PRELIMINARY DRAFT-NOT FOR CITATION

ADOPTION OF SUSTAINABLE LAND AND FOREST MANAGEMENT TECHNOLOGIES: OUTCOME OF FOREST TENURE REFORM IN DEVELOPING COUNTRIES

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Abstract

This study attempts to identify factors that motivate community for adopting sustainable land and forest management. Data collection was conducted in 2015-2016 at Indonesia, Peru and Uganda by interviewing 2550 household using a structured questionnaire. The study found that majority of tenure reform members adopted sustainable land management technologies in Indonesia and Peru. In Uganda, most non-members of tenure reform adopted sustainable land management technologies as compared to members. The perceptions of tenure security tend to motivate individuals to invest in sustainable land management practices as they are likely to reap the benefits if their investments. On such lands, community use and management is conditioned on the adoption and maintenance of sustainable land management practices. These results suggest that forest tenure reforms implemented in Indonesia, Peru and Uganda have had a positive outcome, regardless of whether rights granted were control and ownership or merely management rights/responsibilities.

Key words:

Introduction

Forest tenure reform has been implemented in many developing countries for about three decades. Many studies have been conducted to assess the outcome of forest tenure reform in particular related to the outcome and impact; and factors influencing the forest tenure reform implementation. But few studies have attempted to systematically document the factors on how community who participated in the forest tenure reform adopt the technique on sustainable land and forest management.

This study attempts to generate insights into the underlying factors that influence community to adopting sustainable land and forest management technologies. In particular it identifies the factors that motivate community for improving their land and forest management sustainably. By focusing on the community experience, we expect to gain a deeper understanding of the characteristics, underlying assumptions, and motivation for them to adopt sustainable land and forest management technique. Some of the technique for achieving sustainable land are comprise of (1) soil and water conservation (e.g. terraces, mulching, green manure application,

cleaning bushes and other vegetation, rock bunds, soil bunds; (b) Irrigation (e.g. bore well, dug well, water storage, irrigation channels); (c) Trees planted and maintained for improving soil fertility or for boundary demarcation; (d) Trees planted and maintained for cash income (e.g. coffee, timber, fruit); or even by (e) Efficient on cooking stoves. While for the technique of sustainable forest management that can be adopted by communities are tree nurseries, tree planting, reforestation, management plans, annual cutting plans, and fire control.

Ultimately, we aim to provide policy makers and practitioners with information and knowledge that will enable them to modify existing implementation strategies on community empowerment in order to meet policy goals. Such knowledge and information will also provide opportunities for adaptive learning and change.

Research Methodology

The study sought to investigate factors that influence adoption of sustainable land and forest management technologies in Peru, Indonesia and Uganda. Adoption of sustainable land and forest management technologies was measured as a binary variable thereby promoting the use of binary dependent models. Binary dependent models such as probit or logit models can be used to estimate the effect of independent variables on a binary dependent variable. Green (2012) argues that the difference between probit and logit models is the assumption of the distribution of the error term, where the distribution of the error term of a probit model is assumed to be normal while that of a logistic model is assumed to follow a logistic distribution. Given that individuals in the three countries are either none members or members of tenure reform group and the decision to adopt sustainable land and forest management technologies maybe made simultaneously with the decision to become a member of tenure reform group then a model that accounts correlation of the error terms for adoption and membership models need to be specified. Based on this understanding, the study estimated a bivariate probit model to estimate the influence of various covariates on adoption of sustainable land and forest management and membership of tenure reform group. The bivariate probit model can be specified as;

$$y_1^* = \boldsymbol{\beta_1' x_1} + \varepsilon_1,\ y_1 = 1(y_1^* > 0) \quad (1)$$

$$y_2^* = \boldsymbol{\beta_2' x_2} + \varepsilon_2,\ y_2 = 1(y_2^* > 0) \quad (2)$$

$$\begin{pmatrix}\varepsilon_1\\ \varepsilon_2\end{pmatrix} \sim N\left[\begin{pmatrix}0\\ 0\end{pmatrix}, \begin{pmatrix}1 & \rho\\ \rho & 1\end{pmatrix}\right] \quad (3)$$

Where y_1^* and y_2^* are the latent variables capturing adoption of sustainable land and forest management and membership of tenure reform group respectively. X is a vector of independent variables that influence adoption of sustainable land and forest management and membership of tenure reform group (see appendix 1 for definition of these variables). ε_1 and ε_2 are disturbance terms for equation 1 and 2 respectively while ρ is the conditional tetrachoric correlation between equations for adoption of sustainable land and forest management and membership of tenure reform group. The log likelihood can be specified as;

$$logL = \sum_{i=1}^{n} log\vartheta_2 \begin{bmatrix} (2y_{i1}-1)\beta_1' x_{i1}, \\ (2y_{i2}-1)\beta_2' x_{i2} \\ (2y_{i1}-1)(2y_{i2}-1)\rho \end{bmatrix}$$

$$= \sum_{i=1}^{n} log\vartheta_2 \left[q_{i1}\beta_1' x_{i1}, q_{i2}\beta_2' x_{i2}, q_{i1}, q_{i2}, \rho\right] \quad (4)$$

Note: $q_{i1} = (2y_{i1}-1) = -1\ if\ y_{i1} = 0\ and + 1\ if\ y_{i1} = 1$, ϑ_2 is the bivariate normal cumulative distubtion function (CDF) which is estimated using quadrature (Pindyck & Rubinfeld, 1998). The study estimated the bivariate probit model using full information maximum likelihood.

Result

Descriptive Statistics

The study found that majority (79%) of members of tenure reform group adopted sustainable land management technologies in Indonesia while in Peru all respondents were members of tenure reform group . In peru, majority (92%) of respodnents who were members of tenure reform group adopted sustainable land management technologies. In Uganda, majority of nonmembers of tenure reform group adopted sustainable land management technologies as compared to members of tenure reform group. Overall, adopted of sustainable land management technologies significantly varied with membership in only Indonesia while adoption of sustainable land management technologies did not significantly vary with membership in Uganda (table 1).

Table 1: Adoption of sustainable land management technologies by membership

Membership	Indonesia			Uganda			Peru		
	Adopted SLM			Adopted SLM			Adopted SLM		
	No	Yes	Total	No	Yes	Total	No	Yes	Total
Not Member	37	95	132	175	267	442			
	16.59	12.04	13.04	67.31	61.24	63.51			
Member	186	694	880	85	169	254	66	776	842
	83.41	87.96	86.96	32.69	38.76	36.49	100	100	100
Total	223	789	1,012	260	436	696	66	776	842
	100	100	100	100	100	100	100	100	100
	Pearson chi2(1)= 3.1753*			Pearson chi2(1) = 2.5886					

*** p<0.01, ** p<0.05, * p<0.1

In Indonesia majority (90%) of members of tenure reform group adopted sustainable forest management technologies as compared to nonmembers. In Uganda, slightly more than half (53%) of nonmembers of tenure reform group adopted sustainable forest management

technologies as compared to members of tenure reform group while in Peru all respondents were members of tenure reform group. Majority (61%) of members of tenure reform group in Peru did not adopt sustainable forest management technologies. Overall, adopted of sustainable forest management technologies significantly varied with membership in only Uganda while it did not significantly vary by membership in Indonesia (table 2).

Table 2: Adoption of sustainable forest management technologies by membership

Membership	Indonesia			Uganda			Peru		
	Adopted SFM			Adopted SFM			Adopted SFM		
	No	Yes	Total	No	Yes	Total	No	Yes	Total
Not member	82	34	116	253	126	379			
	12.65	10.46	11.92	69.32	52.94	62.85			
Member	566	291	857	112	112	224	512	328	840
	87.35	89.54	88.08	30.68	47.06	37.15	100	100	100
Total	648	325	973	365	238	603	512	328	840
	100	100	100	100	100	100	100	100	100
	Pearson chi2(1) = 0.9911			Pearson chi2(1) = 16.5426***					

*** p<0.01, ** p<0.05, * p<0.1

The descriptive statistics of variables used in the analysis shows that majority of respondents in Indonesia, Peru and Uganda adopted sustainable land management technologies and nearly half of the respondents in Peru perceived improved tenure security. As compared to Uganda, majority of respondents in Peru indicated that tenure regime was where land is owned by communities. As compared to Uganda, majority of respondents in Peru and Indonesia indicated that they were born in the current village. In Peru, all the respondents were members of tenure reform group while in Indonesia majority of the respondents belonged to a tenure reform group. As compared to Indonesia and Uganda, majority of respondents in Peru had contacts with external actors, earned off-farm income and had high value of assets. Majority of respondents in Peru and Uganda viewed forest product extraction rules as more restrictive than they used to be. This finding is summarized in table 3.

Table 3: Descriptive statistics of variables used in the analysis

	Peru					Indonesia					Uganda				
Variable	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max
Adoption of sustainable land management	1013	.93	.26	0	1	1012	.78	.41	0	1	696	.63	.48	0	1
Adopted of sustainable forest management	1011	.35	.48	0	1	973	.33	.47	0	1	603	.39	.49	0	1
Perceived tenure security	900	.50	.50	0	1	940	.31	.46	0	1	622	.24	.43	0	1
State land designated to / Use by communities	1013	0	0	0	0	1012	.45	.50	0	1	696	.29	.45	0	1
State land used by companies	1013	0	0	0	0	1012	.26	.44	0	1	696	0	0	0	0
Land owned by communities	1013	.83	.38	0	1	1012	0	0	0	0	696	.24	.43	0	1
Owned by individuals/firms	1013	.002	.04	0	1	1012	0	0	0	0	696	.23	.42	0	1
Unrecognized customary lands	1013	.17	.37	0	1	1012	.30	.46	0	1	696	.24	.43	0	1
Married	1012	.95	.21	0	1	1012	.93	.25	0	1	695	.82	.38	0	1
widow/widower	1012	.01	.12	0	1	1012	.06	.25	0	1	695	.10	.30	0	1
divorced/separated	1012	.02	.14	0	1	1012	0	0	0	0	695	.06	.24	0	1
never married	1012	.01	.12	0	1	1012	.004	.06	0	1	695	.02	.14	0	1
Gender (1=male)	1013	.51	.50	0	1	1012	.50	.50	0	1	696	.42	.49	0	1
Age in years	1013	41.42	13.9	18	85	1012	42.86	11	18	84	696	40.51	14.4	18	102
Years of education	1013	6.58	3.74	0	18	1012	8.22	3.6	0	18	696	6.22	3.88	0	19
Household size	564	4.88	2.02	0	14	534	4.45	2.1	0	19	396	5.87	3.28	0	16
Ancestry	1012	.51	.50	0	1	1012	.52	.50	0	1	696	.39	.49	0	1
Membership tenure reform group	842	1	0	1	1	1012	.87	.34	0	1	696	.36	.48	0	1
External contact	1011	.66	.47	0	1	1005	.40	.49	0	1	662	.26	.44	0	1
Own dwelling	564	.98	.15	0	1	533	.88	.33	0	1	396	.87	.34	0	1
Total assets (Thousands)	1013	3.2	22.2	0	184.4	1	0.05	0.7	0	21.6	696	0.04	0.2	0	3.6
Off-farm income	1013	.67	.47	0	1	1011	.50	.50	0	1	696	.28	.45	0	1
Distance to the nearest all season road	658	14.78	48.1	0	666	1012	4.06	11	0	240	696	21.88	35.6	0	250
More restrictive forest extraction rules	708	.83	.38	0	1	873	.47	.50	0	1	624	.73	.44	0	1
Forest extraction rules are same as before	708	.16	.37	0	1	873	.44	.50	0	1	624	.18	.39	0	1
Less restrictive forest extraction rules	708	.01	.10	0	1	873	.10	.29	0	1	624	.08	.28	0	1
Fires threat	899	.11	.31	0	1	1012	.87	.33	0	1	682	.78	.41	0	1
Logging threat	899	.76	.43	0	1	1012	.84	.36	0	1	682	.66	.48	0	1
Land/forest related conflict	1013	.19	.40	0	1	1010	.05	.21	0	1	687	.18	.39	0	1

Diagnostics tests

The study conducted various diagnostic tests in order to specify the correct model. These diagnostics tests were test of multicollinearity and test of bivariate relationship between membership and adoption of sustainable land, and forest management technologies. The test of multicollinearity was based on variance inflation factor and the result showed that the values of all the variables were less than 10 indicating that severe multicollinearity was absent (table 4).

Table 4: Test of multicollinearity

Variable	VIF	SQRT VIF	Tolerance	R-Squared
Perceived tenure security	1.3	1.14	0.7721	0.2279
State land designated to / Use by communities	8.76	2.96	0.1141	0.8859
State land used by companies	4.99	2.23	0.2005	0.7995
Owned by individuals/firms	3.64	1.91	0.2747	0.7253
Unrecognized customary lands	7.24	2.69	0.1381	0.8619
widow/widower	1.56	1.25	0.6392	0.3608
divorced/separated	1.29	1.13	0.7766	0.2234
never married	1.03	1.02	0.9695	0.0305
Gender	1.68	1.3	0.5954	0.4046
Age	1.27	1.13	0.789	0.211
Years of education	1.28	1.13	0.7812	0.2188
Household size	1.23	1.11	0.8118	0.1882
Ancestry	1.18	1.09	0.847	0.153
Membership tenure reform group	1.79	1.34	0.558	0.442
External contact	1.42	1.19	0.7037	0.2963
Own dwelling	1.11	1.06	0.8979	0.1021
Total assets	1.04	1.02	0.957	0.043
Off-farm income	1.21	1.1	0.8293	0.1707
Distance to the nearest all season road	1.11	1.06	0.8977	0.1023
More restrictive forest extraction rules	1.49	1.22	0.6715	0.3285
Less restrictive forest extraction rules	1.29	1.13	0.7776	0.2224
Fires threat	1.96	1.4	0.5102	0.4898
Logging threat	1.14	1.07	0.877	0.123
Land/forest related conflict	1.18	1.09	0.8477	0.1523
Peru	9.74	3.12	0.1026	0.8974
Indonesia	3.59	1.89	0.2788	0.7212

Mean VIF = 2.48

In order to estimate a bivariate probit model, adoption of land and forest management technologies and membership of tenure reform needed to have a bivariate relationship. This study tested for presence or absence of bivariate relationship using cross tabulation and chi square. The results show that there was a bivariate relationship between adoption of SLM and membership (Pearson chi2 =104.0435 and significant at 1% level) and between adoption of sustainable forest management technologies and membership Pearson chi2 =5.5510 and significant at 5% level) as shown in table 5. This finding justifies the use of bivariate probit model.

Table 5: Test of Bivariate Relationship

Membership	**Adopted SLM**			**Adopted SFM**		
	No	**Yes**	**Total**	**No**	**Yes**	**Total**
Non Member	212	362	574	335	160	495
	38.62	18.09	22.51	21.97	17.96	20.49
Member	337	1,639	1,976	1,190	731	1,921
	61.38	81.91	77.49	78.03	82.04	79.51
Total	549	2,001	2,550	1,525	891	2,416
	100.00	100.00	100.00	100.00	100.00	100.00
	Pearson chi2(1) 104.0435***			Pearson chi2(1) = 5.5510**		

*** p<0.01, ** p<0.05, * p<0.1

Bivariate Probit Regression Results

The study estimated bivariate probit model where by the two dependent variables were adoption of sustainable land and forest management technologies and membership of tenure reform group and the results are presented in table 6 and 7. However, the study also estimated single equations of adoption of sustainable land and forest management technologies where membership of tenure reform group was assumed to be one of the independent variable (see appendix 2). The results in table 4.6 and 4.7 show that the conditional tetrachoric correlation between adoption of sustainable land and forest management technology and membership (rho=0.17 and significant at 5%) was significant indicating that the two equations are strongly correlated. Additionally, the likelihood-ratio test had a chi square that was significant at 5% level justifying the need to estimate bivariate probit model. The Wald chi square for both equations were significant at 1% suggesting that the independent variables used jointly influenced adoption of sustainable land and forest management technologies and membership of tenure reform group.

The regression results presented in table 6 (model 1) show that compared to land owned by communities, unrecognized customary lands increased the likelihood of individuals adopting sustainable land management technologies. Individuals who were not married had lower probability of adopting sustainable land management as compared to individuals who were married. Study also found that as individuals grow old and increase the number of years of education they would have higher probability of adopting sustainable land management technologies as compared to young and less education individuals. Compared to migrants

(individuals not born in the current village), individuals born in the current village had lower probability of adopting sustainable land management technologies. Having contact with external actors, high valued assets, staying far away from all season road and less restrictive forest product extraction rules increases the likelihood of an individual adopting sustainable land management technologies. Compared to Uganda, individuals in Peru had high likelihood of adopting sustainable land management technologies.

Table 6: Bivariate Probit Results for Adoption of Sustainable Land management Technologies

Variables	**(1) Adoption of Sustainable Land Management Technologies**	**(2) Membership of Tenure Reform Group**
Perceived tenure security	0.0417	0.1690
	(0.0998)	(0.1416)
State land designated to / Use by communities	0.2541	-1.3338***
	(0.2568)	(0.2836)
State land used by companies	-0.0802	-0.8200**
	(0.2943)	(0.3525)
Owned by individuals/firms	-0.0004	-0.9470***
	(0.2651)	(0.2884)
Unrecognized customary lands	0.7980***	-0.4165
	(0.2714)	(0.3072)
Widow/widower	0.0606	-0.0589
	(0.1826)	(0.2529)
Divorced/separated	-0.1707	-0.3258
	(0.2470)	(0.3247)
Never married	-0.6060*	0.1231
	(0.3543)	(0.5718)
Gender	-0.0493	-0.1104
	(0.1571)	(0.2280)
Age in years	0.0081**	0.0057
	(0.0038)	(0.0051)
Years of education	0.0281**	0.0294*
	(0.0133)	(0.0174)
Household size	0.0099	0.0068
	(0.0191)	(0.0232)
Ancestry	-0.1712*	0.4339***
	(0.0959)	(0.1361)
External contact	0.2527**	0.4325***
	(0.1001)	(0.1418)
Own dwelling	0.1117	0.3216

	(0.1616)	(0.2003)
Total assets	0.0004**	0.0013
	(0.0002)	(0.0010)
Off-farm income	0.0976	0.1739
	(0.0930)	(0.1266)
Distance to the nearest all season road	0.0036*	0.0042*
	(0.0021)	(0.0025)
More restrictive forest extraction rules	0.1084	-0.2092
	(0.1079)	(0.1449)
Less restrictive forest extraction rules	0.4181**	-0.0715
	(0.1887)	(0.2412)
Fires threat	-0.0190	0.1433
	(0.1214)	(0.1536)
Logging threat	-0.1463	-0.4561***
	(0.1096)	(0.1506)
Land/forest related conflict	0.0536	0.1761
	(0.1211)	(0.1619)
Peru	0.5950**	6.0253
	(0.2753)	(993.8434)
Indonesia	-0.1194	1.7255***
	(0.1413)	(0.1740)
Constant	-0.4762	-0.3277
	(0.3746)	(0.4481)
Wald chi2(50)	358.92***	
Athrho	0.1714**	
	(0.0767)	
Rho	.1697112**	
	(.0744868)	
Observations	1,149	1,149

Likelihood-ratio test of rho=0: chi2(1) = 5.07173 Prob > chi2 = 0.0243

Standard errors in parentheses,*** p<0.01, ** p<0.05, * p<0.1

The results for membership (model 2 in both table 6 and 7) show that as compared to land owned by communities, state land designated to / use by communities, state land used by companies and owned by individuals/firms decreased the likelihood of an individual becoming a member of tenure reform group. Been born in the current village, having contact with external actors, logging threat, distance to the nearest all season road and years of education increases the likelihood of joining tenure reform group. As compared to Uganda, individuals in Indonesia had high likelihood of joining tenure reform group.

The results show that individuals who perceived improved tenure security had high likelihood of adopting sustainable forest management technologies. Compared to land owned by communities, state land designated to/use by communities increased the likelihood of

individuals adopting sustainable forest management technologies. Individuals who were widowed had lower probability of adopting sustainable forest management as compared to individuals who were married. As individuals get older and acquire more education they would have higher probability of adopting sustainable forest management technologies as compared to young and less education individuals. Compared to migrants (individuals not born in the current village), individuals born in the current village had higher probability of adopting sustainable forest management technologies. Having contact with external actors, more restrictive forest product extraction rules and having experienced land/forest related conflict increases the likelihood of an individual adopting sustainable forest management technologies.

Table 7: Bivariate Probit Results for Adoption of Sustainable Forest management Technologies

Variables	(1)	(2)
	Adoption of Sustainable Forest Management Technologies	**Membership of Tenure Reform Group**
Perceived tenure security	0.1924**	0.1488
	(0.0921)	(0.1436)
State land designated to / Use by communities	0.6379**	-1.3539***
	(0.2974)	(0.3017)
State land used by companies	0.3210	-0.7917**
	(0.3333)	(0.3700)
Owned by individuals/firms	0.4384	-0.9521***
	(0.3032)	(0.2970)
Unrecognized customary lands	-0.1429	-0.4871
	(0.3086)	(0.3184)
Widow/widower	-0.5252***	-0.1356
	(0.1833)	(0.2617)
Divorced/separated	-0.1773	-0.2299
	(0.2447)	(0.3290)
Never married	0.5541	0.5611
	(0.4323)	(0.6692)
Gender	-0.0367	-0.0111
	(0.1464)	(0.2393)
Age in years	0.0108***	0.0052
	(0.0035)	(0.0051)
Years of education	0.0288**	0.0221
	(0.0124)	(0.0178)
Household size	-0.0084	-0.0003
	(0.0179)	(0.0236)
Ancestry	0.3053***	0.4162***
	(0.0883)	(0.1398)

External contact	0.8201***	0.4186***
	(0.0963)	(0.1428)
Own dwelling	0.0815	0.2947
	(0.1625)	(0.2022)
Total assets	-0.0000	0.0011
	(0.0000)	(0.0011)
Off-farm income	-0.0270	0.1390
	(0.0885)	(0.1290)
Distance to the nearest all season road	-0.0004	0.0041
	(0.0012)	(0.0026)
More restrictive forest extraction rules	0.1799*	-0.1812
	(0.1055)	(0.1511)
Less restrictive forest extraction rules	0.1842	-0.0862
	(0.1758)	(0.2451)
Fires threat	0.0635	0.1445
	(0.1137)	(0.1585)
Logging threat	-0.0811	-0.4317***
	(0.1032)	(0.1551)
Land/forest related conflict	0.5419***	0.1486
	(0.1081)	(0.1665)
Peru	0.0185	5.9913
	(0.3004)	(1,021.3590)
Indonesia	-0.1268	1.7144***
	(0.1415)	(0.1792)
Constant	-1.8353***	-0.2507
	(0.3958)	(0.4651)
Wald chi2(50)	425.86***	
Athrho	0.1739**	
	(0.0811)	
Rho	.1722005**	
	(.0786643)	
Observations	1,123	1,123

Likelihood-ratio test of rho=0: chi2(1) = 4.62334 Prob > chi2 = 0.0315

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Conclusion

The study found that majority of members of tenure reform group adopted sustainable land management technologies in Indonesia and Peru. In Uganda, the majority of nonmembers of tenure reform group adopted sustainable land management technologies as compared to members of tenure reform group. This result is a bit different compare to the adoption of sustainable forest management technique. Most respondents in the three countries reported that they are not adopted yet the sustainable forest management technique

The model show that individuals who perceived improved tenure security had high likelihood of adopting sustainable land and forest management technologies. Compared to land owned by communities, state land designated to/use by communities increased the likelihood of individuals adopting sustainable forest management technologies. Individuals who were widowed had lower probability of adopting sustainable forest management as compared to individuals who were married. As individuals get older and acquire more education they would have higher probability of adopting sustainable forest management technologies as compared to young and less education individuals. Compared to migrants (individuals not born in the current village), individuals born in the current village had higher probability of adopting sustainable forest management technologies. Having contact with external actors, more restrictive forest product extraction rules and having experienced land/forest related conflict increases the likelihood of an individual adopting sustainable forest management technologies.

These results are uncontroversial and generally support expectation i.e. that perceptions of tenure security tend to motivate individuals to invest in sustainable land management practices as they are likely to reap the benefits if their investments. It is also usual that individuals holding partial rights to forests resources are more likely not motivated to adopt sustainable practices, it is however consistent with how community management of state lands is approached. On such lands, community use and management is conditioned on the adoption and maintenance of sustainable land management practices. External actors such as government officials and NGOs often provide communities with seedlings and provide them training and skills on nursery/tree management, which tends to increase adoption. However, it's unclear why experience of tenure related conflict would motivate the adoption of forest management technologies. This would suggest that such an investment would constitute a way of establishing or strengthening claims to land and forest resources.

In sum, these results suggest that forest tenure reforms implemented in Indonesia, Peru and Uganda have had a positive outcome, regardless of whether rights granted were control and ownership or merely management rights/responsibilities. Moreover, contact with external actors appears to be critical in advancing sustainability and should be encouraged.

References

Greene, W. H. (2012). Econometric Analysis, 7th ed. Upper Saddle River, NJ: Prentice Hall.

Pindyck, R. S., & Rubinfeld, D. L. (1998). Econometric Models and Economic Forecasts, 4th ed. New York: McGraw–Hill.

Annex. Result of Data Analysis

Table 1: Test of Bivariate Relationship

Membership	Adopted SLM			Adopted SFM		
	No	Yes	Total	No	Yes	Total
Non Member	212	362	574	335	160	495
	38.62	18.09	22.51	21.97	17.96	20.49
Member	337	1,639	1,976	1,190	731	1,921
	61.38	81.91	77.49	78.03	82.04	79.51
Total	549	2,001	2,550	1,525	891	2,416
	100.00	100.00	100.00	100.00	100.00	100.00
	Pearson chi2(1) 104.0435***			Pearson chi2(1) = 5.5510**		

*** p<0.01, ** p<0.05, * p<0.1

Table 2: Bivariate Probit Results for Adoption of Sustainable Land management Technologies

Variables	(1) Adoption of Sustainable Land Management Technologies	(2) Membership of Tenure Reform Group
Perceived tenure security	0.0417	0.1690
	(0.0998)	(0.1416)
State land designated to / Use by communities	0.2541	-1.3338***
	(0.2568)	(0.2836)
State land used by companies	-0.0802	-0.8200**
	(0.2943)	(0.3525)
Owned by individuals/firms	-0.0004	-0.9470***
	(0.2651)	(0.2884)
Unrecognized customary lands	0.7980***	-0.4165
	(0.2714)	(0.3072)
Widow/widower	0.0606	-0.0589
	(0.1826)	(0.2529)
Divorced/separated	-0.1707	-0.3258
	(0.2470)	(0.3247)
Never married	-0.6060*	0.1231
	(0.3543)	(0.5718)

Gender	-0.0493	-0.1104
	(0.1571)	(0.2280)
Age in years	0.0081**	0.0057
	(0.0038)	(0.0051)
Years of education	0.0281**	0.0294*
	(0.0133)	(0.0174)
Household size	0.0099	0.0068
	(0.0191)	(0.0232)
Ancestry	-0.1712*	0.4339***
	(0.0959)	(0.1361)
External contact	0.2527**	0.4325***
	(0.1001)	(0.1418)
Own dwelling	0.1117	0.3216
	(0.1616)	(0.2003)
Total assets	0.0004**	0.0013
	(0.0002)	(0.0010)
Off-farm income	0.0976	0.1739
	(0.0930)	(0.1266)
Distance to the nearest all season road	0.0036*	0.0042*
	(0.0021)	(0.0025)
More restrictive forest extraction rules	0.1084	-0.2092
	(0.1079)	(0.1449)
Less restrictive forest extraction rules	0.4181**	-0.0715
	(0.1887)	(0.2412)
Fires threat	-0.0190	0.1433
	(0.1214)	(0.1536)
Logging threat	-0.1463	-0.4561***
	(0.1096)	(0.1506)
Land/forest related conflict	0.0536	0.1761
	(0.1211)	(0.1619)
Peru	0.5950**	6.0253
	(0.2753)	(993.8434)
Indonesia	-0.1194	1.7255***
	(0.1413)	(0.1740)
Constant	-0.4762	-0.3277
	(0.3746)	(0.4481)
Wald chi2(50)	358.92***	
Athrho	0.1714**	
	(0.0767)	
Rho	.1697112**	
	(.0744868)	
Observations	1,149	1,149

Likelihood-ratio test of rho=0: chi2(1) = 5.07173 Prob > chi2 = 0.0243

Standard errors in parentheses,*** p<0.01, ** p<0.05, * p<0.1

Table 3: Bivariate Probit Results for Adoption of Sustainable Forest management Technologies

Variables	(1)	(2)
	Adoption of Sustainable Forest Management Technologies	Membership of Tenure Reform Group
Perceived tenure security	0.1924**	0.1488
	(0.0921)	(0.1436)
State land designated to / Use by communities	0.6379**	-1.3539***
	(0.2974)	(0.3017)
State land used by companies	0.3210	-0.7917**
	(0.3333)	(0.3700)
Owned by individuals/firms	0.4384	-0.9521***
	(0.3032)	(0.2970)
Unrecognized customary lands	-0.1429	-0.4871
	(0.3086)	(0.3184)
Widow/widower	-0.5252***	-0.1356
	(0.1833)	(0.2617)
Divorced/separated	-0.1773	-0.2299
	(0.2447)	(0.3290)
Never married	0.5541	0.5611
	(0.4323)	(0.6692)
Gender	-0.0367	-0.0111
	(0.1464)	(0.2393)
Age in years	0.0108***	0.0052
	(0.0035)	(0.0051)
Years of education	0.0288**	0.0221
	(0.0124)	(0.0178)
Household size	-0.0084	-0.0003
	(0.0179)	(0.0236)
Ancestry	0.3053***	0.4162***
	(0.0883)	(0.1398)
External contact	0.8201***	0.4186***
	(0.0963)	(0.1428)
Own dwelling	0.0815	0.2947
	(0.1625)	(0.2022)
Total assets	-0.0000	0.0011
	(0.0000)	(0.0011)
Off-farm income	-0.0270	0.1390
	(0.0885)	(0.1290)
Distance to the nearest all season road	-0.0004	0.0041
	(0.0012)	(0.0026)
More restrictive forest extraction	0.1799*	-0.1812

rules		
	(0.1055)	(0.1511)
Less restrictive forest extraction rules	0.1842	-0.0862
	(0.1758)	(0.2451)
Fires threat	0.0635	0.1445
	(0.1137)	(0.1585)
Logging threat	-0.0811	-0.4317***
	(0.1032)	(0.1551)
Land/forest related conflict	0.5419***	0.1486
	(0.1081)	(0.1665)
Peru	0.0185	5.9913
	(0.3004)	(1,021.3590)
Indonesia	-0.1268	1.7144***
	(0.1415)	(0.1792)
Constant	-1.8353***	-0.2507
	(0.3958)	(0.4651)
Wald chi2(50)	425.86***	
Athrho	0.1739**	
	(0.0811)	
Rho	.1722005**	
	(.0786643)	
Observations	1,123	1,123

Likelihood-ratio test of rho=0: chi2(1) = 4.62334 Prob > chi2 = 0.0315

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1