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

Ryo Takahashi* and Yasuyuki Todo†

Abstract

This study uses remote sensing data to quantitatively examine the impact of establishing participatory forest management associations in Ethiopia. The results indicate that where there is a forest association, forest area declines more in the year the association is established than it does in a forest area where there is no association. This suggests that villagers may engage in "last-minute" logging. However, one year after associations are established, forest area where there is an association increases substantially, probably due to the associations planting trees at boundary areas between forest and non-forest and monitoring illegal logging. On average, where there are forest associations, forest area increases by 1.5 percent in the first two years, while forest area where there is no association declines by 3.3 percent. Totaling this impact over two years yields a 4.8 percent positive net increase in the rate of change.

Keywords: impact evaluation, remote sensing, forest protection, community management, Ethiopia

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1. Introduction

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

Among the many factors driving such deforestation, agricultural expansion due to indefinite rights of land ownership and use are the most common in Sub-Saharan Africa (Geist and Lambin 2002). To prevent deforestation, African countries have recently been promoting community forest management rather than centralized forest management, in light of the many studies advancing the concept that local communities may be able to manage common-property resources[1] more efficiently and sustainably than government agencies (Agrawal and Yadama 1997; Ostrom 1999; Adams et al. 2003). According to Hayami and Godo (2005), this is more likely to be the case in less developed countries, as most local societies in less developed countries are based on trust and cooperation among members of a community, and hence they monitor and punish irresponsible users.[2]

A large number of empirical studies find evidence of the effectiveness of community forestry in forest conservation (Edmonds 2002; Somanathan et al. 2005; Dalle et al. 2006; Ellis and Porter-Bolland 2008; Lund and Treue 2008). However, the empirical results have not converged on a consensus: other studies such as Kijima et al. (2000) find that private ownership is more efficient than common ownership as a forest management method. In addition, most

1. Common-property resources include: (1) property owned by a government, (2) property owned by no one, and (3) property owned and defended by a community of resource users (Schlager and Ostrom 1992). The term “community forest management” used in this study refers to systems of management by the local community of common-property resources in forests.
2. We would not argue this is always the case, as we recognize the existence of power struggles, corruption, and ethnic strife at the community level in less developed countries.

existing studies on forest management in less developed countries target Asia or South America, and there is insufficient evidence available for Africa.

Therefore, as a case study from Africa, this study examines forest management in Ethiopia, where deforestation is severe, and quantifies the impact on forest protection of the Participatory Forest Management Project in Belete-Gera Regional Forest Priority (hereafter, "the project") implemented by Japan International Cooperation Agency (JICA), a Japanese foreign aid agency. In the project, participatory forest management associations (hereafter, "forest associations") were established at the sub-village level to identify the border between forest and homestead/farmland and to prohibit logging in the forest area.

One important contribution of this study is the use of remote sensing data from satellite images to create a panel data set of the rate of change in forest areas and other geographic variables for each sub-village between 2006 and 2010. Although remote sensing data have been used to examine determinants of deforestation in existing studies, such as Cropper et al. (1999), Geoghegan et al. (2001), and Deng et al. (2011), the spatial unit of observation used in these studies was quite large: for example, one square kilometer in Deng et al. (2011). This study uses a much smaller unit (30 square meters) to estimate changes in forest area more precisely.

We estimate the impact of the project on the rate of change in forest area, using two stage least squares (2SLS) to control for possible biases due to the selection of sub-villages for implementing the participatory forest associations. In the 2SLS estimations, we use as instrumental variables the predicted probability of establishing a forest association determined by geographic variables such as the distance between each sub-village and a JICA office in the region. We also estimate the effect of forest associations as they were being established. This effect can be negative if villagers engaged in "last-minute" logging while forest associations were being established, probably due to concerns that they may not be allowed to use the forest any more. In fact, in informal conversation with the authors, project managers and local staff mentioned the possibility that such last-minute logging occurred in the project area.

Furthermore, we examine whether establishing forest associations causes deforestation in the surrounding forest area, as such a leakage effect is often found (Chakraborty 2001; Ostrom and Nagendra 2006; Balooni et al. 2007). Because establishing forest associations comes together with being prohibited from using the forest area, villagers in sub-villages with forest associations may extract wood in neighboring forest areas where forest associations have not yet been established.

The estimation results indicate that where there are forest associations, forest area decreases more in the year the associations are established than it does where there is no association, possibly because of "last-minute" logging. However, one year after a forest association is established, its forest area increases substantially. As a result, in sub-villages with a forest association, the forest area increases by 1.5 percent on average in the first two years while and after the association is established, whereas without the association, the sub-villages would have lost 3.3 percent of their forest area during the same period. Another important result is that we could not find any significantly negative impact of forest associations on the surrounding forest area. This finding suggests that wood extraction in neighboring forest areas where forest associations had not yet been established did not increase due to logging by villagers from sub-villages with a forest association.

1. Description of the project[3]

2.1 Project area

The project targeted Belete-Gera Regional Forest Priority Area (RFPA), which is located in Gera District and Shabe Sombo District in Oromia Region (Figure 1), and has a total forest area of about 1,500 square kilometers: an area more than twice as large as Singapore. There are 30 villages and 81 sub-villages in Gera District and 14 villages and 42 sub-villages in Shabe Sombo District. Forest residents are mostly farmers, producing cereals such as wheat,

3. This section is mostly based on the terminal evaluation report of the project (JICA 2010) and interviews with managers of the project.

barley, and teff, as well as vegetables, honey, milk, and coffee.

The forest cover in the RFPA has declined significantly despite the government's declaration to prohibit wood extraction in the forest area. According to our estimates using satellite images, the forest area in the two districts in the RFPA decreased by 40 percent during the period 1985-2010. Forest destruction can be visually identified in images of the forest area (Figure 2). There are three possible explanations for the rapid deforestation in this area: (1) the expansion of farmland and/or grazing land into the forest; (2) wood extraction for home consumption and the commercial sale of firewood and timber; and (3) illegal settlement by migrants from other regions.

2.2 Project outline

In 2003, JICA and Oromia Forest and Wildlife Enterprise, a public institution in charge of forest preservation in the Oromia Region, launched the project to undertake forest protection in the RFPA. The major component of the project was to establish participatory forest management associations (called "WaBuBs" in the local language) at the sub-village level. Before the implementation of the project, extracting wood from the forest and expanding farmland or grazing land into the forest area were left to the judgment of individual villagers. However, once a forest management association was established, the border between homestead/farmland and forest was clearly identified and marked with paint by association members; from that point, exploiting the registered forest area, such as for expanding farmland, extracting wood, and planting trees, was strictly prohibited, except for necessary thinning and permitted harvesting of wood for home construction. Members of the associations regularly monitored and evaluated conditions in the forest. In addition, forest associations planted trees in boundary areas between homestead/farmland and forest and in wastelands within forests.

In return, the members were given the right to live in the forest area, to use non-timber forest products, and to produce coffee and honey in the forest area. In addition, the project provided two channels of income generation to the association members. Firstly, farmer field schools (WaBuB field schools) were established together with the forest management associations to provide agricultural skills training to the association members. Secondly, a WaBuB forest coffee certification program supported producers of forest coffee in obtaining forest coffee certification from the Rainforest Alliance, a US-based NGO, whereby the price of certified coffee at the farm gate became 15-20 percent higher than the regular price.

Table 1 shows the number of forest management associations established by year. Preparation for establishing an association usually started in October and was completed around August and September the following year, although it was completed earlier in some cases. Therefore, the number of associations established in year *t* in Table 1 actually shows the number of associations established from October in the year *t*-1 to September in the year *t*. Associations were established at a slow rate in the early period of the project, but this accelerated in 2008. Forest management associations had been established in all the sub-villages in the Belete-Gera RFPA by September 2010.

3. Data

3.1 Data source

To estimate the forest area at the sub-village level, we use data from satellite images taken by Landsat 5 and 7. Landsat satellite images offer the longest period of observation: Landsat 5 started recording images in 1984;[4] the pixel size is 30 m by 30 m. For our analysis, we used Landsat images of bands 3 and 4 from path/row 170/55 for January in the following nine years: 1985, 1995, 2001, 2005, 2006, 2007, 2008, 2009, and 2010. The reason for selecting January as the target month is that January in Jimma zone is during the dry season, and so satellite images taken during this month are least likely to be affected by cloud. Because the

4. It should be noted that Landsat 7, which has been recording images since 1999, experienced a failure of its Scan Line Corrector (SLC), meaning that there are data gaps in the satellite images. We fill in these gaps with predicted images which we estimate using neighborhood statistics.

image for 2008 was affected by cloud, we built a composite image using data for December 2007. Ground truthing was conducted in May 2010, and six points from three villages were chosen: one from the Gera forest and two from the Belete forest.[5]

The boundaries of the forest associations were recorded by walking along the boundaries carrying a GPS device. However, it should be noted that the boundaries thus recorded do not exactly match the actual boundaries, simply because in some cases the terrain made this impossible. In such cases, we approximate the boundaries by connecting several recorded boundary data points. The total number of forest associations in our study area is 92, with 56 in Gera forest and 36 in Belete forest.

Establishing the forest associations took about a year each, with proceedings usually starting in August or September. The first three were set up in 2007, followed by another 32 in 2008, and 57 in 2009. However, whereas the forest associations were set up in August or September, the sensing data we use, as mentioned above, were collected in January. Thus, the timing of the data collection does not match the timing of establishing the forest associations. As Figure 3 shows, the first three were established in August or September in 2007, and the rate of change in forest area from January 2007 to January 2008 for these forest associations includes the establishment period, which was from January to August or September 2007. We define this period as the "year of establishment" and "last-minute" logging may be observed at this point. Any positive impact of the forest associations is most likely to be observed later: that is, one or two years after they were established.

To distinguish between forest areas and non-forest areas using satellite images, we utilize the Normalized Difference Vegetation Index (NDVI), a measure of vegetation commonly used in remote sensing studies such as Tucker et al. (1985), Davenport and Nicholson (1993), and Tucker et al. (2001). The NDVI is calculated from Landsat bands 3 (red) and 4

5. Ground truthing refers to fieldwork conducted to ensure that the pixels of a satellite image accurately represent features on the surface of the earth. We used a GPS device to collect several data points at the boundaries of forest areas, inside forest areas, and on grazing land.

(near-infrared) based on the following formula:

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}, \qquad (1)$$

where *RED* and *NIR* stand for the spectral reflectance measurements acquired in the red and near-infrared spectral bands, respectively. The NDVI takes a value between -1.0 and 1.0 and increases with the degree of vegetation coverage (Jensen 1996). Following Southworth et al. (2004) and White and Nemani (2006), we determine an NDVI threshold value for forest areas based on information from satellite images and fieldwork. Details of the procedure to determine the threshold are explained in the Appendix. Next, we classify each locational unit in the satellite images (30 square meters) with an NDVI value above the threshold as a forest area and other locations as non-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 land, young fallow, rangeland, cleared areas, bare-soil areas, and urban areas.

An advantage of our method using satellite images is that we can identify forest areas for multiple years, and thus we can estimate the annual rate of change in forest area at the sub-village level during the period examined. Although forest areas in the same region were identified using aerial photographs in 1998 in another JICA project (JICA 1998), that method is limited in that it provides information on forest areas only in one year. Figure 4 illustrates the annual rate of change in the forest area for each sub-village in the project area estimated using the NDVI-based method outlined above. The figure shows that the rate of change differs across forest association areas.

3.2 Summary statistics

Our sample consists of all sub-villages in the project area in which forest associations were established in or before 2009 (the data collection year). Our sample does not include sub-villages having no association in 2009, because the boundaries of such sub-villages were not available. In addition, we do not use forest areas outside the RFPA as control observations, as such forests may be substantially different in natural environment from the forest in the RFPA. However, we still can estimate the impact of forest associations on reforestation, because the year of establishment differs across sub-villages in the RFPA. In other words, we will compare the rate of change in forest area where forest associations had already been established with that of other areas where associations had not yet been established but would be later.

Summary statistics of the area of the forest associations are provided in Table 2. The total area that came under management by forest associations in 2007 was 8,442 ha. Approximately 21,500 ha were added to this total area in 2008 and approximately 31,000 ha in 2009, for a total of approximately 61,000 ha of forest area that came under management by forest associations between 2007 and 2009. Comparing the Gera and Belete forest areas (Table 3), the forest area under management by forest associations and the number of households per forest association tend to be larger in Gera. The forest area decreased about 1.7 percent annually on average between 1995 and 2006 in this study area. The average elevation in Gera forest is higher than in Belete forest ($p < 0.05$). On the other hand, the average slope is greater in Belete forest than in Gera forest ($p < 0.01$). The proportion of acrisol is close to zero in both Gera and Belete forest areas.[6]

4. Empirical framework

This section provides an overview of the empirical framework employed in this study. To examine the impact of the forest associations, we employ a difference-in-differences approach, estimating the impact of establishing forest associations on the rate of change in

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

forest area at three points in time, i.e., the year a forest association is established, one year after being established, and two years after being established. We also estimate the effect on the surrounding forest area. The estimation equation is specified as follows:

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

where y_{it} is the forest area of sub-village i in year t, and therefore log y_{it} - log $y_{it\text{-}1}$ indicates the rate of change in forest area of sub-village i between year t and t-1. To examine the impact of establishing forest associations on the rate of change in forest area at three different points in time, we create three dummy variables for each point. $EST^{0}_{it\text{-}1}$ takes a value of 1 if sub-village i was in the process of establishing a forest association in year t-1. $EST^{1}_{it\text{-}1}$ and $EST^{2}_{it\text{-}1}$ take a value of 1 if sub-village i had had a forest association for one and two years in year t-1, respectively. To examine the possibility that establishing forest associations has a negative effect on the surrounding forest area, we also include the dummy variables $PERI^{07}_{it\text{-}1}$ and $PERI^{08}_{it\text{-}1}$ in equation (2), which take a value of 1 if sub-village i is located next to an area where a forest association was established in 2007 or 2008, respectively. Although there is a possibility that the leakage effect goes beyond adjacent sub-villages, we assume that this possibility is low due to poor accessibility between sub-villages in this mountainous area.

X_{it} denotes environmental factors of sub-village i during the observation period, and includes the following: the distance to the nearest paved road; the number of households in the sub-village; the average elevation; the average slope; and the proportion of acrisol. Many studies show evidence that population growth reduced forest area (Cropper and Griffiths 1994; Cropper et al. 1999; Zhang et al. 2005), and thus we would expect a positive effect on the change in forest area from a negative effect in the number of households in the sub-village. We also presume, as suggested by Chen et al. (1999) and Cropper et al. (1999), that forest is affected by the three environmental variables: the average elevation, the average slope, and the proportion of acrisol.

The independent variables EST^{0}_{it-1}, EST^{1}_{it-1}, and EST^{2}_{it-1} in equation (2) are endogenous, as they are correlated with ε_{it} due to selection of sub-villages for establishing forest associations. Although forest associations were to be set up in all sub-villages by the end of the project in 2010, some associations were established relatively early, while others were established relatively late, in the project period. The selection of sub-villages for establishing forest associations earlier was not random, and was likely determined by the accessibility of the sub-villages or by forest conditions. The selection may generate biases in the ordinary least squares (OLS) estimation of equation (2). Therefore, in this study, we take the following two steps to reduce endogeneity. Similar procedures are employed in, for example, Duflo and Pande (2007).

First, we use a multinomial logistic model and identify the determinants of establishing forest associations:

$$\text{Prob}(EST_i = j) = \frac{\exp(\gamma_j' Z_i + \delta_j' X_i)}{1 + \sum_{j=1}^{2} \exp(\gamma_j' Z_i + \delta_j' X_i)}, \quad (3)$$

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.

X_i represents the environmental characteristics of sub-village i that determine the change in forest area and which are thus included in the estimation of equation (2): the distance to the nearest paved road; the number of households in the sub-village; the average slope; and the proportion of acrisol. We include these variables as independent variables in equation (3), as they are assumed to be exogenous in equation (2) and may have affected the project manager's decisions on the order in which sub-villages were selected for establishing forest associations.

Z_i represents variables that determine the selection of sub-villages for forest associations but which do not determine the change in forest area, including the distance to the closest JICA office (JICA has two offices: one in Jimma City and the other in Gera District), the deforestation rate between 1995 and 2006, and the dummy variable for Gera District. We select these variables because the project may have chosen sub-villages that were located closer to the project office for forest associations to be established earlier, and may have selected forests in which deforestation in the pre-project period was more substantial.

Using the results of the multinomial logistic estimation, we calculate the predicted probability of forest associations being established for each year and define three variables $E\hat{S}T^{0}_{it-1}$, $E\hat{S}T^{1}_{it-1}$, and $E\hat{S}T^{2}_{it-1}$ as the predicted probability that a forest association would be established in sub-village *i* in year *t* - 1, *t* - 2, and *t* - 3, respectively.

Second, to reduce biases due to endogeneity of the dummy variables for forest associations being established in each year, we employ a 2-stage least squares (2SLS) approach to estimate equation (2) using $E\hat{S}T^{0}_{it-1}$, $E\hat{S}T^{1}_{it-1}$, and $E\hat{S}T^{2}_{it-1}$ as instruments for EST^{0}_{it-1}, EST^{1}_{it-1}, and EST^{2}_{it-1}. The predicted probabilities of associations being established are closely related to the dummies for the actually established associations, but are obtained from a nonlinear function of geographic variables such as slopes and distance. Therefore, the predicted probabilities are most likely to be unrelated to the error term in equation (2) after controlling for necessary geographic variables (*X*), and thus can be used as instruments in the 2SLS estimation of (2).[7]

5. Estimation results

The estimation results from the multinomial logistic model are presented in Table 4, with column 1 showing the results for forest associations established in 2007 and column 2

7. Cropper et al. (1999) find a negative effect of roads on forest. However, when the distance to the nearest paved road is included in *X* in the estimation of equations (2) and (3), the effect of any independent variable in the multinomial logistic estimation becomes insignificant, probably due to multicollinearity. Therefore, we do not use the distance to the nearest paved road. Note, however, that when we used the insignificant coefficients from the multinomial logistic estimation to compute the predicted probabilities, we found that the results from the 2SLS were virtually the same as the benchmark results.

those for forest associations established in 2008. As expected, distance to the closest JICA office has a negative and significant effect on forest associations being established in 2008, implying that being closer to a JICA office increased the likelihood of early selection. On the other hand, the result for this variable is insignificant for 2007, but the reason for this may be that the number of observations is very small: 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 having been selected in 2007 but not in 2008, indicating that forest associations were established in larger sub-villages in the earlier period of the project. Finally, in 2008, the deforestation rate between 1995 and 2006 had a weakly significant ($p < 0.10$) positive effect on the selection of forest associations. This indicates that the higher the rate of deforestation, the more likely a village was to be selected in 2008.

Next, we perform 2SLS to estimate the impact of the forest associations using the predicted probability of the forest associations in each period as instruments. The results of the first stage of the 2SLS are presented in columns 1 to 3 in Table 5, showing that the predicted probabilities are significantly correlated with the actual establishment and presence of forest associations. Therefore, the instruments seem not to be weak in the 2SLS estimation.

The results of the second stage of the 2SLS estimation are presented in column 4. There are two important findings from the estimation results. First, the dummy for the year of establishment is negative and significant at the 5-percent 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 12.0 percentage points lower than that for sub-villages without a forest association. This result suggests that deforestation actually accelerated, as villagers may have engaged in “last-minute” logging due to concerns that they may not be allowed to use the forest any more. Second, we find that the dummy for one year after establishment is positive and significant at the 10-percent level of significance.[8] This result indicates that even though the rate of change in forest area decreased during the establishment period, once a forest association had been set up, the rate of change in the forest area with forest associations became higher than that without forest associations by 16.9 percentage points. On the other hand, we find no significant effect on the change in forest area two years after establishing a forest association, but again the reason may be that the number of observations for forest associations established in 2007 is extremely small (i.e., three).

To highlight the results, let us consider what would happen if a forest association were established in a hypothetical sub-village with a forest area of 1 square kilometer (km^2) and possessing the average characteristics of all sub-villages. The average annual instantaneous rate of change in forest area (i.e., the first difference in the log of forest area) in this study area is about -1.7 percent, and so, without a forest association, the forest area of the sub-village would become 0.983 km^2 (= $e^{-0.017}$) a year later and 0.967 km^2 (= $e^{-0.017-0.017}$) two years later. However, if an association were set up, the forest area would become 0.872 km^2 (= $e^{-0.017-0.120}$) a year later. It is important to note that because the dependent variable in our estimation is the first difference in the log of forest area, i.e., the instantaneous rate of change, defined as $(dy_{it}/dt)/y_{it}$, rather than the discrete-time rate of change, defined as $(y_{it}- y_{it-1})/y_{it-1}$, the forest area one year after establishing 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 establishing 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 establishing a forest association increases the forest area by 1.5 percent in the first two years, as compared with a decrease by 3.3 percent without the association. Thus,

8. We realize that the 10-percent level of significance found in these estimations is not very high. However, we check the robustness of the results by changing the independent variables in equation (2), and we still find the same statistical significance (see column 5 in Table 5).

establishing forest associations leads to a net increase in forest area of 4.8 percent.[9]

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

To check the robustness of the benchmark results, we drop all the control variables in the second stage of the 2SLS, as they were found to be insignificant. The results presented in column 5 of Table 5 are qualitatively the same as, and quantitatively similar to, the results in column 4. We also experiment with several sets of the control variables and find that the results are virtually the same. For simplicity of presentation, the latter results are not presented here, but are available from the authors upon request.

For reference, we also show the results from an OLS estimation in column 6 of Table 5. The dummies for the year of establishment and for one year after establishment, which were found to be significant in the 2SLS estimation, are insignificant in the OLS estimation. The difference between the 2SLS and the OLS results, combined with the results from the multinomial logistic model in Table 4, suggests that because sub-villages that were in more danger of deforestation were chosen for establishing forest associations earlier, a simple comparison of the change in forest area between sub-villages with and without a forest association is misleading in evaluating the effect of the project.

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9. Alternatively, we can calculate the effect of a forest association in the first two years by summing equation (2) and the corresponding equation for the previous period:

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

Assuming that a forest association is established in year *t*-2 implies $EST^0_{it-2} = 1$, $EST^1_{it-2} = 0$, $EST^0_{it-1} = 0$, and $EST^1_{it-1} = 1$. Therefore, this equation indicates that the instantaneous rate of change in forest area from year *t* -2 to *t*, due to establishing the forest association in year *t*-2, is $\beta_1 EST^0_{it-1} + \beta_1 EST^0_{it-2} + \beta_2 EST^1_{it-1} + \beta_2 EST^1_{it-2} = \beta_1 + \beta_2 = 0.049$. This value is slightly different from 4.8 percent, reflecting the conceptual difference between the instantaneous rate of change and the discrete-time rate of change.

6. Conclusion

This study empirically examined the effects of establishing forest associations 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 selection of the targeted sub-villages: a first step for estimating a multinomial logistic model to compute the predicted probabilities of forest associations being established; and a second step for examining the impact of forest associations on the rate of change in forest area by employing an instrumental variable approach using the predicted probabilities as instruments.

The results indicate that, on average, the forest area where there are forest associations decreases more in the year of establishing the association than it does in forest area where there is no association. This suggests that villagers may engage in "last-minute" logging. However, one year after establishment, the forest area where there are associations increases substantially, probably because the associations plant trees at boundary areas between forest and non-forest and monitor illegal logging. On average, the forest area where there are forest associations increases by 1.5 percent in the first two years, while forest area where there is no association declines by 3.3 percent. Totaling the impact over two years yields a positive net increase in the rate of change by 4.8 percentage points.

In addition, we did not find any significant negative effect on surrounding forest areas, which suggests that wood extraction in forests where a forest association had not yet been established did not increase due to logging by villagers from sub-villages with a forest association. The conclusion to be drawn from these results is that in order to maximize the positive effects of establishing forest associations, it is essential to monitor forest areas during the process of setting up participatory forest management associations.

Appendix: Determination of the NDVI threshold value for forest areas

To set an NDVI threshold value for forest areas, we employ three ground truth steps. First, we collect locational data (the longitude and the latitude) of 17 points at boundaries between forest and non-forest areas that were boundaries at least during the period 2007-2010 (according to interviews with local residents). Second, we check whether these locations on the actual boundaries are on apparent boundaries in false color images from remote sensing analysis. Finally, among the actual boundary locations that are also on boundaries in satellite images, we choose the one with the highest NDVI value for each year and set the threshold value for forest areas at this highest value. The threshold value is 0.2801 in 2007, 0.3805 in 2008, 0.3913 in 2009, and 0.1902 in 2010. Note that the threshold value is different across years, as the NDVI varies depending on the conditions of the air and the weather when satellite images are taken.

Although this methodology is used in many studies such as Southworth et al. (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, as the same error would affect any locational unit within the same year, the rate of change in forest area for sub-villages with and without a forest association is over- or under-estimated 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.

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Figure 1: Belete-Gera regional forest priority area

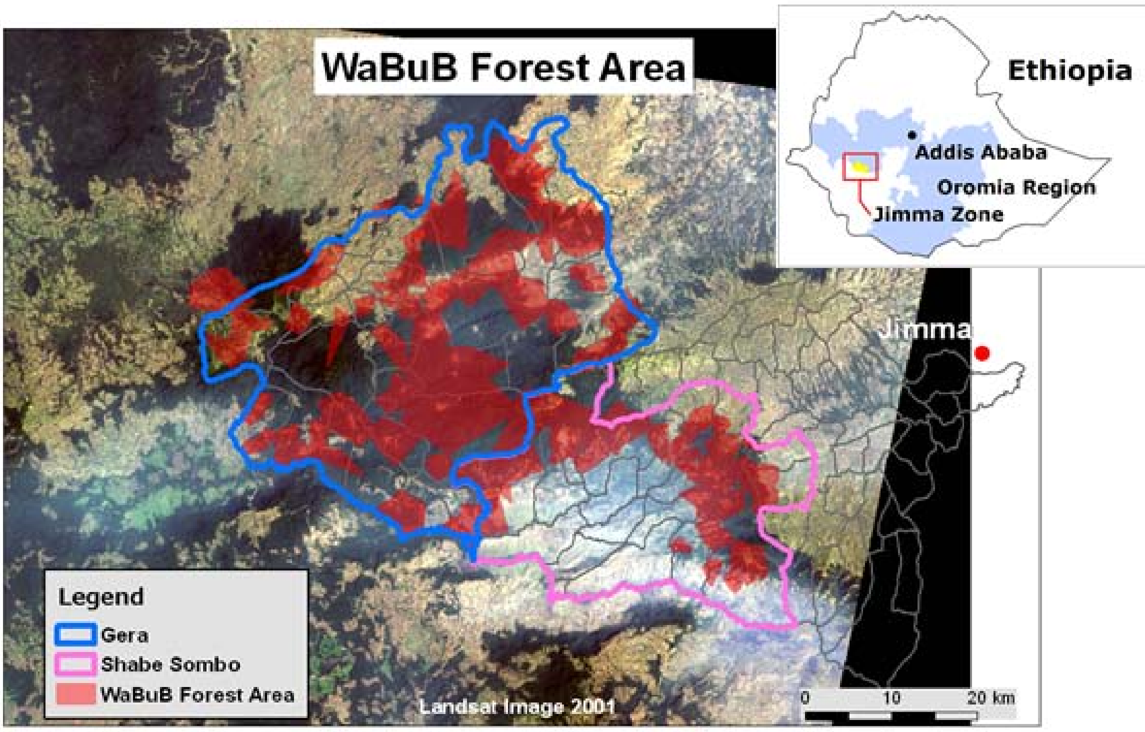
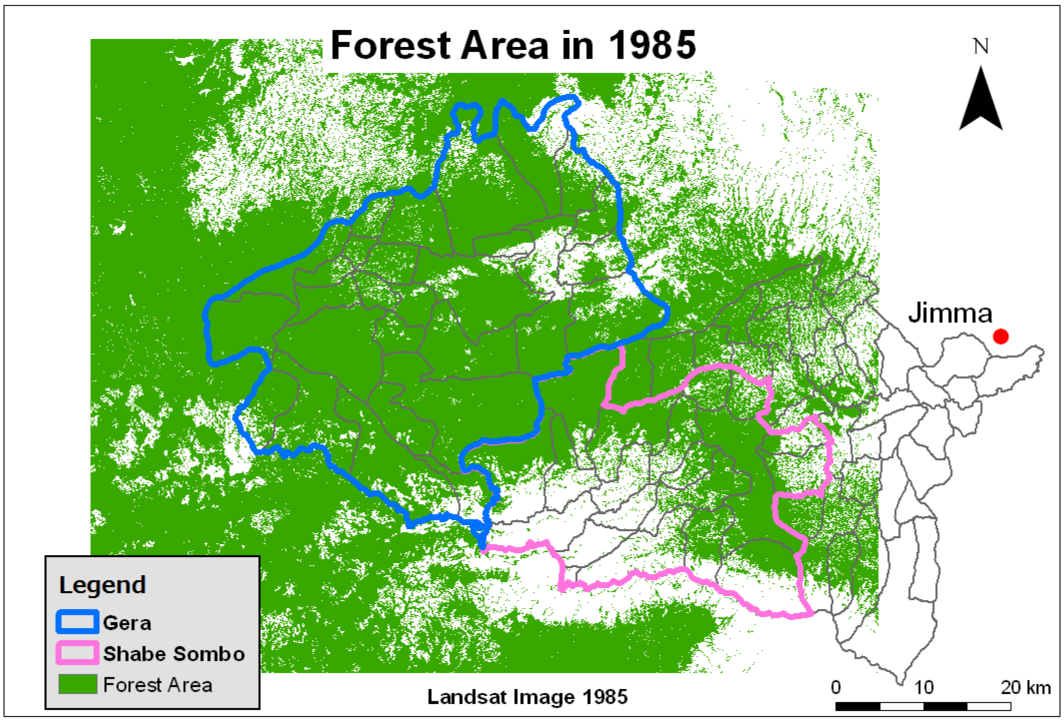


Figure 2: Maps of the project area

(A) Forest area in 1985



(B) Forest area in 2009

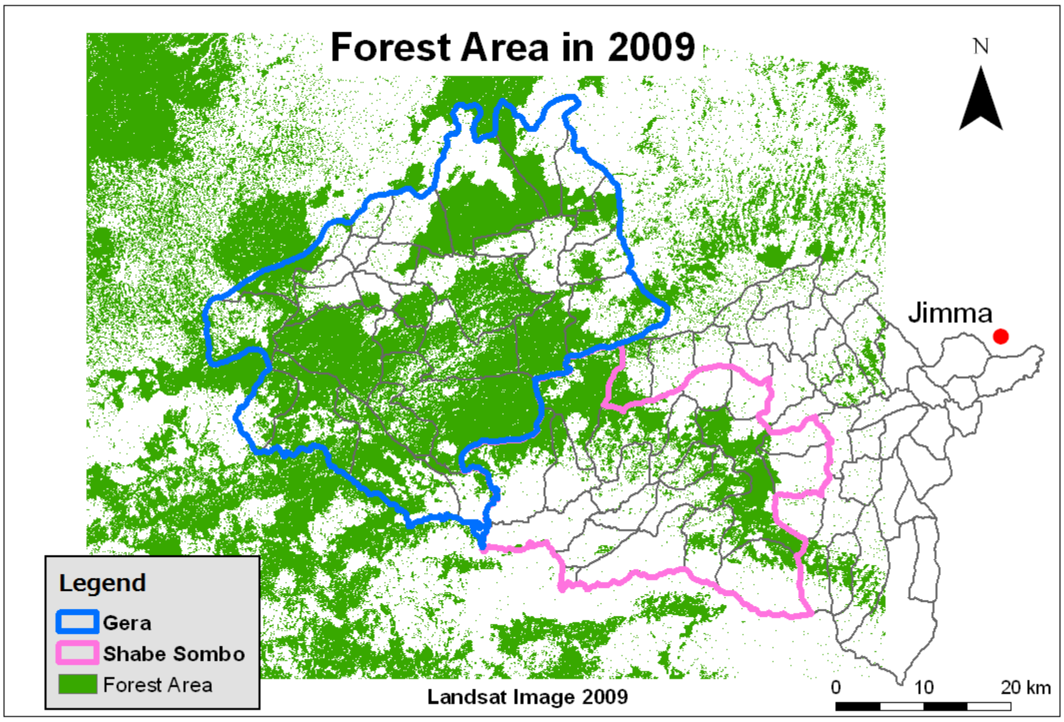
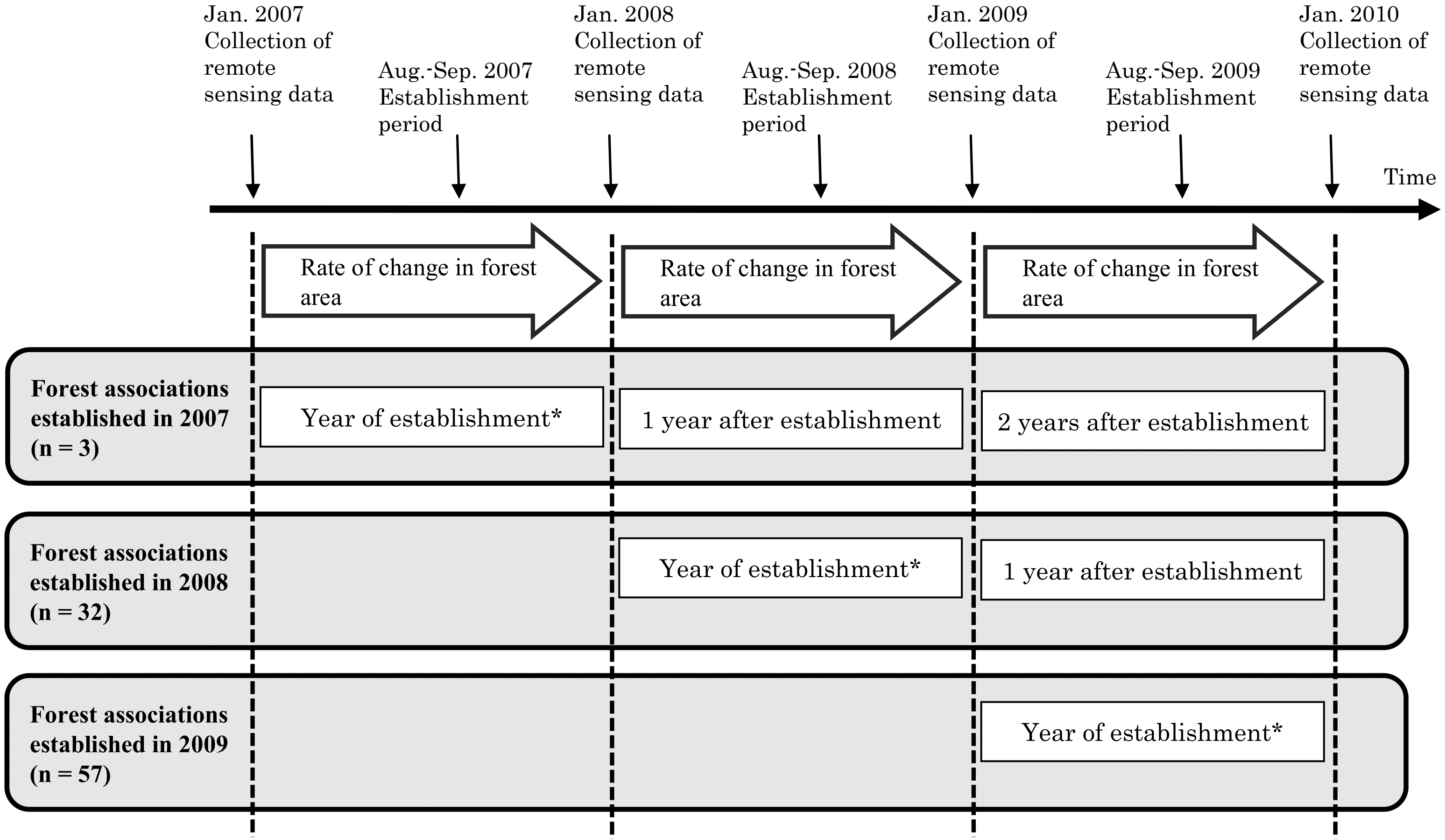


Figure 3: Timing of collection of remote sensing data and establishment of forest associations



* The rate of change in forest area includes the establishment period (i.e., from January to August or September in each year). Therefore, any positive impact from establishing forest associations is likely to be small in the year of establishment, and is most likely to be observed only from the following year: that is, one year or two years after establishment.

Figure 4: Annual rate of change in forest area (2006–2009)

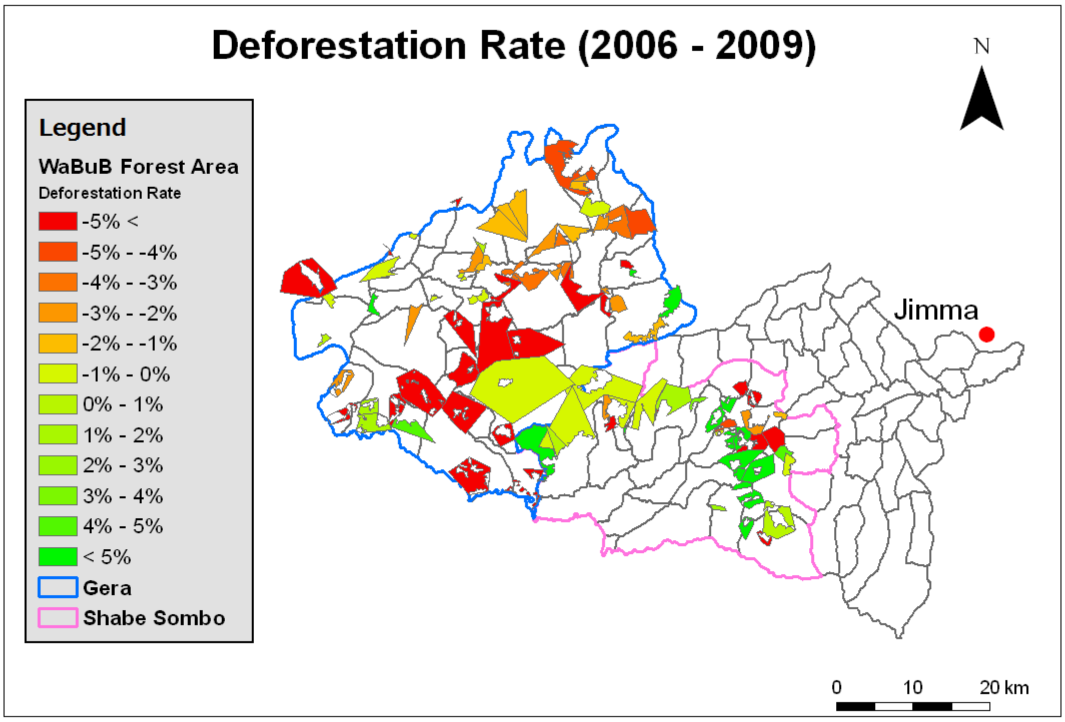


Table 1: Establishment of forest management associations

	Total number of sub-villages in RFPA	Number of associations established			
		2007	2008	2009	2010
Gera Forest	80	2	19	36	23
Belete Forest	45	1	13	22	9
Total	125	3	32	58	32

Table 2: Summary statistics of areas under management by forest associations by year of establishment

	No. of forest associations	Area (ha)					
		Mean	S.D.	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 environmental characteristics of Gera and Belete forests

	Gera Forest (n = 56)				Belete Forest (n = 36)			
	Mean	S.D.	Min.	Max.	Mean	S.D.	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

Table 4: Results from multinomial logistic estimation

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

Note: *z* statistics are in parentheses; *, **, and *** indicate statistical significance at the 10, 5, and 1 percent levels, respectively.

Table 5: Results from instrumental variable estimation

Independent variables	(1)	(2)	(3)	(4)	(5)	(6)
	2SLS				2SLS	OLS
	1st stage	1st stage	1st stage	2nd stage		
Number of households in sub-village	0.0025	-0.0018	-0.0010	-0.0066		-0.0027
	(0.1102)	(-0.1065)	(-0.1956)	(-0.3987)		(-0.1751)
Average slope	0.0010	-0.0004	-0.0000	0.0005		0.0005
	(0.2861)	(-0.1476)	(-0.0030)	(0.1883)		(0.1984)
Proportion of acrisol	-2.9666	0.0192	0.0033	-2.2260		-1.9662
	(-0.5004)	(0.0044)	(0.0024)	(-0.5191)		(-0.4646)
Dummy for areas located near a forest association established in 2007	-0.0782	-0.0001	0.0003	-0.0965		-0.0886
	(-0.6682)	(-0.0013)	(0.0095)	(-1.1363)		(-1.0593)
Dummy for areas near a forest association established in 2008	-0.3623***	-0.0266	-0.0001	0.0310		0.0403
	(-5.0769)	(-0.5015)	(-0.0079)	(0.5954)		(0.7904)
Predicted probability of a forest association being established	1.0362***	0.0057	0.0006			
	(13.7566)	(0.1018)	(0.0335)			
Predicted probability of having a forest association for 1 year	-0.0885	0.9941***	-0.0033			
	(-0.6980)	(10.5509)	(-0.1105)			
Predicted probability of having a forest association for 2 years	-0.1098	-0.0019	1.0443***			
	(-0.2987)	(-0.0069)	(12.1616)			
Year of establishment dummy				-0.1199**	-0.1084**	-0.0424
				(-2.2710)	(-1.9813)	(-1.4326)
1 year after establishment dummy				0.1685*	0.1600*	0.0612
				(1.8832)	(1.7705)	(1.4086)
2 years after establishment dummy				0.2486	0.2095	0.0970
				(0.9785)	(0.8986)	(0.7029)
Constant	0.0155	0.0063	0.0007	0.0123	0.0075	0.0002
	(0.3923)	(0.2146)	(0.0771)	(0.4264)	(0.4473)	(0.0067)
Observations	352	352	352	352	352	352
Adjusted R-squared	0.4562	0.3373	0.3417	-0.0284	-0.0229	0.0223

Note: t-statistics are in parentheses; *, **, and *** indicate statistical significance at the 10, 5, and 1 percent levels, respectively.

Abstract (in Japanese)

要約

本論文は、エチオピアの JICA プロジェクト『ベレテ･ゲラ参加型森林管理プロジェクト』において、参加型森林管理組合の設立が森林保全に対して及ぼす効果を、定量的に推計したものである。人工衛星によって収集され、リモートセンシングの技術によって解析されたデータを利用することで、森林管理組合ごとの森林面積の推移は、かなりの精度で推計することができる。その調査／解析結果によると、森林管理組合を設立した集落においては、それ以外の集落と比較して、管理組合設立前後の 1 年間に、むしろ森林面積が減少することが明らかとなった。これは、管理組合の設立直前に、駆け込みで木を伐採することがあるからだと考えられる。しかし、その後の 1 年間では、管理組合を設立した集落の森林面積は、それ以外の集落と比べて、増加している。その結果を総合すると、森林管理組合が設立された集落の森林面積は､設立後の 2 年間に平均して 1.5%増加したのに対して、管理組合のない集落では、平均して 3.3%減少している。つまり、森林管理組合設立によって、森林面積の変化率は、約 4.8%改善したことが明らかとなった。

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Working Papers from the same research project

“Impact Evaluation Analyses for the JICA Projects”

JICA-RI Working Paper No. 30

Impact of Farmer Field Schools on Agricultural Income and Skills: Evidence from an Aid-Funded Project in Rural Ethiopia

Yasuyuki Todo and Ryo Takahashi