

Supplementary material A

A1 Condition selection protocol

Environmental governance is a complex process and its environmental effectiveness relies on the complicated interaction of numbers of condition. Our number of cases is 59 and our number of conditions is suggested to be five to six (number of cases is equal to 2^k , where K is the number of conditions included in the study). As only a handful of conditions can be considered for valid inferences by QCA, we have to select the most relevant ones.

Step 1: Listing of potential conditions through literatures

This step was carried by a broad searching of socioeconomic and institutional conditions through a systematic review of 164 international scientific articles and additional complementary literatures. Numbers of conditions, including household characteristic, such as age, education and gender (Chen et al. 2009), income change (Yao, Guo et al. 2010), household diversification (Liang, Li et al. 2012), off-farm labor allocation (Uchida, Xu et al. 2005), equity (Uchida, Xu et al. 2007) and local economic development (Yin and Zhao 2012) have all been listed as potential relevant socioeconomic conditions. Similarly, enrollment decision (Bennett 2008), participation, attitude toward SLCP (Cao, Xu et al. 2009), social norm (Chen, Lupi et al. 2012), social network, trust (Tu, Mol et al. 2011), bureaucratic hierarchy (Trac, Harrell et al. 2007), governance structure, leadership, property rights clarification (Bennett, Mehta et al. 2011), regular monitoring (Yin and Yin 2010), local institutional interaction (Yin and Yin 2010) have been listed as potential relevant institutional conditions. The result of step 1 is 20 potential conditions.

Step 2: Local household interview to shorten the condition list

As our study is at the household level, the definition of the condition should rely on the local knowledge. We interviewed local household in Jingyuan County during our first field trip in 2014 to verify the conditions from step 1. A total of 24 interviews with 6 village head (current and previous) and 18 household heads were completed. The interviews had helped us to adapt and restructure the scientific-based conditions into the perception of household. Some similar conditions were merged into one general condition and some less household-relevant conditions were excluded. For example, enrollment decision, participation and attitude had been putted under the label of household involvement, because households told us enrollment decision is a joint-decision of the village and many involvements in different phases are needed. Social norm, social network and trust were merged into social capital. The result of step 2 is seven potential conditions, including 1) household involvement, 2) off-farm labor allocation, 3) social capital, 4) sufficient financial incentive, 5) governance structure, 6) property rights and 7) effective monitoring.

Step 3: Local expert workshop to select the most relevant conditions

Workshops with ten SLCP officials from province, prefecture, county and township level were carried to discuss the most relevant conditions in Jingyuan county. In this step, social capital and governance structure were excluded. While household involvement, social capital and governance structure are interacting with each other, experts chose household involvement among the three conditions as more relevant to the environmental outcome. As a result, 1) household involvement, 2) off-farm labor allocation, 3) sufficient financial incentive, 4) property rights and 5) effective monitoring were finally selected as the most relevant conditions from step 2.

A2 The justification of considering QCA as an appropriate method

Firstly, QCA is particularly powerful to analyzing multiple conjunctural and asymmetrical causation. 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.

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 is very difficult because both household interview and field observation were very time-consuming. Therefore, QCA appears to be a suitable option for our size.

A3 The verification of the inconsistencies and non-coverage for success solution

The first term covered 14 successful households. For this term, high levels of household involvement, effective monitoring and combining with financial incentive led to the environmental effectiveness. 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, the second one is his brother and the third one is the village elder. The special politic and social position may explain why these unsuccessful households were covered by the two paths.

A4 The verification of the inconsistencies and non-coverage for failure solution

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. 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.

Supplementary material B

Table B1 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 B2 Basic QCA terminology

QCA term	Definition	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
Raw consistency	Raw consistency determines whether to regard a configuration of conditions to consistently contribute to an outcome.	Nicolas, 2013
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

Raw coverage	Raw coverage measures the proportion of memberships in the outcome explained by each term of the solution.	Ragin, 2008
Unique coverage	Unique coverage measures the proportion of memberships in the outcome explained solely by each individual solution term (memberships that are not covered by other solution terms).	Ragin, 2008
Frequency	Frequency indicates the extent to which the combinations of causal conditions as expressed in the rows of the truth table are empirically represented.	Ragin, 2008
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 B3 Calibration of conditions and outcome

Condition /Outcome	Fuzzy set	Definition of fuzzy set value	Measurement ¹
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.	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 feels unsatisfied about the result.	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.

¹ 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 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	

Supplementary material C

Figure C1 The distribution of 64 observed SLCP-enrolled plots in Shengli village²

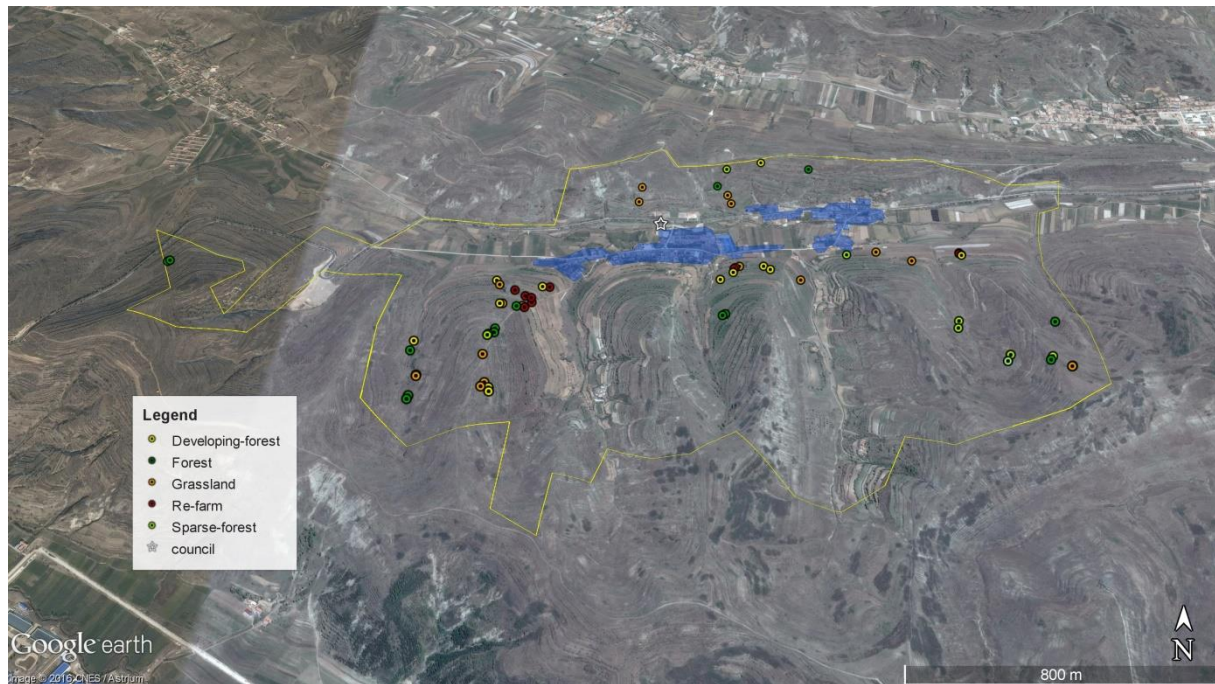


Figure C2 The distribution of 64 observed SLCP-enrolled plots in Miaowan village



² The blue area is housing area of the village and the yellow line is the village boundary.

Figure C3 forest, sparse forest, developing forest or grass and re-farm, photo by Cheng Chen

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

Figure C4 Truth table of success

part	prop	off	moni	fina	number	out	raw consist. ▾
1	0	1	1	1	2		0.934358
1	1	1	1	1	4		0.919856
1	0	0	1	1	4		0.860855
1	1	0	1	1	8		0.857951
1	1	1	1	0	2		0.824345
1	1	0	1	0	1		0.797082
0	0	1	1	1	2		0.796148
0	1	0	1	1	3		0.783037
0	1	1	0	1	1		0.780870
1	1	0	0	1	1		0.767742
1	1	1	0	0	1		0.760377
1	0	1	0	1	2		0.744102
0	0	1	0	1	2		0.713551
1	0	0	0	1	2		0.697260
1	0	0	1	0	3		0.693316
1	1	0	0	0	1		0.678973
0	1	1	0	0	1		0.678295
0	1	0	0	1	4		0.636588
1	0	0	0	0	2		0.628253
0	0	0	0	1	4		0.610054
0	0	1	0	0	1		0.567708
0	0	0	1	0	3		0.554034
0	1	0	0	0	4		0.547718
0	0	0	0	0	1		0.506579

Figure C5 Truth table of failure

part	prop	off	moni	fina	number	~out	raw consist. ▾
0	0	1	0	1	2		0.943396
0	1	1	0	1	1		0.942609
0	1	1	0	0	1		0.936047
0	1	0	0	1	4		0.918418
0	0	1	0	0	1		0.914063
0	0	0	0	1	4		0.910326
0	1	0	0	0	4		0.908714
1	0	1	0	1	2		0.880218
1	1	1	0	0	1		0.875472
0	0	1	1	1	2		0.871589
0	0	0	0	0	1		0.855263
1	1	0	0	0	1		0.841092
1	1	0	0	1	1		0.829677
0	0	0	1	0	3		0.828006
1	0	0	0	1	2		0.819178
0	1	0	1	1	3		0.816568
1	1	1	1	0	2		0.796610
1	0	0	0	0	2		0.752788
1	0	0	1	0	3		0.748362
1	1	0	1	0	1		0.737401
1	0	0	1	1	4		0.665549
1	0	1	1	1	2		0.638268
1	1	0	1	1	8		0.623321
1	1	1	1	1	4		0.610048