Environmental Management (2012) 50:396–404
DOI 10.1007/s00267-012-9887-5

Impact of Community-Based Forest Management on Forest Protection: Evidence from an Aid-Funded Project in Ethiopia

Ryo Takahashi · Yasuyuki Todo

Received: 13 September 2011 / Accepted: 20 May 2012 / Published online: 27 June 2012

Abstract Many African countries have adopted community-based forest management (CBFM) to prevent deforestation. However, empirical studies have not reached a consensus on the effectiveness of CBFM. The purpose of this study is to examine the impact of the establishment of participatory forest management associations in Ethiopia. We used remote sensing data to gauge the change in forest area and employed a two-stage least squares model to correct for possible biases. The results indicate that the forest area managed by forest associations declines more in the year of establishment than forest areas with no association. This finding suggests that villagers may engage in "last-minute" logging. However, 1 year after the establishment of the forest associations, the forest area of the associations increased substantially, most likely because the associations monitor illegal logging, enabling the regeneration of open areas within the registered forest area. On average, the forest area of the forest associations increased by 1.5 % in the first 2 years, whereas forest areas not managed as part of an association declined by 3.3 %. The cumulative impact over 2 years yields a net increase in the rate of change of 4.8 %. These results demonstrate that it is important to improve the monitoring of forest areas during the initial establishment of participatory forest management associations to maximize the effects of association establishment.

Keywords Impact evaluation · Remote sensing · Forest protection · Community-based forest management · Ethiopia

R. Takahashi (✉) · Y. Todo
Department of International Studies, University of Tokyo,
5-1-5 Kashiwanoha, Kashiwa, Chiba 277-8563, Japan
e-mail: ggt000@hotmail.com

Introduction

The deforestation of tropical forests is a widespread problem in less developed countries, including those in Sub-Saharan Africa (Achard and others 2002). For example, 35 % of the total land area of Ethiopia was covered by forest in the early twentieth century, but by the early 1950s, forest cover had drastically declined to 16 % (Ethiopian Forestry Action Programme 1994, cited in Urgessa 2003). This decline has continued in recent years, with the total forest cover falling from 13.8 % in 1990 to 12.7 % in 2005 (United Nations Statistical Division 2010).

Among the many factors driving deforestation, agricultural expansion due to poorly defined land ownership and land-use rights are the most common in Sub-Saharan Africa (Geist and Lambin 2002). To prevent deforestation, African countries have recently promoted community-based forest management (CBFM) rather than centralized forest management (Ribot and others 2010) in response to studies showing that local communities manage resources more sustainably than government agencies (Agrawal and Yadama 1997; Ostrom 1999; Adams and others 2003). This effectiveness of local management is more likely in less developed countries, where most local societies are based on trust and cooperation among members of a community, leading to the monitoring and punishment of irresponsible users (Pretty and Ward 2001; Hayami and Godo 2005; Tole 2010).

A large number of empirical studies have found evidence of the effectiveness of CBFM on forest conservation (Edmonds 2002; Somanathan and others 2005; Dalle and others 2006; Matta and Alavalapati 2006; Ellis and Porter-Bolland 2008; Lund and Treue 2008). In contrast, a research study conducted by Kijima and others (2000) found that private ownership was a more efficient way of managing forests than common ownership. Thus, there is a lack of consensus in the literature. Moreover, these studies focused only on the post-implementation effects, and the effects during the process of CBFM implementation were overlooked. Alemagi (2010) noted that the establishment of community-based procedures is considerably time consuming; for example, this process took an average of approximately 18 months in Cameroon and 18–24 months in Canada. Such intervals may influence the behavior of residents in the community, thereby affecting the rate of change in forest area.

The objective of this study, therefore, is to quantify the impact of CBFM on forest protection as well as the effect of CBFM during the process of its implementation. As a case study, we use Ethiopia, where deforestation is severe, because most of the existing studies on deforestation in less developed countries target Asia or South America, and the data for Africa is insufficient. The form of community-based forest management analyzed is forest associations, which have grown to number over 100 in Ethiopia.

In 2007, the Participatory Forest Management Project (hereafter, "the project") was implemented in the Belete–Gera Regional Forest Priority Area (RFPA), located in the southwest of Ethiopia, by the Japan International Cooperation Agency (JICA), a Japanese foreign aid agency that establishes participatory forest management associations (hereafter, "forest associations"). Forest associations were established at the sub-village level, the lowest level of residence, to identify the border between forest and homestead/farmland and to prevent logging in the forest area. After establishment, the forest associations are tasked with managing the registered forest area.

Description of the Project

The project targets the RFPA located in the Gera District and the Shabe Sombo District in the Oromia Region (Fig. 1).

In 2007, the project began establishing participatory forest management associations ("WaBuB" in the local language) at the sub-village level to undertake forest protection in the RFPA, together with income-generation activities, such as farmer field schools and coffee certification (Takahashi and Todo 2011; Todo and Takahashi 2011). Table 1 shows the number of forest management associations established by year. Preparation for the establishment of an association usually takes 1 year, beginning in October and ending around August or September in the following year.

Before the implementation of the project, the decision to extract wood from the forest and expand farming or grazing land into the forest area was left to the individual judgment of the villagers. However, once a forest management association is established, the border between homestead/farmland and forest is clearly identified and marked with paint by association members; using the registered forest area for activities such as expanding farmland, extracting wood, or planting trees is strictly prohibited, except in the case of necessary thinning. Members of the associations regularly monitor and evaluate the conditions of the forest. When they find open spaces in the registered forest area, the forest

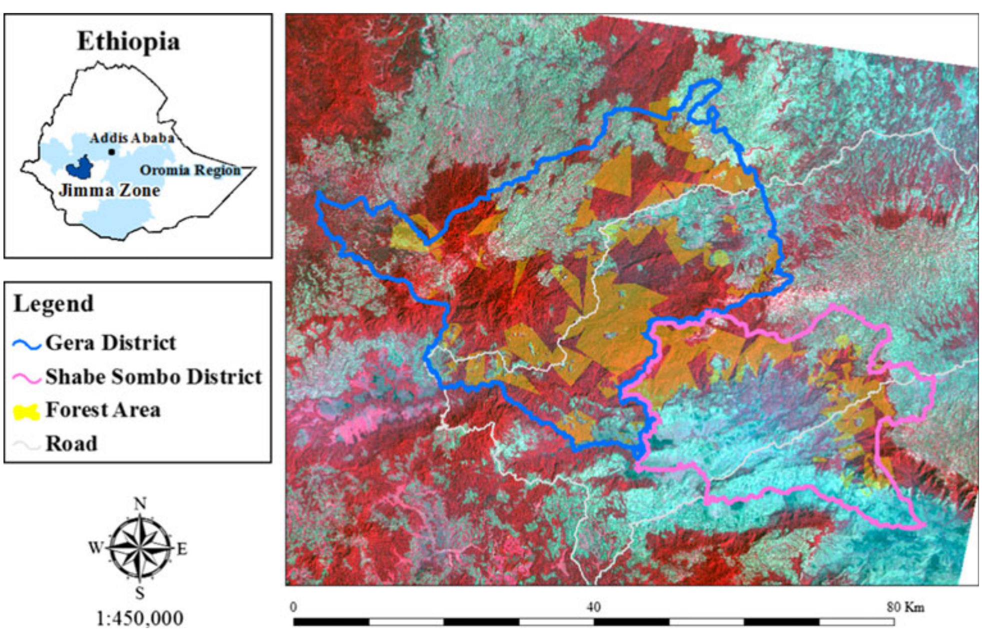

Fig. 1 The Belete–Gera Regional Priority Area. The participatory forest management associations (''WaBuB'' in the local language) were established at the sub-village level, which is shown in *yellow*. The background image is a false-color image of Landsat 5 imagery taken in January 2001. Active vegetation appears *red-pink*, bare soil and fallow fields are *green*, and urban structures are *bluish-white*

Table 1 The establishment of forest management associations

	Total number of sub-villages in RFPA	Number of associations established in			
		2007	2008	2009	2010
Gera Forest	80	2	19	35	24
Belete Forest	45	1	13	22	9
Total	125	3	32	57	33

association holds a meeting to plan for the care of these spaces and prevent the degradation of the forest. In addition, forest associations plant trees along the boundary of the forest area to demarcate the boundary and distinguish the forest area from areas of agroforestry.

Data

To estimate the forest area at the sub-village level, we use data from satellite images of Landsat 7 with a resolution of 30 m. Landsat images from path/row 170/55 for January in the following 5 years were used for our analysis: 2006, 2007, 2008, 2009, and 2010. Because the image for 2008 was affected by cloud cover, we build a composite image using data from December 2007.

To distinguish between forest areas and non-forest areas, we utilize the Normalized Difference Vegetation Index (NDVI), a measure of vegetation commonly used in remote sensing studies, such as those by Tucker and others (1985), Davenport and Nicholson (1993), and Tucker and others (2001). The NDVI takes values of between -1.0 and 1.0 and increases with the degree of vegetation biomass (Jensen 1996). Following Southworth and others (2004), we determined a threshold value of the NDVI for forest areas based on information from satellite images and fieldwork. We conducted ground truthing to collect locational data for 17 points at boundaries between forest and non-forest areas that were in place during the study period (according to interviews with several local residents) and chose the point with the highest NDVI value for each year as the threshold value for forest areas. Forest areas are defined as areas that function as forest either physically or socially for local communities (Southworth and Tucker 2001). Non-forest areas include agricultural lands, fallow fields, rangelands, cleared areas, bare soil areas, and urban areas.

Although this methodology has been used in previous studies, such as those by Southworth and others (2004) and White and Nemani (2006), there may be some errors in estimating the NDVI threshold value, and these errors may lead to errors in the rate of change in forest area. However, because the same error would affect any locational unit within the same year, the rate of change in the forest area for sub-villages with and without a forest association would be over- or underestimated to the same extent. Therefore, the possible error in the estimation of forest area from satellite images does not lead to a bias in the estimation of the impact of forest associations on the rate of change in forest area.

The boundaries of the registered forest areas were recorded by with a global positioning system (GPS) device. The total number of forest associations and the average and total area are provided in Table 2. The total area brought under the management of forest associations between 2007 and 2009 (a total of 92 forest associations) was approximately 60,000 ha. A comparison of the environmental characteristics of the Gera and Belete Forest Areas is listed in Table 3. The forest area decreased by an average of approximately 1.7 % annually between 1995 and 2006 in the areas studied.

Empirical Framework

This section provides an overview of the empirical framework employed in this study. First, to control for time-invariant unobservable characteristics, we use the difference in the rate of change in forest area as a dependent variable. Second, we apply a two-stage least squares (2SLS) model to control for possible biases and estimate the impact of the establishment of the forest associations on the rate of change in forest area. The estimation equation is specified as follows:

$$\begin{aligned} \log y_{it} - \log y_{it-1} = & \alpha + \beta_1 \mathrm{EST}^0_{it-1} + \beta_2 \mathrm{EST}^1_{it-1} \\ & + \beta_3 \mathrm{EST}^2_{it-1} + \beta_4 \mathrm{PERI}^{07}_{it-1} \\ & + \beta_5 \mathrm{PERI}^{08}_{it-1} + \beta_6 X_{it} + \varepsilon_{it}, \end{aligned} \quad (1)$$

where y_{it} is the forest area of sub-village i in year t; therefore, $\log y_{it} - \log y_{it-1}$ indicates the rate of change in forest area of sub-village i between the years t and $t-1$. To

Table 2 Summary statistics of the area under management by forest associations by year of establishment

	Number of forest associations	Area (ha)					
		Mean	SD	Median	Min.	Max.	Total area
Established in 2007	3	2,814	3,762	977	323	7,141	8,442
Established in 2008	32	671	738	421	57	2,782	21,468
Established in 2009	57	549	617	338	20	2,932	31,272
Total	92	665	944	378	20	7,141	61,182

Table 3 Summary statistics of the environmental characteristics of Gera and Belete Forests

	Gera Forest ($n = 56$)				Belete Forest ($n = 36$)			
	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
Average annual rate of change in forest area between 1995 and 2006	−0.014	−0.032	−0.165	0.043	−0.021	−0.070	−0.179	0.201
Average area of forest associations (ha)	752	1,076	38	7,141	529	684	20	2,932
Number of households	158	82	33	529	106	47	22	208
Average elevation (m)	2,101	283	1,408	2,725	1,971	217	1,534	2,380
Average slope (%)	8.2	5.0	0.8	20.0	13.0	6.2	1.6	30.4
Proportion of acrisol (%)	0.1	0.3	0	1.7	0.2	0.3	0	1.5

Acrisol is a type of soil classified by the Food and Agriculture Organization (FAO) and the United Nations Educational, Scientific and Cultural Organization (UNESCO) with a subsurface accumulation of low activity clays and low base saturation. As such, acrisol is relatively unfertile

examine the impact of the establishment of forest associations and the effect of their establishment, we create three dummy variables at three different points in time. EST^0_{it-1} takes a value of 1 if sub-village i was in the process of establishing a forest association in year $t-1$. EST^1_{it-1} and EST^2_{it-1} take a value of 1 if sub-village i has had a forest association for 1 or 2 years, respectively, in year $t-1$.

We also include the dummy variables $\mathrm{PER1}^{07}_{it-1}$ and $\mathrm{PER1}^{08}_{it-1}$, which take a value of 1 if sub-village i is located next to an area where a forest association was established in 2007 and 2008, respectively. Some previous studies found that the establishment of forest associations induces deforestation in the surrounding forest area (Chakraborty 2001; Ostrom and Nagendra 2006; Balooni and others 2007). These dummy variables would capture such a negative leakage effect if the establishment of forest associations causes deforestation in the surrounding forest area.

We refer to the previous studies and employ environmental variables for the estimation (Cropper and Griffiths 1994; Chen and others 1999; Cropper and others 1999; Zhang and others 2005). X_{it} denotes the environmental factors of sub-village i during the observation period and includes the following: the number of households in the sub-village, the average slope, and the proportion of acrisol present.

The independent variables EST^0_{it-1}, EST^1_{it-1}, and EST^2_{it-1} in Eq. (1) are endogenous because they are correlated with ε_{it}; as a result, we take two steps to reduce endogeneity, as suggested in Duflo and Pande (2007).

First, we use a multinomial logistic model to identify the determinants of the establishment of forest associations:

$$\mathrm{Prob}(\mathrm{EST}_i = j) = \frac{\exp(\gamma_j' Z_i + \delta_j' X_i)}{1 + \sum_{j=1}^{2} \exp(\gamma_j' Z_i + \delta_j' X_i)}, \tag{2}$$

where EST_i represents the year of establishment in sub-village i: 2007 ($j = 2$), 2008 ($j = 1$), or 2009 ($j = 0$). We assume $\gamma_0' = 0$ and $\delta_0' = 0$ for normalization.

Z_i represents variables that determine the selection of sub-villages for forest associations but do not determine the change in forest area, including the distance to the closest project office (the project has two offices: in Jimma City and Gera District), the deforestation rate between 1995 and 2006, and the dummy variable for Gera District.

Second, to reduce biases due to endogeneity, we calculate the predicted probability of the establishment of forest associations for each year from Eq. (2) and employ the predicted probability as instruments for a 2SLS model of Eq. (1). The predicted probabilities of the establishment of associations are closely related to the dummies for the actual establishment, but they are controlled by a nonlinear function of geographic variables. Therefore, the predicted probabilities are most likely to be unrelated to the error term in Eq. (1) and are able to serve as instruments to estimate impact of the forest associations.

Estimation Results

The estimation results from the multinomial logistic model are presented in Table 4, with columns 1 and 2 showing the results for forest associations established in 2007 and 2008, respectively. As expected, the distance to the closest project office has a negative and significant effect on the establishment of forest associations in 2008, implying that being closer to a project office increases the likelihood of early selection. In contrast, the result for this variable is insignificant for 2007; however, this finding may be an effect of the small number of observations; that is, only three forest associations were established in 2007. The size of a sub-village as indicated by the number of households has a significant positive impact on a sub-village being selected in 2007 but not in 2008, indicating that forest associations were established in larger sub-villages earlier in the implementation of the project. Finally, in 2008, the deforestation rate between 1995 and 2006 had a weakly

Table 4 Results from the multinomial logistic estimation

Variables	Established in 2007 (1)	Established in 2008 (2)
Number of households in sub-village	0.8611* (1.7986)	−0.5566 (−1.2289)
Average slope	0.2143 (1.1635)	0.0746 (1.3947)
Proportion of acrisol	−18.5952 (−0.0840)	−19.2497 (−0.2415)
Deforestation rate between 1995 and 2006	11.2334 (0.5582)	8.6530* (1.6869)
Distance to the closest project office	−0.2014 (−1.0318)	−0.0799** (−2.2814)
Dummy of district (1 = Gera)	−3.2898 (−0.7082)	−1.7849* (−1.8377)
Constant	−0.6576 (−0.1154)	1.7689 (1.3154)
Observations	92	
Log likelihood	−61.655	
Pseudo R^2	0.136	

t Statistics are in parentheses

* and ** indicate statistical significance at the 10 and 5 % levels, respectively

significant ($P < 0.10$) positive effect on the selection of forest associations. This finding indicates that the higher the rate of deforestation, the more likely a village was to be selected in 2008.

We then perform 2SLS to estimate the impact of the forest associations using the predicted probability of the establishment of forest associations in each period as an instrument. The results of the first stage of 2SLS are presented in columns 1–3 in Table 5, showing that the predicted probabilities are significantly correlated with the actual establishment and presence of forest associations. Therefore, the instruments appear to be robust for the 2SLS estimation.

The results of the second stage of the 2SLS estimation are presented in column 4. The results indicate that the dummy for the year of establishment is negative and significant at the 5 % level of significance. The value of the coefficient indicates that the rate of change in forest area for sub-villages with a forest association was 12 % lower than that in sub-villages without a forest association.

In contrast, we find that the dummy for 1 year after the establishment is positive and significant at the 10 % level of significance. We acknowledge that the 10 % level of significance found in these estimations is not very high. However, we check the robustness of the results by varying the independent variables in Eq. (1), and we still find the same statistical significance (see column 5 in Table 5). This result indicates that even though the rate of change decreased during the establishment period, once a forest association had been set up, the rate of change in the areas with forest associations is 16.9 % points higher than in areas without forest associations. In the case of the dummy for 2 years after the establishment, we find no significant effect; however, as above, this finding may reflect the small number of observations for forest associations established in 2007 (i.e., three).

To highlight the results, let us consider what would happen if a forest association were to be established in a hypothetical sub-village with a forest area of 1 km^2 and the average characteristics of all sub-villages. The average annual instantaneous change rate in forest area (i.e., the first difference in the log of the forest area) in this study area is approximately −1.7 %, causing the forest area of the sub-village to be reduced to 0.983 km^2 (=$e^{-0.017}$) 1 year later and 0.967 km^2 (=$e^{-0.017-0.017}$) 2 years later without a forest association. However, if an association were to be set up, the forest area would be reduced to 0.872 km^2 (=$e^{-0.017-0.120}$) 1 year later. It is important to note that the dependent variable in our estimation is the first difference in the log of the forest area, i.e., the instantaneous change rate defined as $(dy_{it}/dt)/y_{it}$, rather than the discrete-time change rate defined as $(y_{it} - y_{it-1})/y_{it-1}$. Therefore, the forest area 1 year after the establishment of the forest association is not $1 - 0.017 - 0.120 = 0.863$, but $e^{-0.017-0.120} = 0.872$, although the two values are close to each other. Two years after the establishment of the forest association, the forest area would become 1.015 km^2 (=$e^{-0.017-0.120-0.017+0.169}$). Therefore, our results suggest that the establishment of a forest association increases the forest area by 1.5 % in the first 2 years compared with a decrease of 3.3 % without the association. Thus, the establishment of forest associations leads to a net increase in forest area of 4.8 %.

Another important finding is that both dummy variables for areas located near forest associations established in 2007 and 2008 are insignificant, which suggests that the establishment of forest associations does not exert greater pressure on surrounding forest areas.

Furthermore, we test for the endogeneity of the three dummy variables in Eq. (1) using Durbin–Wu–Hausman (DWH) tests. The null hypothesis is rejected ($P < 0.01$); in other words, these dummy variables are endogenous.

Table 5 Results from the instrumental variable estimation

Independent variables	(1) 2SLS	(2)	(3)	(4)	(5) 2SLS
	1st Stage	1st Stage	1st Stage	2nd Stage	
Number of households in sub-village	0.0025 (0.1102)	−0.0018 (−0.1065)	−0.0010 (−0.1956)	−0.0066 (−0.3987)	
Average slope	0.0010 (0.2861)	−0.0004 (−0.1476)	−0.0000 (−0.0030)	0.0005 (0.1883)	
Proportion of acrisol	−2.9666 (−0.5004)	0.0192 (0.0044)	0.0033 (0.0024)	−2.2260 (−0.5191)	
Dummy for areas located near a forest association established in 2007	−0.0782 (−0.6682)	−0.0001 (−0.0013)	0.0003 (0.0095)	−0.0965 (−1.1363)	
Dummy for areas near a forest association established in 2008	−0.3623*** (−5.0769)	−0.0266 (−0.5015)	−0.0001 (−0.0079)	0.0310 (0.5954)	
Predicted probability of the establishment of a forest association	1.0362*** (13.7566)	0.0057 (0.1018)	0.0006 (0.0335)		
Predicted probability of having a forest association for 1 year	−0.0885 (−0.6980)	0.9941*** (10.5509)	−0.0033 (−0.1105)		
Predicted probability of having a forest association for 2 years	−0.1098 (−0.2987)	−0.0019 (−0.0069)	1.0443*** (12.1616)		
Year of establishment dummy				−0.1199** (−2.2710)	−0.1084** (−1.9813)
1 Year after establishment dummy				0.1685* (1.8832)	0.1600* (1.7705)
2 Years after establishment dummy				0.2486 (0.9785)	0.2095 (0.8986)
Constant	0.0155 (0.3923)	0.0063 (0.2146)	0.0007 (0.0771)	0.0123 (0.4264)	0.0075 (0.4473)
Observations	352	352	352	352	352
Adjusted R^2	0.4562	0.3373	0.3417	−0.0284	−0.0229

t Statistics are in parentheses

*, **, and *** indicate statistical significance at the 10, 5, and 1 % levels, respectively

Therefore, we can be reasonably confident that the 2SLS model can be used for the estimation.

Discussion

Our empirical results find an overall positive impact resulting from the establishment of forest associations. However, an acceleration of deforestation was also observed during the process of their establishment. This negative effect may be explained by "last-minute" logging by villagers. In fact, during an informal conversation, forest experts assigned to the Belete–Gera RFPA and managers of the project mentioned that such "last-minute" logging was most likely to occur in the project area. We assume that the reason for this behavior among the villagers initially is the concern over losing access to the forestry resources. Although the provision of forest associations ensures the rights of villagers—such as the right to collect wood on the ground, use non-timber forest products, and produce coffee and honey in the forest area—villagers may be concerned that they may no longer be allowed to use the forest after the establishment of the associations, resulting in the engagement in "last-minute" logging.

In contrast, the results show positive effects on forest cover after the establishment of forest associations, implying that villagers stopped engaging in logging in the forest areas. We can think of two possible reasons for this finding. First, villagers gradually improved their understanding of the concept of the project and regulations, resulting in a reduction of concern among villagers. Second, villagers followed the regulations because trust and cooperation among members of a community are strong. Some studies have noted the significance of strong mutual trust within the local community in Ethiopia (Benin and Pender 2006; Negassa 2007), and such strong relations of trust may be the key to the effective functioning of CBFM. Our results suggest that the establishment of forest associations increases the forest area by 1.5 % in the first 2 years. This result suggests that CBFM can more efficiently manage common forest areas than private management systems. However, it is important to note that, as some studies have noted (Ostrom 1990; Klooster 2000), CBFM had been widely advocated not because it increases the size of the forest area but because it enhances the forest cover. Therefore, such an increase in the areas in this study does not imply an increase in forest area over the forest boundary but the enhancement of forest cover within the registered forest area or, more precisely, the regeneration of open areas within the registered forest area.

One potential implication of the results of the CBFM project presented here is that to maximize the outcome of the establishment of forest associations, it is important to improve the monitoring of forest areas during the process of establishing participatory forest management associations. Such a monitoring system may help to prevent "last-minute" logging by villagers.

In this study, we only evaluate the impact of CBFM in the short run. If the ongoing cooperation among members is ensured, the negative effect of the initial tendency of the villagers to intensify logging may return in the long run. Further research, such as a qualitative analysis of the sustainability of forest associations and long-run impact evaluations, is needed.

Conclusion

This study empirically examined the effects of CBFM on forest protection in rural Ethiopia. To this end, we used remote sensing data to identify the forest area and examined the impact of forest associations on the rate of change in forest area. To gauge the impact of forest associations on forest protection, our empirical analysis consisted of two steps to correct for possible biases due to the selection of targeted sub-villages: (1) estimating a multinomial logistic model to compute the predicted probabilities of the establishment of forest associations and (2) examining the impact of forest associations on the rate of change in forest area by employing a 2SLS model using the predicted probabilities as instruments.

The results indicate that, on average, the forest area of the forest associations decreases more in the year of establishment than in a forest area with no association. This finding indicates that villagers may engage in "last-minute" logging due to concerns that they will no longer be allowed to use the forest after the establishment of the association. However, 1 year after the establishment, the forest area of the associations increases substantially, most likely because the associations plant trees at boundary areas between forest and non-forest areas and monitor illegal logging. On average, the forest area of the forest associations increases by 1.5 % in the first 2 years, whereas the forest area of areas with no association declines by 3.3 %. Thus, the cumulative impact over 2 years yields a net increase of 4.8 % points in the rate of change.

We conclude that to maximize the positive effects of the establishment of forest associations, the monitoring of forest areas during the process of setting up participatory forest management associations is important.

Acknowledgments This research was conducted as part of the research project on the "Impact Evaluation of Aid Projects of the Japan International Cooperation Agency" at the JICA Research Institute. The authors would like to thank Yasuyuki Sawada (the Project Leader) and Keiichi Tsunekawa (Director of the JICA Research Institute) for providing us with the opportunity to engage in this research. The authors are also grateful to Naoki Ando, Toru Inada, Takahiro Nakamura, Fumiaki Saso, Hideki Watanabe, and, particularly, Tsutomu Nishimura for their help with data collection.

References

Achard F, Eva HD, Stibig HJ, Mayaux P, Gallego J, Richards T, Malingreau J (2002) Determination of deforestation rates of the world's humid tropical forests. Science 297:999–1002

Adams WM, Brockington D, Dyson J, Vira B (2003) Managing tragedies: understanding conflict over common pool resources. Science 302:1915–1916

Agrawal A, Yadama GN (1997) How do local institutions mediate market and population pressures on resources? Forest panchayats in Kumaon, India. Development and Change 28:435–465

Alemagi D (2010) A comparative assessment of community forest models in Cameroon and British Columbia, Canada. Land Use Policy 27:928–936

Balooni K, Ballabh V, Inoue M (2007) Declining instituted collective management practices and forest quality in Central Himalayas. Economic and Political Weekly 42:1143–1152

Benin S, Pender J (2006) Collective action in community management of grazing lands: the case of the highlands of northern Ethiopia. Environment and Development Economics 11:127–149

Chakraborty RN (2001) Stability and outcomes of common property institutions in forestry: evidence from the Terai Region of Nepal. Ecological Economics 36:341–353

Chen J, Saunders SC, Crow TR, Naiman RJ, Brosofske KD, Mroz GD, Brookshire BL, Franklin JF (1999) Microclimate in forest ecosystem and landscape ecology. Bioscience 49:288–297

Cropper M, Griffiths C (1994) The interaction of population growth and environmental quality. The American Economic Review 84:250–254

Cropper M, Griffiths C, Mani M (1999) Roads, population pressures, and deforestation in Thailand, 1976–1989. Land Economics 75:58–73

Dalle SP, de Blois S, Caballero J, Johns T (2006) Integrating analyses of local land-use regulations, cultural perceptions and land-use/land cover data for assessing the success of community-based conservation. Forest Ecology and Management 222: 370–383

Davenport ML, Nicholson SE (1993) On the relation between rainfall and the normalized difference vegetation index for diverse vegetation types in East Africa. International Journal of Remote Sensing 14:2369–2389

Duflo E, Pande R (2007) Dams. Quarterly Journal of Economics 122:601–646

Edmonds EV (2002) Government-initiated community resource management and local resource extraction from Nepal's forests. Journal of Development Economics 68:89–115

Ellis EA, Porter-Bolland L (2008) Is community-based forest management more effective than protected areas? A comparison of land use/land cover change in two neighboring study areas of the Central Yucatan Peninsula, Mexico. Forest Ecology and Management 256:1971–1983

Ethiopian Forestry Action Programme (1994) The challenge for development: final report. Addis Ababa

Geist HJ, Lambin EF (2002) Proximate causes and underlying driving forces of tropical deforestation. Bioscience 52:143–150

Hayami Y, Godo Y (2005) Development economics: from the poverty to the wealth of nations. Oxford University Press, Oxford

Jensen J (1996) Introductory digital image processing. Prentice Hall, Englewood Cliffs

Kijima Y, Sakurai T, Otsuka K (2000) Iriaichi: collective versus individualized management of community forests in postwar Japan. Economic Development and Cultural Change 48:867–886

Klooster D (2000) Institutional choice, community, and struggle a case study of forest co-management in Mexico. World Development 28:1–20

Lund JF, Treue T (2008) Are we getting there? Evidence of decentralized forest management from the Tanzanian Miombo woodlands. World Development 36:2780–2800

Matta JR, Alavalapati JRR (2006) Perceptions of collective action and its success in community based natural resource management: an empirical analysis. Forest Policy and Economics 9:274–284

Negassa A (2007) The role of trust among actors in common-pool resource management: empirical evidence from participatory forest management in Ethiopia. Participatory forest management. In: International conference of biodiversity and livelihoods in Africa, Addis Ababa, Ethiopia, pp 151–161

Ostrom E (1990) Governing the commons: the evolution of institutions for collective action. Cambridge University Press, Cambridge

Ostrom E (1999) Self-governance and forest resources. Centre for International Forestry Research Occasional Paper 20, Bogor

Ostrom E, Nagendra H (2006) Insights on linking forests, trees, and people from the air, on the ground, and in the laboratory. Proceedings of the National Academy of Science of the USA 103:19224–19231

Pretty J, Ward H (2001) Social capital and the environment. World Development 29:209–227

Ribot JC, Lund JF, Treue T (2010) Democratic decentralization in Sub-Saharan Africa: its contribution to forest management, livelihoods, and enfranchisement. Environmental Conservation 37:35–44

Somanathan E, Prabhakar R, Mehta BS (2005) Does decentralization work: forest conservation in the Himalayas. BREAD Working Paper 096

Southworth J, Tucker CM (2001) Forest cover change in western Honduras: the role of socio-economic and biophysical factors, local institutions, and land tenure. Mountain Research and Development 21:276–283

Southworth J, Munroe D, Nagendra H (2004) Land cover change and landscape fragmentation—comparing the utility of continuous and discrete analyses for a western Honduras region. Agriculture Ecosystems and Environment 101:185–205

Takahashi R, Todo Y (2011) Impact of community management on forest protection: evidence from an aid-funded project in Ethiopia. http://jica-ri.jica.go.jp/publication/assets/JICA-RI_WP_No31_2011.pdf. Accessed 12 Sep 2011

Todo Y, Takahashi R (2011) Impact of farmer field schools on agricultural income and skills: evidence from an aid-funded project in rural Ethiopia. Journal of International Development. doi:10.1002/jid.1819

Tole L (2010) Reforms from the ground: a review of community-based forest management in tropical developing countries. Environmental Management 45:1312–1331

Tucker CJ, Townshend JRG, Goff TE (1985) African land-cover classification using satellite data. Science 227:369–375

Tucker CJ, Slayback DA, Pinzon JE, Los SO, Myneni RB, Taylor MG (2001) Higher northern latitude normalized difference vegetation index and growing season trends from 1982 to 1999. International Journal of Biometeorology 45:184–190

United Nations Statistical Division (2010) Environmental indicators. http://unstats.un.org/unsd/environment/forestarea.htm. Accessed 12 Sep 2011

Urgessa K (2003) Perceptions of forest cover and tree planting and ownership in Jimma zone, Ethiopia. Unasylva 54:18–22

White MA, Nemani RR (2006) Real-time monitoring and short-term forecasting of land surface phenology. Remote Sensing of Environment 104:43–49

Zhang Q, Devers D, Desch A, Justice CO, Townshend J (2005) Mapping tropical deforestation in central Africa. Environmental Monitoring and Assessment 101:69–83