XY plot (Figure 5) that can be used to visualize the coefficient of consistency. For a condition or a combination of conditions to be sufficient, all cases need to be located around or above the bisecting line. It is notable that in this figure, most cases are around or even on the bisecting line.

Figure 5 XY Plot of solution for sufficient condition

4.3 The analysis of failure in terms of environmental effectiveness

Similar to our analysis of environmental success, we assumed that the absence of household involvement, property rights, effective monitoring and financial incentive are 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 ~ as the status of absent.

Necessary conditions

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

Sufficient conditions

We use the intermediate solution as a result because it balances parsimony and complexity via the injection of additional theoretical knowledge in the analysis. Again, we set 0.8 as the threshold according to the natural break (figure A5) and the frequency at 2. Thus, we identified three solution terms for sufficient conditions for failure (Table 5).

Table 5 Sufficient condition intermediate solution

Assumptions: $\sim$ fina (absent) $\sim$ moni (absent) $\sim$ prop (absent) $\sim$ part (absent)					
Term	Solution	raw coverage	unique coverage	consistency	Covered household number
1	$\sim$ off* $\sim$ 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	$\sim$ prop* $\sim$ invo	0.434441	0.048640	0.892613	5,6,7,14,26,27,28,37,40,41,49,51,59
3	fina* $\sim$ moni* $\sim$ prop	0.322054	0.073112	0.889816	5,6,9,28,36,37,41,46,50,59

Model: out = f($\sim$ part, $\sim$ prop, $\sim$ off, $\sim$ moni, $\sim$ fina)

Solution coverage: 0.680061, Solution consistency: 0.873836

Frequency cutoff: 2.000000, Consistency cutoff: 0.816568

The first term of on-farm labor allocation together with household non-involvement covered 19 failed households as the main path, due to the high coverage. In general, their livelihood largely depended on farming. Their opinions were largely ignored during implementation in the early phase of the program. To date, their acceptance of the program remains low. The second term of non-property rights together with household non-involvement covered 13 failed households. Households raised doubt about their property rights and felt that the trees belong to the “nation” rather than themselves. The third term of financial incentive, poor monitoring and non-property rights covered 10 failed households. The households covered by this term felt that the compliance mechanism in the village is not reliable and talked about the need for the government to provide more financial assistance. Therefore, they only considered the payment as an unconditional compensation rather than a conditional payment. Contradiction analysis showed that none of the solutions covered successful households. However, 14 failed households were not covered by any solution, which explains the low coverage of 0.68.

5. Discussion

5.1 Success in terms of 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 indicated that the combination of certain conditions rather than a single condition alone is crucial to the success in

terms of environmental effectiveness. The result revealed one main path and one complementary path. The two different paths can independently lead to the environmental success (conjunctural causation). We make Interpretations based on our in-depth knowledge generated by household and expert interview.

Both paths contain the combination of household involvement and effective monitoring, illuminating them as fundamental combination. This combination can build platforms for negotiation and capacity-building between stakeholders. Both social systems and ecosystems are non-static and the governmental PES needs to cope with abrupt change. Particularly, a reforestation program such as SLCP requires stakeholders to closely cooperate, ranging from general planning, location targeting, tree species selecting and unsatisfied problem solving. Households need to appropriately initiate the SLCP on their enrolled land, following the steps from choosing saplings, planting at the right time, digging a good-sized 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 foundation for further growth; the older well-developed trees are more resistant to other environmental challenges. Followed by initiation, livestock open grazing is the most frequent cause of damage to the newly established saplings. Meanwhile, different environmental challenges such as drought, cold and rodent damage are common. For example, 2007 was 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 re-plantation. 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, Wunder et al. 2016). Nevertheless, the environmental success can only be expected from the occurrence of fundamental combination with either 1) a financial incentive or 2) both property rights and off-farm labor allocation.

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

Due to the high coverage (14 out of 16 successful cases), the combination of household involvement, effective monitoring and financial incentives is important to foster the main path to the environmental success. The first path shows that the combination of household involvement and effective monitoring has to be in line with financial incentives. When households received the reasonable payment, this combination could encourage them to properly conduct re-plantation and maintain long-term management. The payment of those who failed to pass the checking standard can be largely deducted for the contribution of re-plantation cost. This combination may provide a richer set of information of ecosystem dynamics and help create feedback loops for improved management.

Broadly speaking, Huber et al. (Huber, Briner et al. 2013) conceptualized the positive social-ecological interactions as the feedback from farm-based behavior, policy options and ecosystem dynamics. Local forest experts told us that, this combination is the classic model for local implementation, as all three conditions fit with the traditional command-and-control approach.

Notably, clear property right and off-farm labor allocation are missing in the combination. With contradiction to the many existing studies, this means that without the presence or absence of clear property right and off-farm labor allocation the main path can still lead to the environmental success. It is not surprised, when consider the uncertainty over the vague of property rights in rural China and instability of off-farm work. In Jingyuan County, local employment opportunities are limited. Most off-farm employment is in the construction sector and this kind of jobs is very unsure and unstable. Therefore, off-farm labor allocation may not play a decisive role for most successful households.

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

The second path shows that environmental success can also be expected in the presence of fundamental combination together with clear property rights and off-farm labor allocation. As the complementary to the main path, this path describes how to reach environmental success for the special group of off-farm household. Recognition of property rights encourages the temporary off-farm employment of rural labor. Although the majority income came from off-farm employment and their dependency on the land was increasingly weak, off-farm household wanted to strengthen their ownership of the trees and land as their safeguard in case they lost their off-farm employment or the employment became too hard once they aged. Therefore, property rights may be even more important to the off-farm household because off-farm employment is riskier than their old way of living. Our results are supported by Mullan et al. (Mullan, Grosjean et al. 2011), who found that the interplay of secure property and off-farm employment may affect the effectiveness of land conservation programs. However, our results challenge the argument that off-farm labor allocation may endanger tree management due to time conflict between off-farm employment and management of the SLCP forest (Bennett, Mehta et al. 2011, Li, Bennett et al. 2017). In our cases, most off-farm household members commute between the construction sites and their home in the village every working day and the interviewed households told us it is not problem to manage both work. It is out of our expectation to notice that financial incentive is not a component of the path for off-farm household.

5.2 Failure in terms of environmental effectiveness

Similar to the path to success, the failure of environmental effectiveness can be expected by the combination of certain conditions rather than single conditions alone. In particular, household non-

involvement is found in the first and second paths which showed that the SLCP was a business as usual rather than an institutional innovation. This corresponds to the discussion in section 5.1, confirming the determining role played by household involvement. However, the path to failure is more complicated than the path to success. Again, multiple conjunctural causation can be found in the link between institutional and socio-economic conditions and failure in terms of environmental effectiveness.

Path 1: the combination of household non-involvement and on-farm labor allocation

Path 1 showed that the implementation was informed rather than discussed and households have continued their dependence on farming for their livelihoods. Households complained about the poor choice of saplings and enrolled location. As Bennett found (Bennett 2008), incomplete involvement may place some households in an unfair situation in terms of resource distribution. In deed, some households complained that the saplings they received were bad quality comparing to those who keep close relationship with local forest officials.

Moreover, households covered by this path have lost the chance to diversify their income. Many scholars assumed that it is more likely that the on-farm labor allocating household and relatively poor households will reconvert some of SLCP forest back to farming when the program ends (Chen, Lupi et al. 2009, Grosjean and Kontoleon 2009). The households covered by this path confirmed this assumption, where five households had already reconverted some of SLCP forest back to nursery sampling or forage (Alfalfa) planting. Our results reflect the assumption of Barbier (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 re-plantation because they were not convinced by the program benefits and they simply need the land for agricultural use. We, therefore, argue that the environmental failure can be expected in the presence of household non-involvement and on-farm labor allocation, where implementation unacceptance, initiation failure, poor re-plantation and farm dependency are all mutually reinforcing.

Path 2: the combination of poor property rights and household non-involvement

The combination of household non-involvement and poor property rights can lead to failure. While half of the covered households of the second path overlap with the first path due to the presence of household non-involvement, it stands as a different path due to the appearance of poor property rights. This confirms the results of Wunder (Wunder 2013) that land tenure clarity and security among service providers is the most restrictive PES precondition. To date, forest tenure reform allocated forestland to households but caused more ambiguity about forest ownership (He, Lang et al. 2014). Households covered by this path have doubts about their property rights and hardly

consider the enrolled land as their property, discouraging them to manage the forest appropriately in the long term. In Vietnam (Kolinjivadi and Sunderland 2012), Cambodia (Clements, John 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 the correct tool in some developing countries. In particular, our results show when both property rights and household involvement are missing, the environmental outcome of PES schemes could be in danger.

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

This path may be viewed as a form of welfare entitlement or a profitable cheating strategy by households. Particularly when the payment is attractive, monitoring is not in place and property right is not clear, households consider SLCP as a compensation or subsidy instead of a payment with conditions. When local officials fail to monitor their reforestation sites and simply report success, households feel a compliance mechanism is not in place. Our results are supported by the study of Ezzine-de-Blas et al. (Ezzine-de-Blas, Wunder et al. 2016), who found that governmental PES schemes that are perceived to be ill-monitored will often eventually lead to widespread non-compliance. It is worth mentioning the trade-off effect of financial incentives since it is a component of a successful path as well as a failed path. It may be considered as inconsistency by regression analysis but it is absolutely normal in QCA analysis. The multiple conjunctural causation of QCA allows one condition can have different impacts on the outcome, depending on its combination with other condition. It shows that when combining with different conditions, financial incentives can not only trigger success but also failure. Our results show that the financial incentive can have a negative effect when it is not accompanied by property rights and effective monitoring. As Muradian et al. (Muradian, Arsel et al. 2013) warned, PES should not over-rely on payment.

5.3 Policy implications

Our study could be a reference for governmental PES programs. Governmental PES has great potential to create significant economies of scale and cost efficiency compared to other types of PES (Engel, Pagiola et al. 2008). Governmental PES can achieve environmental effectiveness and poverty reduction to some extent where there is strong and sufficient state capacity (Wunder, Engel et al. 2008). However, without the fundamental combination of household involvement and effective monitoring, the tremendous investment from the state does not necessarily guarantee the expected environmental outcome.

Attention should be paid to understanding the combination effect of conditions on PES program design. Number of studies have presented certain design features and synthesized some common conditions for PES (Sattler and Matzdorf 2013, Wunder 2015). However, most existing studies

considered conditions individually and independently with only two exceptions. In theoretical level, Wunder (Wunder, Brouwer et al. 2018) conceptualizes one precondition (ES demand values exceed ES supply costs) as PES foundation which should partly or fully combine with three supplementary preconditions or alternative design features. In empirical level, Meyer et al. (Meyer, Reutter et al. 2015) first showed that combinations of certain design rules conditioned 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 long-term reforestation programs require long-lasting management and a trustable reward system, this combination can foster a positive feedback loop by building long-lasting cooperation between households and government. We, therefore, call for more attention to combination effects when designing a PES scheme.

Our study provided new empirical evidence that can have implications for SLCP policy makers. First, our field observation was in agreement with the claim that the environmental effectiveness decreased to below those stipulated for payment. Second, the effect of labor allocation is clear in our results. On 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, it is worth noting that the income structure change does not make those off-farm households relax their property rights to their SLCP land and trees. Therefore, the strength of property rights is needed in future policy, especially for those off-farm households who successfully developed the trees. Finally, the termination of SLCP payment in 2016 did not offer a solution to those households who failed to meet the evaluation standard. Therefore, timely policies should be made to these “ignored” 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 socioeconomic and institutional constraints.

5.4 Methodological discussion

The Braun-Blanquet method was used to evaluate the canopy coverage of SLCP-enrolled spots as an indicator for 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, broad leaf trees (e.g., black locust, Elm) in general have larger coverage than coniferous trees (e.g., dahurian larch, pine). In our study region, both broad leaf 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 comparing survival rates.

Our result confirms that QCA has the advantage in the identification of necessary and sufficient conditions and multiple conjunctural causation. However, disadvantage of QCA, including reduced case numbers, limited causal conditions (Rihoux and Lobe 2009), subjective condition selection and imperfect calibration (Basurto and Speer 2012) has 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 cases and conditions may affect the result. Moreover, the selection of cases and conditions has a strong impact on the research results. Therefore, the selection must be based on careful consideration and strong arguments in order to avoid subjectivity. In our SLCP study, the conditions were selected based on theoretical knowledge and the calibration of conditions occurred through an extensive participatory process. Nevertheless, it constantly demands authors to justify their choices and make them transparent. As the 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 definition and calibration of conditions transparent and open to criticism. We thus believe that this openness has help to balance the subjectivity inevitably involved in any qualitative research.

Ragin considers QCA as a “middle road” between quantitative and qualitative strategies (Rihoux 2003). While the QCA is a well-established tool for policy research, the application of QCA in the field of environmental governance is rare. By correctly reflecting its potential and limits through empirical study, we call for more serious look for the added value of QCA as an alternative method or a complementary method to conventional approaches.

6. Conclusions

Our study made contributions in three aspects. Firstly, our field observation data from 128 SLCP-enrolled plots is arguably the only data set yet available for SLCP field-observed evaluation. We show that sixteen out of 59 households had successfully implemented the SLCP and 9 households had re-converted their SLCP-enrolled land back to agricultural use. Secondly, our study is the pioneering work to use fsQCA in PES research and the added value of QCA might be discovered. Thirdly and most importantly, link between the institutional and socio-economic conditions and field-observed environmental effectiveness was explored for SLCP in the first time.

At the household level, the success and failure in terms of environmental effectiveness can be expected by the combination of certain conditions rather than single conditions alone. Our result revealed one main path and one complementary path which can both independently lead to the environmental success. As a component of both paths, the combination of household involvement and effective monitoring has a fundamental role for SLCP initiation and follow-up re-plantation. By

jointing with financial incentive, the fundamental combination can achieve the environmental effectiveness through a positive interaction. Additionally, the environmental success can also be expected in the presence of fundamental combination together with clear property rights and off-farm labor allocation, which fits with the special group of off-farm households. The pathways to failure in terms of environmental effectiveness was more complicated. The first path and second paths were model of business as usual and the third path was a form of welfare entitlement or a profitable cheating strategy.

By using fsQCA, we concluded that governmental PES, such as SLCP, must be capable of adapting to different local conditions in a combinatory manner. In the absence of certain conditions, governmental PES may fail to achieve its environmental goal. While the existing studies assumed individual conditions or a set of conditions as policy panaceas, we call for considering the combination effect of conditions when one designs a governmental PES.

7. Acknowledgements

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Appendix

Table A1 Membership scores for conditions and outcome (Fuzzy data matrix)

Household	invo	prop	off	moni	fina	Outcome
1	0,4	0,67	0,67	0	0,67	0
2	1	0	0,33	0,33	0	0,67
3	1	1	0,33	1	0,67	1
4	0,6	1	0,67	0,67	0,67	0,67
5	0,4	0,33	0,67	0,33	0,67	0,33
6	0,4	0	0,33	0,33	1	0,33
7	0,4	0,33	0,67	0,67	0,67	0,33
8	0,8	0,67	0,67	1	0,67	1
9	0,6	0,33	1	0	0,67	0,33
10	0,8	0,67	1	0,33	0,33	0,33
11	0,6	0,33	0	0,67	0,33	1
12	0,2	0,67	0,33	0,33	0	0
13	0,6	0,33	0	0,67	0,67	0
14	0,2	0,33	0,67	0,33	0,33	0,33
15	0,8	0,33	0,67	1	1	1
16	0,6	1	1	0,67	0,33	0,33
17	0,6	0,67	1	1	0,33	0,33
18	0,6	0,33	0	0,67	0,33	0,33
19	1	0,67	0,33	0,67	0,67	1
20	0,2	0,67	0,33	0,33	1	0
21	0,4	1	0	0,33	0,33	0,33
22	0,6	1	0,33	0,67	0	0,33
23	1	0,33	0	0,67	1	1
24	0,6	0,33	0,67	0,67	0,67	1
25	0,6	1	0	0	0,33	0
26	0,4	0,33	0,33	1	0	0,33
27	0,2	0,33	0,33	0,67	0	0
28	0,4	0	0,33	0,33	1	0,33
29	1	0,67	0,33	1	0,67	0,67
30	1	0,33	0,33	0,33	0	0,33
31	0,8	0	0	1	0,33	0,33

32	0,4	0,67	0	1	0,67	0,33
33	0,6	0,67	0	1	1	1
34	0,2	0,67	1	0	0,33	0,33
35	0,8	1	0	1	1	0,33
36	0,8	0,33	0	0,33	1	0,33
37	0	0,33	0,33	0,33	1	0,33
38	0,4	1	0,33	0,33	0,33	0,33
39	0,6	0,67	0,67	1	1	0,33
40	0,2	0,33	1	1	0,67	0,33
41	0,2	0,33	0,33	0,33	0,67	0
42	1	1	0	0,33	1	0,33
43	0,8	0,67	0	1	1	0,33
44	0,6	1	0	1	0,67	1
45	0,2	1	0	0	0,67	0,33
46	1	0,33	0	0,33	1	0,33
47	0,2	0,67	0	0,33	0,33	0,33
48	0,2	0,67	0,33	0,33	1	0,33
49	0,4	0,33	0	1	0,33	0
50	1	0,33	0,67	0,33	1	0,33
51	0,4	0	0	0,33	0,33	0
52	1	0,67	1	1	1	1
53	0,4	0,67	0,33	0,33	1	0,33
54	0,2	0,67	0	1	1	0,33
55	1	0,33	0,33	1	1	1
56	0,8	0,67	0	1	1	0,67
57	0,8	0	0	1	0,67	1
58	0,4	0,67	0	1	1	0,33
59	0,2	0,33	0,67	0,33	1	0,33

Table A2 Basic QCA terminology

QCA term	Definiation	Reference
Condition	Explanatory factors, similar to independent variables and determinant	Ragin, 2009
Outcome	The explanans, similar to dependent variable	Ragin, 2009
Configuration	A specific combination of conditions (factors) that produces a given outcome of interest.	Ragin, 2009
Calibration	The process of using empirical information on cases for assigning set membership to them	Schneider and Wagemann, 2012
Necessary condition	A condition is necessary, if always when the outcome is present, the condition is also present. The necessary condition is a super-set of the outcome .	Ragin 2000
Sufficient condition	A condition can be interpreted as sufficient, if always when the condition is present, the outcome is also present. Consequently, the sufficient condition is sub-set of the outcome.	Ragin 2000
Truth table	A truth table sorts cases by the combinations of causal conditions they exhibit. All logically possible combinations of conditions are considered, even those without empirical instances.	Ragin 2008
Consistency	The degree to which the cases sharing a given condition or combination of conditions agree in displaying the outcome in question. Consistency indicates how closely the subset relation is approximated. It is calculated by dividing the number of cases sharing a given combination of causal conditions and the outcome from the number of cases that exhibit the same combination but do not show the outcome.	Ragin, 2006
Consistency cutoff	Ragin recommends that the minimum acceptable consistency cutoff level should be set at 0.80	Ragin, 2008
Coverage	The degree to which a cause or causal combination “accounts for” instances of an outcome. When there are several paths to the same outcome, the coverage of any given causal combination may be small. Thus, coverage gauges empirical relevance or importance	Ragin, 2006
Frequency	Frequency indicates the extent to which the combinations of	Ragin, 2008

causal conditions as expressed in the rows of the truth table are empirically represented.

Frequency cutoff	A frequency cut-off ensures that the assessment of the fuzzy subset relations occurs only for those configurations exceeding a specific minimum number of cases	Ragin, 2008
Complex solution	A complex solution avoids using any counterfactual cases.	Ragin and Sonnett, 2005
Parsimonious solution	A parsimonious solution permits the use of any remainder that will yield the simplest recipes.	Ragin and Sonnett, 2005
Intermediate solution,	An intermediate solution uses only the remainders that survive counterfactual analysis based on theoretical and substantive knowledge.	Ragin and Sonnett, 2005
Remainders	A remainder is a potential counterfactual case.	Soda and Furnari, 2012
Counterfactual analysis	Counterfactual analysis consists of evaluating the plausibility of given counterfactual configurations and their outcomes.	Soda and Furnari, 2012

Table A3 Calibration of conditions and outcome

Condition /Outcome	Fuzzy set	Definition of fuzzy set value	Measurement ⁵
Household involvement	1	Household is fully involved in decision making.	Household is fully involved in the village general plan, selection of tree species, targeting of location and they are satisfied with the result.
	0.8	Household is mostly involved in decision making and feels satisfied about the result.	Household is involved in the village general plan and is satisfied with the result despite the absence of making decision for tree selection or location.
	0.6	Household is mostly involved in decision making but feels unsatisfied about the result.	<ol style="list-style-type: none"> 1) Household is involved in the village general plan, the selection of tree species and location. Household is unsatisfied about the result 2) Household is involved in the village general plan but not involved in the selection of tree species and location. Household is unsatisfied about the result 3) Household is not involved in the village general plan but is involved with the selection of tree species and location. Household is unsatisfied about the result.
	0.4	Household is partly involved in decision making but but feels unsatisfied about the result.	<ol style="list-style-type: none"> 1) Household is involved in the village general plan but not involved in the decision of tree species or location. Household does not care about the result. 2) Household is involved in the program design but not in the decision of both tree species and location and feel dissatisfied. Household does not care about the result. 3) Household is not involved in village general plan and but partly involved with the selection of tree species and location. Household does not care about the result.

⁵ The measure and survey question of each condition are listed in Table 3. Here the measurement means the result of the measure to generate the fuzzy membership scores. The measurement was decided through a participatory process conducted by the first author together with local forest official and village head.

	0.2	Household is partly involved in decision making but does not care about the result	Household passively involved in the decision making.
	0	Household is not involved in any decision making.	
Property rights	1	Household has strong recognition of the property rights.	Household can benefit from the tree during the SLCP as well as when the program ends. Household owes the land
	0.67	Household recognizes the property rights.	1) Household can benefit from the tree during the SLCP as well as when the program ends. Household does not owe the land 2) Household can only benefit from the tree during the SLCP. Household owes the land 3) Household can only benefit from the tree when the program ends. Household owes the land
	0.33	Household hardly recognizes the property rights.	1) Household can only benefit from the tree during the SLCP. Household does not owe the land 2) Household can only benefit from the tree during the SLCP. Household does not owe the land 3) Household can not benefit from the tree during the SLCP as well as when the program ends. But household owes the land
	0	Household recognizes no property rights.	Household can not benefit from the tree during the SLCP as well as when the program ends. Household does not owe the land
Off-farm labor allocation	1	Off-farm household	More than 90% of income comes from off-farm employment.
	0.67	Agriculture as complement income household	50%-90% of income comes from off-farm employment.
	0.33	Agriculture as main income household	10%-50% of income comes from off-farm employment
	0	On-farm household	Less than 10% of income comes from off-farm employment.
Effective monitoring	1	The monitoring works effectively.	Household is fully aware about the checking standard and have been checked by local officials and higher level officials
	0.67	The monitoring works.	Household is aware about the checking standard but not been checked

			by both local and higher level officials
	0.33	The effect of monitoring is poor.	1) Household is not aware about the checking standard but has been checked 2) Household is aware about the checking standard but has not been checked
	0	The monitoring not works.	The monitoring system is not in place.
Financial incentive	1	Payment is very attractive comparing to the input that required.	Survey question
	0.67	Payment is attractive comparing to the input that required.	
	0.33	Payment is very little attractive comparing to the input that required.	
	0	Payment is not attractive comparing to the input that required.	
Canopy cover	1	Forest (20%-100%)	Field observation
	0.67	Sparse forest (10%-20%)	
	0.33	Developing forest (5%-10%) and Grass (0-5%)	
	0	Re-farm	

Figure A1 The distribution of 64 observed SLCP-enrolled plots in Shengli village⁶

Figure A2 The distribution of 64 observed SLCP-enrolled plots in Miaowan village

⁶ The blue area is housing area of the village and the yellow line is the village boundary.

Figure A3 forest, spare forest, developing forest or grass and re-farm, photo by Cheng Chen

Forest (20%-100%)
Spare forest (10%-20%)
Developing forest (5%-10%) and Grass (0-5%)
Re-farm

Figure A4 Truth table of success

part	prop	off	moni	fin	number	out	raw consist. ▾	PRI consist.	SYM consist
1	0	1	1	1	2		0.934358	0.846405	0.846405
1	1	1	1	1	4		0.919856	0.829517	0.829517
1	0	0	1	1	4		0.860855	0.706195	0.706195
1	1	0	1	1	8		0.857951	0.721221	0.734463
1	1	1	1	0	2		0.824345	0.536585	0.536585
1	1	0	1	0	1		0.797082	0.564103	0.564103
0	0	1	1	1	2		0.796148	0.386473	0.386473
0	1	0	1	1	3		0.783037	0.458128	0.458128
0	1	1	0	1	1		0.780870	0.207547	0.207547
1	1	0	0	1	1		0.767742	0.423077	0.423077
1	1	1	0	0	1		0.760377	0.341969	0.341969
1	0	1	0	1	2		0.744102	0.318841	0.318841
0	0	1	0	1	2		0.713551	0.165000	0.165000
1	0	0	0	1	2		0.697260	0.373937	0.373938
1	0	0	1	0	3		0.693316	0.450704	0.450704
1	1	0	0	0	1		0.678973	0.331103	0.331103
0	1	1	0	0	1		0.678295	0.165829	0.165829
0	1	0	0	1	4		0.636588	0.183333	0.183333
1	0	0	0	0	2		0.628253	0.399399	0.399399
0	0	0	0	1	4		0.610054	0.186969	0.186969
0	0	1	0	0	1		0.567708	0.165829	0.165829
0	0	0	1	0	3		0.554034	0.278325	0.278325
0	1	0	0	0	4		0.547718	0.167939	0.167939
0	0	0	0	0	1		0.506579	0.226804	0.226804

Figure A5 Truth table of failure

part	prop	off	moni	fin	number	~out	raw consist. ▾	PRI consist.	SYM consist
0	0	1	0	1	2		0.943396	0.835000	0.835000
0	1	1	0	1	1		0.942609	0.792453	0.792453
0	1	1	0	0	1		0.936047	0.834171	0.834171
0	1	0	0	1	4		0.918418	0.816667	0.816667
0	0	1	0	0	1		0.914063	0.834171	0.834171
0	0	0	0	1	4		0.910326	0.813031	0.813031
0	1	0	0	0	4		0.908714	0.832061	0.832061
1	0	1	0	1	2		0.880218	0.681159	0.681159
1	1	1	0	0	1		0.875472	0.658031	0.658031
0	0	1	1	1	2		0.871589	0.613526	0.613527
0	0	0	0	0	1		0.855263	0.773196	0.773196
1	1	0	0	0	1		0.841092	0.668896	0.668897
1	1	0	0	1	1		0.829677	0.576923	0.576923
0	0	0	1	0	3		0.828006	0.721675	0.721675
1	0	0	0	1	2		0.819178	0.626062	0.626062
0	1	0	1	1	3		0.816568	0.541872	0.541872
1	1	1	1	0	2		0.796610	0.463415	0.463415
1	0	0	0	0	2		0.752788	0.600601	0.600601
1	0	0	1	0	3		0.748362	0.549296	0.549296
1	1	0	1	0	1		0.737401	0.435897	0.435897
1	0	0	1	1	4		0.665549	0.293805	0.293805
1	0	1	1	1	2		0.638268	0.153595	0.153595
1	1	0	1	1	8		0.623321	0.260749	0.265537
1	1	1	1	1	4		0.610048	0.170483	0.170483

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