Quantitative Analysis of Collective Action: Methodology and Challenges

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1. Introduction

Natural resources involve large numbers of resource users, and therefore their management often requires coordination of the users' actions, or collective actions. Although significant role of collective actions in sustainable resource management has been recognized well, empirical studies on collective action has been rare except for case studies. We have two major empirical issues in the field of collective action: first, to identify factors affecting the establishment or the emergence of collective action; and second, to examine the performance or the effectiveness of the collective action established. We have developed a simple method to deal with the two issues quantitatively in a systematic way. The idea behind the simplified method is summarized as follows. (i) Definition of the collective action in question should be as simple as possible so that the existence of the collective action can be easily observed. And (ii) Because the collective action defined in such a simple way does not necessarily functioning or effective for natural resource management, its performance need to be examined somehow. The objective of this paper is to present the method with examples of the application. The examples include community forest management in Nepal, India and Japan and water management for rice production in Côte d'Ivoire.

2. Analytical Framework

The analytical framework of the simplified method is given by the following equations.

(1) $CL = f(X_1)$

(2) $PF = g(CL^*, X_2)$

where CL stands for a measure of the collective action in question and PF stands for a performance index of the collective action. X_1 and X_2 are exogenous variables explaining those dependent variables. CL is constructed based on the simplified definition of the collective action. By estimating equation (1) in an appropriate regression method, factors that affect the establishment or the emergence of the collective action will be identified. Then, prediction of CL is obtained from the regression result, which is given by CL^*. Equation (2) is to examine the benefit or impact of the collective action. PF could be anything that is considered to be a benefit for the participants in the collective action, and is explained by the predicted CL^* and exogenous variables. Predicted CL^* is used for estimating equation (2) because of the simultaneity of the collective action and its performance.

3. Definition of Collective Action

A collective action literally requires "collectivity" and "an action." By a narrow sense, collectivity implies group work in which all the members are requested to participate and an action implies physical movement. Of course we can observe a lot of examples of this kind of collective action in natural resource management. However, this definition is too narrow to analyze people's behavior affecting the use of natural resource, because there are many different kinds of group behavior for natural resource management. In this paper, first I would like to broaden the definition of collective action so that it covers most of important behaviors at community level.

With respect to the collectivity, collective actions can be classified into three as shown in Table 1. A collective action is an obligation for all the members,[1] and in this sense the three types of collective action are not different. But they differ in the following way. Type A, or Group Work, requires all the members to participate and work together. Type B, or Organized Work, does not require all the members to get together. But rather, only some of the members work at one time and the duty shifts in an organized way, for example, in rotation. Then type C, or Independent Work, is the case where the obligation is clearly defined but the implementation is individual. The choice among the three partly depends on the type of work: for example, construction of irrigation canals may not be achieved if people work independently. Monitoring and enforcement costs may also affect which collective action a community will select. "Group Work" will be selected when monitoring and enforcement costs in "Independent Work" are high, which can be attributed to either community or nature of work.

As for actions, three kinds of action are considered as shown in Table 2. The first one, Physical Action, is the case where members do something physically, such as tree planting and canal cleaning. However, this physical participation can often be replaced by cash or in-kind payment to the group. Or a group member can hire a laborer and send him/her to the work instead of paying to the group. Although the work itself is still a physical action, the way of participation is not physical in these cases. This is the second type of action, Contribution, in Table 2. And the third type is for non-action or at least non-physical action. This type of collective action includes the case where group members are obliged not to do something, that is, prohibition. Moreover, this type could have the case where group members enforce regulations each other so that no one violates them.[2] The choice between the first and second depends on the condition of labor market, individual member's opportunity costs, liquidity constraints, and also monitoring and enforcement costs. But the third one is quite different from the other two in terms of the objective of the action, although both are often adopted in one group at the same time.

Using the two types of classification, a matrix of collective action is obtained as shown in Table 3. A-1 corresponds the narrow definition of collective action. Forest management activities in community forest, such as weeding, pruning, and thinning, often fall in A-1. Maintenance of common irrigation facilities, such as canal cleaning and bund repairing also often fall in A-1. Since these works usually require quite a large amount of labor force, users' group tends to mobilize all the members. But if it is done in rotation such a collective action falls in B-1 in Table 3. Typical example for B-1 is patrolling of community forest, which is usually done by a few of group members in rotation. In the case of either A-1 or B-1, a member can pay cash or in-kind or hires a laborer instead of participating by him/herself. Then, such collective actions can be classified in either A-2 or B-2. In either case, the type of work does not differ from A-1 or B-1. However, A-2 can include the case where all the members contribute cash (or sometimes in kind) to make an investment in something that requires external expertise. Construction of irrigation systems and community wells are the examples. On the other hand, example of C-1 is the case where users of irrigation canal are obliged to clean each one's part, but it can be done individually. Not-to-do type of collective action is implemented either as a group (A-3) or individually (C-3). The former is the case where community members collectively isolate someone or a group of people from the community. And the latter is the case where community members supervise each other to enforce institutions.

4. Determinants of Collective Action

In this section we discuss how to estimate equation (1). First, we need to identify a collective action to examine. Then, we construct a variable that represents the collective action, CL in equation (1). Although a collective action is defined at community level, we can have two kinds of variable for the collective action. One is community level variable for the existence or the emergence of the collective action in community. And the other is individual/household level variable for the participation in the collective action at individual/household level.

4.1 Existence of Collective Action at Community Level

The existence of the collective action in question is judged at community level by way of group interview in each community. Then, the communities interviewed are largely classified into two: one is for those with the collective action questioned and the other is for those without it. In this way, a binary dummy variable, CL, is constructed, where CL is 1 for the communities with the collective action, whereas CL is 0 otherwise. In order to identify determinants of the existence of the collective action at community level by estimating equation (1), a large enough number of communities are required.

My examples of this kind of study are on community forest management, water users' association for tank irrigation management, and collective land ownership in lowland. In Madhya Pradesh, India 60 villages are randomly selected from 6 districts and about one third of them have a scheme of community forest management. In Tamil Nadu, India 100 villages are randomly selected from 4 districts and about half of them have a water users' association for tank irrigation management.[3] Both of them can fall into the categories of A-1, A-2, B-1, or B-2 according to Table 3. Even if they are based on informal institutions, the institutions are well recognized by community members and hence measurement of this kind of collective action is relatively easy. Unlike them, lowland ownership in Côte d'Ivoire is not explicitly institutionalized, and therefore existence of a collective action is not easily determined.

In Côte d'Ivoire, there are two types of ownership in lowlands: land owned by village as a whole, (collective ownership) and land owned by individuals or individual families (individual ownership). We have some evidence that collective ownership has been gradually individualized in the long run and on the other hand collective ownership is still kept in some villages by villagers based on implicit understanding that land belongs to the village. In other words, mutual supervision to prohibit individualization may be working at community level. Therefore, this is an example of collective actions of C-3 in Table 3. In Bandama Valley region of Côte d'Ivoire, we identified 53 lowlands owned collectively among 213 randomly sampled lowlands that have ever been used for rice cultivation. Accordingly, CL is constructed as a binary dummy variable whose value equals 1 for collectively owned lowlands and 0 otherwise. Then, determinants are identified by a Probit regression as shown in Table 4 (adapted from Sakurai 2000). In terms of lowland characteristics, distance from village has a significantly negative effect on the incidence of collective ownership, which implies that monitoring costs of the mutual supervision is high in remote lowlands. In addition, collective ownership is found in villages far from capital cities (sous-prefectures) and in less populated villages, which suggests that market access and demand for land are driving forces of the individualization. Also the analysis reveals that collective ownership is associated more with villages of Baoulé ethnic group, that is, ethnic culture affects the effectiveness of the mutual supervision.

Another example for the implicit collective action is protection of community plantation in Nepal (Sakurai et al 2001). Members supervise mutually to protect their plantation from grazing, theft, and so on. This collective action needs to be compared with private plantation where such mutual supervision is not expected. Because community plantation and private plantation differ in the origin, they are not subject to choice. Therefore, unlike the case of collective land ownership in Côte d'Ivoire, it is impossible to apply equation (1) to this case.

4.2 Choice of Institutions for Community Level Collective Actions

Another issue related to the existence of collective action at community level is the choice of collective action institutions at community level. As shown in Table 3, a community can select from several different arrangements of collective action to achieve the same objective, for example, forest management. In this kind of analysis, the dependent variable CL equals 1 when a community chooses one type of collective action, while it is 0 when a community chooses the other type of collective action. We have studied the choice between collective management and individual management of community forest in Japan and the choice between collective management and centralized management of community forest in Nepal. Different from the case of collective land ownership in Côte d'Ivoire, these cases of institutional choice are based on explicit decision at community level.

In Japan collectively owned community forests used to be managed by members collectively (A-1 in Table 3). But the forests have been divided and allocated to members so that members can manage individually (C-1 in Table 3). We identified 61 community forests in mountainous area of Gunma Prefecture in Japan, and found 31 of them are individually managed at least partially. Now we have two kinds of dependent variable, CL: one is a binary dummy variable for the individualization, and the other is percentage of individualized area in total community forest area. The regression results shown in Table 5 reveals the followings (Adapted from Kijima et al 2000 and Sakurai et al 2001a). First, large forests in which enforcement of collective agreement will be costly tend to introduce individualized management. Second, the larger the average size of private forest in a community, the less frequently individualized management was adopted. Naturally, demand for an individual plot inside a community forest is lower if community members own large areas of private forest. Third, greater community heterogeneity, as measured by the Gini coefficient of private forest ownership, decreases individualization. This may be explained by the high transaction cost to reach an agreement to divide their community forest among heterogeneous community members.

In Nepal centralized forest management for timber production from natural forests has recently emerged. While collective management of community forests mobilizes members to conduct silvicultural operations, centralized management of community forests hires laborers. Hence, the former falls in A-1 in Table 3, but the latter falls in B-1 in Table 3 because members contribute cash to hire laborers indirectly from the cash revenue of community forestry. We randomly selected 47 community natural forests in Dang district of Nepal, and found 22 of them adopt centralized management. Then, the incidence of centralized management is explained by a Probit regression as shown in Table 6 (adapted from Sakurai et al 2001b). The incidence is affected positively by the proportion of Brahmin households and male high school graduates, and negatively by the proportion of female high school graduates and traveling time to the nearest market town. These results indicate that the centralized management system was introduced in those forests that have favorable access to markets, and that the leadership of Brahmin households and educated males are conductive to the centralized management.

The examples above show that this approach can identify factors at community level that affect the existence or the emergence of a collective action. Monitoring costs, transaction costs, and leadership are important community factors among others, but which factors are more significant depends on the type of collective action questioned. One drawback of the quantitative study at community level is that it requires a large number of communities from which we collect data. In addition, in the case of implicit collective action like in collective lowland ownership in Côte d'Ivoire, it is difficult to obtain consistent data over many villages in group interviews. Therefore, data collection has to be conducted more carefully. Another practical problem is that we usually do not know in advance about the distribution of the existence of a particular collective action over a large number of villages. Consequently we have to take a risk of not having enough number of villages with the collective action in question after large-scale data collection. In the examples above, fortunately randomly selected villages include enough number of villages with the collective action in question; otherwise we need to make stratification for sampling. Finally, the existence of an institution for collective actions does not necessarily mean that the institution effectively induces collective actions. This is the weakness of this analysis, and therefore this approach should be followed by the examination of the performance of the collective action.

4.3 Participation of Individual/Household in Collective Action

Not only the existence of collective action at community level, but also individuals' participation in the collective action is of interest. In the cases of physical action or contribution (1 or 2 in Table 2), once a collective action is clearly defined, participants in it are easily identified. But non-participants also need to be identified for the analysis: they are those who do not participate or contribute to the collective action although it is possible to do it. That is, they should live in the same community and use the same resources.

An example is the analysis of household's participation in forest management activities (e.g. tree planting, trench digging, etc.) in Madhya Pradesh, India. Data were collected from randomly sampled 133 households in 12 villages spread over 5 districts. Here, CL is a binary dummy variable that equals 1 when a household is taking part in community forest management and 0 otherwise. As shown in Table 7, education level of household head has a positive influence on the participation, but no other household factors are found to have a significant effect on it (adapted from Sakurai et al 1997). Rather, several village level factors have a significant effect. This result implies that community level factors are important for individual participation in this community forest management. However, an obvious shortcoming of this analysis is that the number of sample households in each village is not large enough and in some villages the ratio of participants in sample households is close to 1 or 0. Consequently, we could not identify individual factors. For this kind of analysis, we need to sample more household in a village and do stratified sampling to include enough number of participants and non-participants.

5. Performance of Collective Action

As noted above, existence of collective action, either observable or unobservable, does not necessary mean that the action is effective for natural resource management. Therefore we need to evaluate the performance of the collective action. Performance will be measured either directly or indirectly. Examples of direct measurement are: profit of community forestry in Nepal, tree planting in community forestry in Japan, and cost of forest protection in Nepal. On the other hand, indirect measurement is something that should affect resource quality or efficiency of resource management. Examples are the reduction of household livestock holdings as a consequence of the participation in community forest management in India, and the adoption of water control technologies in Cote d'Ivoire's lowlands.

5.1 Direct Measurement of Performance

In the case of community forest management in Nepal, the question is whether the centralized management of community forestry is more efficient than collective management. The efficiency is measured by the profit from community forestry. As shown in Table 8, it is found that the variable for centralized management has a positive and significant coefficient in the second-stage regressions (Adapted from Sakurai et al 2001b). First, expenditure for forest management per hectare is significantly higher in centrally-managed forests than collectively-managed forests, while expenditure for forest protection is not significantly affected by the type of management. Revenue per hectare is also significantly higher in centralized management than in collective management. Then, in spite of the higher expenditure for silvicultural operations, gross profit per hectare in centrally-managed forests is significantly higher than collectively-managed forests because of the significantly higher revenue per hectare. These findings imply that group activities relying on members' physical participation have an incentive problem (e.g. free riders), and therefore less efficient than centralized management system that uses hired labor.

Individualized management and collective management are compared in the case of community forestry in Japan. Comparison of efficiency is done on the basis on timber tree planting in community forest. As shown in Table 9 it is found that the variable for the proportion of forest area under individualized management has positive and significant coefficients (adapted from Kijima et al 2000 and Sakurai et al 2001a). This finding implies that individualized management provides more appropriate incentives to plant timber trees than does collective management. Another finding related to community is that although heterogeneous communities, reflected in the low Gini ratio of private forest ownership, tend to choose collective management, such communities planted more timber trees per member. It may well be that strong leadership exists in heterogeneous communities.

As noted earlier, protection of community plantation in Nepal is an example for the implicit collective action. Performance of this mutual supervision among members is examined by comparison with private plantation where such mutual supervision is not expected. Table 10 shows the regression results (adapted from Sakurai et al 2001b). As would be expected, protection cost (watcher cost per hectare per year) is significantly higher in private plantations, judged from the significant coefficients of dummy variable for private plantations. But first year survival rate is not affected by the type of plantation ownership. That is, community plantations are achieving the same level of protection with lower cost than private plantations.

This finding implies that mutual supervision among members is effective.

5.2 Indirect Measurement of Performance

Direct measurement of performance is not always possible, because data collection of profit or natural resource condition is not easy technically and/or economically. Therefore, performance index that can be obtained relatively easily need to be applied.

In the case of lowland ownership in Côte d'Ivoire, resource use efficiency should be judged by profit from rice production in lowlands. It is technically possible to obtain profit, but it is very difficult to do it more than 200 lowlands. Hence, instead of collecting detailed data to calculate the profit, adoption of water control technologies (i.e. canals and bunds) are surveyed. On the other hand, using a small sample, we have confirmed that water control technologies enhance rice production profit per hectare (Sakurai 2001). The adoption of canals and bunds is explained by exogenous variables by a Probit regression model, as shown in Table 11 (adapted from Sakurai 2001). The regression results reveal that canals and bunds are more frequently constructed in lowlands owned collectively, as indicated by the negative sign of individualized ownership. Note that two-stage regression model is not applied here, because we believe that the choice of ownership had been done before the adoption of water control technologies. The collective ownership is not intentionally implemented at community level to enhance the adoption of water control technologies. But rather, the collective ownership provides more secure use rights to tenant farmers, particularly when they invest in land, according to villagers. This fact explains the high adoption incidence of water control technologies on collective owned lowlands.

Effect of participation in a collective action on individual's behavior is also examined in the same framework. Example is the case of community forest management in India, in which we examine the effect of household's participation in forest management activities on the number of cows the household holds. Because grazing in the forests is one of the most serious problems in forest management, we want to know if the participation in community forest management change the participants' behavior, that is, the reduction of the number of cows. As shown in Table 12, the insignificant estimation for the predicted probability density indicates that there is no self-selection bias. And the significantly negative coefficient for the predicted probability of participation implies that the participation in forest management has an effect of a reduction of cow holdings per household (adapted from Sakurai and Kajisa 1998).

6. Conclusions

In this paper, a method of quantitative analysis of collective action is presented and then, examples of the analyses on the emergence of a collective action, the choice of collective action institutions, and the participation in a collective action are provided. Factors affecting them are quite reasonably identified, and their performance gives us the evidence that the collective actions are effectively working. In other words, the collective actions have a good effect on the quality of natural resources or on the economic activities based on the natural resources. Hence, we could confirm that the method is doing well. However, our examples do not deal with other dimensions of collective actions such as conflict, equity, etc. Since they are not easily observable, data collection will be more challenging.

We should note that the examples presented here are not typical collective actions in a classic sense, because collective actions falling in A-1 or B-1 in Table 3 are considered to be typical. Our findings suggest that more efficient forms of collective action are emerging in the field. On the other hand, we should admit that the collective actions we have analyzed are those that are expected to have good effect. That is why those collective actions were selected for the study. In other words, the selection of collective actions done by researchers is already biased to successful ones. There should be many inefficient, non-functioning collective actions, but they are rarely subject to research unless researchers find any other interesting topics in such collective actions.

Footnote

[1] To be a member of not is usually voluntary. But there are cases where all the community members automatically become the members of collective actions.

[2] Empirically it will be difficult to see if the third type of collective action exists in the community in question. Community members do not do something maybe because it is not allowed, but maybe because it is not necessary. Following the definition given in this paper, only the former case is considered to be "Non-physical Action." Even in the latter case there may be informal institutions that restrict such behavior, but since such restriction is not binding it is not considered as a non-physical action.

[3] Data collection is completed both in Madhya Pradesh and Tamil Nadu, and data cleaning is underway currently. Therefore, determinants of the existence of collective action have not been identified yet.

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Table 1. Degree of Collectivity in Collective Actions

Type of Collectivity	Details
A: Group work	All the members are required to do the work together.
B: Organized work	All the members are required to do the work, but they do not work together. Instead, their work is organized in a certain way, for example in rotation.
C: Independent work	All the members are required to do the work, but they can work independently.

Table 2. ype of Action of Collective Actions

Type of Action	Details
1: Physical action	To do something physically.
2: Contribution	To contribute by cash or in kind instead of physically working.
3: Non-physical action	Prohibition (not to do something). Enforcement of regulations.

Table 3. Examples of Collective Actions

	1: Physical action	2: Contribution	3: Non-physical action
A: Group work	A-1 Weeding in community forests. Cleaning of common irrigation canals.	A-2 The same type of work as in A-1. A member hire labor who participates in the group work instead of him/her, or a member pay cash or in kind instead of participating in the group work..	A-3 Elimination of a person or a group of people from resource use (if with violence, A-1). Isolation of a person or a group of people from community. Institutionalization of regulations on resource use.
B: Organized work	B-1 Patrolling of community forests.	B-2 The same type of work as in B-1. A member hire labor who participates in the group work instead of him/her, or a member pay cash or in kind instead of participating in the group work..	B-3 NA
C: Independent work	C-1 Cleaning of common irrigation canals individually, but only the part along one's field.	C-2 The same type of work as in C-1. A member hire labor who does the work instead of him/her.	C-3 Enforcement of regulations on resource use by mutual supervision (e.g. protection of community forests).

Table 4. Determinants of Land Ownership in Village Lowlands in Côte d'Ivoire[1)]

Independent Variables \ Dependent Variables	Dummy for Village Property
Total Number of Lowlands Ever Utilized for Rice Production	213
Number of Lowlands Owned by Village	53
Intercept	-1.67 (2.54)**
Lowland Characteristics	
Distance from Village (km)	-0.08 (1.89)*
Size of Lowland (ha)	0.02 (3.94)***
Village Location	
Distance to Sous-Prefecture (km)	0.03 (2.50)**
Distance to Bouaké (km)	0.00 (0.12)
Population	
Village Population in 1988 (1000)	-0.83 (2.79)***
Village of Baoulé, dummy	0.77 (1.65)*

1) Probit model is used for the estimation of coefficients. T-statistics are in the parentheses. ***, ** and * indicate significance levels 1%, 5% and 10% respectively.

Table 5. Determinants of choice of individualized management in Japan [a]

	Choice of Individualized Management (Probit)	Proportion of Individualized Area (Tobit)
Intercept	3.03	1.27
	(1.49)	(1.95)
Forest area	0.01**	0.003*
	(2.65)	(1.94)
Number of households	-0.001	-0.0008
	(-0.29)	(-0.33)
Shareholding dummy	0.48	0.39
	(0.96)	(1.24)
Distance	-0.29	-0.18*
	(-1.62)	(-1.67)
Altitude	-0.0007	-0.0004
	(-0.77)	(-0.55)
Slope	0.008	0.002
	(0.28)	(0.11)
Paddy area per household	1.21	1.10
	(0.58)	(0.85)
Private forest area per household	-0.44*	-0.19
	(-1.82)	(-1.24)
Gini of private forest	-4.52*	-2.02**
	(-1.89)	(-2.55)
% of correct prediction	0.75	n.a.
Log Likelihood	-29.41	-35.91
Number of Sample	61	61

[a] T-statistics are in parentheses. ** indicates significance at the 1% level, and * at the 5% level.

Table 6. Determinants of centralized management of community forests in Nepal[a]

	Dummy for centralized management (probit model)
Constant	-0.430 (1.379)
Characteristics of users group/village:	
Years since handing-over	-0.249 (0.220)
Forest area per user (ha)	0.257 (0.258)
Number of users	0.002 (0.002)
Proportion of Brahmin households	0.052 (0.030)*
Proportion of male high school graduates	0.033 (0.015)**
Proportion of female high school graduates	-0.191 (0.114)*
Proportion of households in-migrated in the past 5 years	0.072 (0.097)
Proportion of household out-migrated in the past 5 years	-0.055 (0.160)
Proportion of forest area located on slopes	0.012 (0.009)
Collective management of drinking water (1=yes)	-0.523 (0.588)
Traveling time to market (minutes)	-0.014 (0.006)**
Characteristics of forest:	
Waking time to forest (minutes)	0.008 (0.033)
Proportion of forest area located on slopes	0.012 (0.009)
Land use in 1978 (1=forest)	-0.104 (0.667)
Soil type dummy (gravel)	0.073 (0.520)
Soil type dummy (sandy loam)	0.594 (0.643)
Soil type dummy (loam)	0.309 (0.759)
Soil type dummy (clayey loam)	1.352 (0.848)
Fraction of correct predictions	0.745
Number of positive observations	22
Number of samples	47

[a] Standard errors are in parentheses.

* significant at the 10% level; and ** significant at the 5% level.

Table 7 Determinants of Participation in Community Forest Management in India

	Coefficient	Standard Error
Constant	1.959	1.199
<Household Variables>		
Education of Household Head (years)	0.068*	0.041
Upper Caste Dummy	-0.009	0.163
Household Size	-0.016	0.032
Own Land per Household Member (ha)	-0.027	0.391
% of Household Member Working Off-Farm	-0.917	0.614
% of irrigated land in Total Own Land	-0.068	0.372
Dummy for Tube-Well User	0.305	0.313
<Village Variables>		
Population Density per km^2	-0.491**	0.240
% of Upper Caste	-0.049*	0.028
Distance from District Capital (km)	0.014	0.031
Female Literacy Rate (%)	0.096*	0.051
Real Wage Rate for Adult Male (Rs/day)	-0.220***	0.075
Average Time for Fuelwood Collection (hours)	0.043	0.172
Number of Samples	133	
Number of Participants	74	
Log of Likelihood Function	-78.507	
R-squared	0.173	

Probit model is used.

***, ** and * indicate significance levels 1%, 5% and 10% respectively.

Upper caste is defined as Brahman and agricultural castes.

Table 8. Effect of centralization on expenditures, revenue, and profit of community forests in Nepal [a]

	Expenditure for forest protection (rupees/year/ha) OLS model	Expenditure for forest management (rupees/year/ha) Tobit model	Total revenue (rupees/year/ha) OLS model	Gross profit (rupees/year/ha) OLS model
Predicted probability of centralization	66.8 (82.3)	503 (149)***	891 (351)**	541 (300)*
Years since handing-over	-0.43 (17.2)	-0.29 (23.8)	-25.5 (52.3)	-26.3 (51.7)
Total forest area (ha)	-0.42 (0.12)***	-0.08 (0.29)	-1.39 (0.51)***	-0.71 (0.41)*
Proportion of forest area located on slopes	0.07 (0.57)	2.36 (1.21)*	5.55 (2.91)*	4.29 (2.32)*
Traveling time to market (min)	0.09 (0.29)	0.27 (0.71)	1.43 (1.13)	1.05 (1.02)
Waking time to forest (min)	-1.01 (1.64)	-9.42 (5.06)*	-25.2 (9.85)**	-20.1 (8.06)**
Number of trees per ha, DBH=5-20cm [b]	-0.18 (0.08)**	0.15 (0.22)	0.26 (0.51)	0.47 (0.43)
Number of trees per ha, DBH=20-25cm [b]	-0.16 (2.14)	1.32 (4.88)	-12.5 (14.7)	-10.1 (13.6)
Number of trees per ha, DBH>25cm [b]	1.04 (2.69)	3.75 (5.23)	28.6 (13.9)**	23.3 (14.0)
Constant	240 (91.9)**	-433 (187)**	152 (284)	-8.98 (292)
R squared	0.38	NA	0.44	0.38
Number of positive observations	NA	19	NA	NA
Number of samples	47	47	47	47

[a] Standard errors are in parentheses.

[b] DBH stands for diameter at breast height (1.37 m).

Table 9. Determinants of tree planting per household in Japan [a]

	Tree Planting per Household (Second-stage) [b]
Intercept	-0.24
	(-1.09)
Forest area	0.002**
	(4.73)
Number of households	-0.0006
	(-1.45)
Shareholding dummy	0.11*
	(2.30)
Distance	0.03**
	(2.52)
Altitude	-0.0002*
	(-1.80)
Slope	0.002
	(0.54)
Paddy area per household	-0.58**
	(-2.61)
Private forest area per household	0.03
	(1.14)
Gini of private forest	0.50**
	(2.72)
Percentage of tree planted area in 1955	-0.001
	(-1.58)
Proportion of individualized area	0.32*
	(1.71)
Adjusted R^2	0.42
Log Likelihood	8.65
Number of Sample	61

[a] T-statistics are in parentheses. ** indicates significance at the 1% level, and * at the 5% level.

Table 10. Determinants of protection cost and performance in Nepal[a]

	Protection cost [b] (1000 rupees/ha) 2SLS Model	First year survival rate (%) 2SLS Model
Constant	-18.8 (28.4)	106 (48.9)**
Dummy for private plantation	14.1 (6.53)**	4.14 (6.39)
Planting density (1000/ha) [c]	0.73 (1.18)	-2.41 (1.32)*
Percentage of sisso species (%) [c]	-0.05 (0.27)	-0.18 (0.44)
Total plantation area (100ha)	0.64 (1.81)	-0.11 (0.05)**
Walking time to plantation (min)	-0.09 (0.10)	-0.02 (0.08)
Years since plantation	-2.13 (1.26)*	-0.79 (1.44)
Number of users	0.02 (0.02)	-0.01 (0.04)
R squared	0.19	0.17
Number of Samples	44	44

[a] Standard errors are in parentheses.

[b] Watcher cost per hectare per year.

[c] Endogenous variables.

significant at 10%level; ** significant at 5% level; and *** significant at 1% level

Table 11. Determinants of Technology Adoption in Village Lowlands in Côte d'Ivoire[1)]

Dependent Variable	Dummy for Canals	Dummy for Bunds
Intercept	4.03 (1.07)***	2.50 (1.01)**
Land Owned Individually (dummy)	-0.66 (0.33)**	-0.02 (0.67)
Lowland Characteristics		
Distance from Village (km)	0.11 (0.07)*	0.13 (0.07)*
Size of Lowland (100 ha)	-0.17 (0.48)	0.40 (0.50)
Village Location		
Distance to Sous-prefecture (km)	-0.03 (0.02)*	-0.05 (0.02)**
Distance to Bouaké (km)	-0.03 (0.01)***	-0.02 (0.01)**
Population		
Village Population in 1988 (1000)	-0.09 (0.59)	-1.37 (0.76)*
Village of Baoulé, dummy	-2.81 (0.70)***	-2.01 (0.67)***
Number of Immigrants (100)	0.25 (0.26)	0.78 (0.37)**
Village Facilities		
Years since Primary School Built	-0.00 (0.01)	0.02 (0.01)*
Market in the Village, dummy	0.31 (0.64)	-0.59 (0.71)
Fraction of Correct Prediction	0.71	0.71
# of Lowlands with Canals/Bunds	36	35
# of Lowlands with Rice Cultivation	108	

1) Probit model is used for the estimation of coefficients. Standard errors are in parentheses. ***, ** and * indicate significance levels of 1%, 5% and 10% respectively.

Table 12. Determinants of Household Cow Holdings in India

	Coefficient		Standard Error
Constant	8.954	**	4.163
<Household Variables>			
Education of Household Head (years)	0.148	**	0.068
Upper Caste Dummy	0.184		0.355
Household Size	0.048		0.032
Own Land per Household Member (ha)	-0.133		0.373
% of Household Member Working Off-Farm	-2.544	**	1.141
% of irrigated land in Total Own Land	-0.552	**	0.211
Dummy for Tube-Well User	0.219		0.139
Predicted Probability of Participation in Community Forest Management (Φ)	-8.752	**	3.950
Predicted Probability Density of Participation in Community Forest Management (ϕ)	1.146		1.710
<Village Variables>			
Population Density per km^2	-3.163	**	1.324
% of Upper Caste	-0.327	**	0.165
Distance from District Capital (km)	0.032		0.042
Female Literacy Rate (%)	0.564	**	0.234
Real Wage Rate for Adult Male (Rs/day)	-0.923	**	0.511
Average Time for Fuelwood Collection (hours)	1.607	**	0.645
Real Price of Cow (Rs/cow)	0.003	**	0.001
Number of Samples	106		
R squared	0.332		

Dependent variable is the number of cows per household member.

***, ** and * indicate significance levels 1%, 5% and 10% respectively.

Upper caste is defined as Brahman and agricultural castes.