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Emmanuel Benjamin

Technische Universität München, Germany

Matthias Blum

Queen’s Management School, Belfast

Working Paper MS WPS ECO 15 03

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WORKING PAPER SERIES

185 Stranmillis Road

Belfast BT9 5EE

May 2015

Participation of smallholders in carbon-certified small-scale agroforestry: A lesson from the rural Mount Kenyan region

Emmanuel O. Benjamin[1] and Matthias Blum[2]

[1] Technische Universität München, Department of Agriculture and Food Economics, Alte Akademie 12 85354 Freising, Germany and Bergische University of Wuppertal (BUW), Department of Macroeconomics Theory and Politics, Rainer-Gruenter-Str. 21, 42119 Wuppertal, Germany.

Final version

Abstract:

This study examines factors that determine the participation of smallholder farmers in certified agroforestry programs involving payments for ecosystem services (PES) in the mount Kenyan region, Kenya. A random utility model and logit regression was used to test a set of non-monetary and monetary factors that influence participation in the international small group tree planting programme (TIST). This study employs survey data compiled in 2013 on 210 randomly selected smallholders; equally split between TIST and non-TIST members. The findings suggest that the spread of information via formal and informal networks as well as credit constraints are three important drivers of participating in the TIST program. Conversely, participation in TIST is not influenced by farm size, proximity to market, and level of education. Given the importance of smallholder poverty alleviation and credit market accessibility in the presence of climate change, our findings suggest that sustainable development policies should focus on strengthening the social capital and informal networks.

Keywords: Agroforestry program, network, spillover, payment for ecosystem services (PES), adoption, information, sub-Saharan Africa.

JEL codes: D8, O1, O3, Q1, Q2

[2] Queen's University Belfast, Queen's University Management School, 185 Stranmillis Road, Belfast BT9 5EE, Northern Ireland, United Kingdom.

Introduction

Agriculture is central to ensuring food security as it provides jobs and livelihoods for large shares of the population in developing and emerging economies. It offers a channel for smallholder farmers to escape poverty and increases incomes above subsistence levels. In future, agriculture will be crucial in the move towards achieving sustainable economic production by providing food and feed as well as eventually producing the crops for bioenergy (replacing fossil fuels). Agriculture also plays a major role in mitigating the effect of climate change (Smith et al., 2007; Garnett et al., 2013); using diverse technologies and adopting them to local circumstances is an effective way to achieve these goals. Medium- and high income farmers have means to adopt new technologies since their farm infrastructure often includes modern communications, education, a skilled labor force, and access to financial markets. For example, it has been observed that in Costa Rica and Senegal, forestry programs that enable farmers to obtain payments for ecosystem services (PES) may be adopted predominantly by larger farms with highly-skilled staff and off-farm income (Zbinden and Lee, 2005; Tschakert, 2007).

Conversely, smallholders often face little asset endowment due to small farm size and insecure property rights, thus they have limited opportunities to enter credit markets and adopt sustainable or modern technologies. Networks of smallholders may help foster information flows and induce spillover effects among them, helping to achieve the aforementioned goals, despite substantial disadvantages (Benjamin et al. 2015). PES from land use programs benefits poor smallholder farmers in developing countries—depending on the distribution of land quality—through productivity compensation and increases in output prices and labor demand (Zilberman et al., 2008). Empirical evidence suggests that participation in emissions trading and corresponding PES may ease smallholder farmers' financial credit constraints and lower interest rates of borrowers over the long term (Benjamin et al., 2015). Easier access to credit markets in turn is associated with more investment in agriculture, health and education, and subsequently, higher incomes. Agroforestry projects with PES may promote poverty alleviation amongst poor smallholders by increasing incomes, contributing to soil fertility, and reducing soil erosion, all of which can lead to increased food security. It is argued that participation by the poorest smallholders in agroforestry with PES may help in the attainment of international poverty alleviation objectives such as the Millennium Development Goals (Garrity, 2004; Pagiola et al., 2005; Saliu et al., 2010; Shames, 2012; Miyazawa, 2012).

This paper contributes to our understanding of how networks, farm characteristics, and farmers' individual characteristics function with respect to the adoption of innovative production methods. We focus on smallholders' participation in agroforestry with PES, a means to generate additional revenue through the acquisition of pollution rights (carbon storage through agroforestry) and the sale of these pollution rights on the compliance market (clean development mechanism (CDM)) or voluntary carbon market (voluntary carbon standards (VCS)). The rationale behind this study is to understand motives and determinants of smallholders' level of participation in PES.

We use data from *The International Small Group Tree Planting Programme* (TIST) around the Mount Kenya region in Kenya. Participation in TIST is voluntary and unrestricted. TIST contributes to the local agricultural sector through the provision of credit and savings infrastructure, farm management training, plus training in agricultural techniques and technologies. TIST encourages participation in the carbon markets and ensures collaboration with carbon developers who serve as intermediaries, helping to link Kenyan smallholders with carbon markets. This empirical study uses information about smallholders to assess their reasons and incentives for participating in TIST, as well as participation barriers. This paper may serve as a manual to the investigation of country-specific effects, leading to a more comprehensive picture. In the Kenyan case, we find evidence that the spread of information, existing networks, and peer involvement in the TIST program are forces driving participation in TIST. Conversely, smallholders' participation in TIST seems to be uninfluenced by education levels, land ownership, or asset endowment. Contrary to some sources, we found weak evidence that the adoption of agroforestry with PES in the Mount Kenyan region increases with a smallholder's age.

The remainder of this article is structured as follows. In section 2 we discuss materials and methods used in this study. In section 3 we provide a selective review of the literature and discuss potential determinants for participation in agroforestry with PES. In sections 4 and 5 we present our data and discuss empirical results, respectively, and Section 6 outlines our conclusion.

Material and methods

The Model

Conservation farming, depending on level of investment, has greater benefits, e.g. higher productivity, when compared to conventional farming (Byiringiro and Reardon, 1996). It is therefore assumed in this study that farming practices, $Y_{F,}$ available to farmers, *i*, in sub-Saharan Africa is divided into conservation and conventional with utility U_c and U_a. These farmers choose the practice that gives the highest utility given resource constraints. Smallholder farmers maximize not only profit but also welfare, with multiple objectives ranging from food and social security to reduction in diverse consumption risks (Scherr, 1995). Wunscher et al. (2011) analyzed the effect of non-monetary variables of the opportunity cost of agroforestry with PES on adoption using a utility model. The utility function of agroforestry with PES, U_c, similar to that of Wunscher et al. (2011) is also defined in this study as:

$$U_c = U_c(P_{\exp}(C_{payment}, C_{t+p}, R, I)N_c) \quad (1)$$

U_c is a function of *Pexp*: → were *Pexp* is the expected net payment of ecosystem services

Expected net payment, *Pexp*, is a function of:
a. $C_{payment}$: Offered payment for ecosystem services
b. C_{t+p}: Transaction and protection cost of ecosystem services
c. *R*: Perceived and behavioral risk in ecosystem services
d. *I* : Information on ecosystem services
e. *Nc*: Non-monetary as well as certain monetary cost and benefits of conservation i.e. ecosystem services

The utility of alternative agricultural land use, U_a, is defined as:

$$U_a = U_a(B_{\exp}(C_{opp}, R, I)N_a) \quad (2)$$

U_a is a function of B_{exp}: Expected net payment from other land use

Expected net payment from other land use, B_{exp}, is a function of:
a. C_{opp}: Opportunity cost of alternative land use
b. *R*: Perceived and behavioral risk in alternative land use
c. *I*: Information on alternative land use
c. N_a: Non-monetary and monetary costs and benefits of alternative land use.

This analysis differs from that of Wunscher et al. (2011) as it concentrates on the effects of monetary and non-monetary variables on the adoption of agroforestry with PES rather than opportunity cost analysis. The PES from agroforestry involves monetary or economic incentives incentive which may influence the adoption decisions of smallholders (Pattanayak et al., 2003). However, low carbon market prices and revenues accruable to smallholder farmers may be a setback to agroforestry projects. The PES from agroforestry to smallholders around the Mount Kenyan region is approximately US$10 per hectare per year or US$0.02 per tree per year (Shames et al., 2012). This is similar to payments observed in Bolivia, where forest conservation generates US$7 per hectare per year, whereby in some instances PES are lower than the opportunity cost (Wunder, 2007; Landell-Mills and Porras, 2002). Despite current low PES, smallholder farmers in developing countries continue to voluntarily participate in agroforestry programs, in part due to long contract phases or awareness of non-PES-related benefits. The effect of soil and natural resource conservation, an important part of sustainable agroforestry, on the livelihood of smallholders cannot be overemphasized (Nicoll et al., 2005; Sanchez et al., 1997; Benjamin, 2012). Franzel (1999) argues that factors that influence the adoption of agroforestry practice as a conservation method in Africa may be classified into feasibility, profitability, and acceptability. Ogada (2012) and Wunscher et al.(2011) argue that if the utility of participating in agroforestry with PES, U_c, is greater than the alternative use of land U_a, it then follows that smallholders will likely adopt agroforestry and vice versa. This can be denoted as:

$$U_c > U_a \tag{3}$$

$$U_c(P_{\exp}(C_{payment}, C_{t+p}, R, I)N_c) > U_a(B_{\exp}(C_{opp}, R, I)N_a) \tag{4}$$

Given the limited impulse of momentary incentive on agroforestry adoption we also focus on the effect of non-monetary variables on the adoption of agroforestry with PES amongst smallholder farmers. This study therefore emphasizes the role of social capital i.e. the spread of information through social interaction on the benefits of agroforestry with PES. The importance of social capital on the adoption of sustainable agricultural conservation in communities has been illustrated by diffusion in innovation theory (Wejnert, 2002; Knowler and Bradshaw, 2007). The flow of information is essential to the adoption of agricultural innovation; the more complex the innovation, the more information that will be sought. The innovation-decision process has been described as an information-seeking and information-processing activity which in the long run reduces uncertainty amongst adapters through proper communication channels (Rogers 2003). Social capital and consultative norms were observed to positively influence the adoption of agriculture technology in Tanzania (Isham, 2000). The model by Foster and Rozenweig (1995) on the effect of knowledge on innovation adoption by rural households in India suggests that low levels of knowledge are a major barrier. The model also gives evidence of learning spillover from experienced neighbors. It is argued that social information channels and farmer-to-framer communication amongst smallholder can increase the adoption of conservation practices with PES (Garbach et al., 2012).

Households producing ecosystem services at or below the fixed set of PES will accept current market prices, while those producing above the fixed set may decide not to enroll in PES schemes (Jack et al., 2008). However, non-monetary benefits from agroforestry with PES may motivate households in the latter category to stay in the program[3]. In other words, households may be quite aware of the future earnings of PES as well as the non-monetary benefits via information received from extension services and informal meetings (Zbinden and Lee, 2005).

The information disparity level amongst family members is argued to be minimal (Pollak, 1985). This may lead to a high monitoring of projects whereas household members themselves serve as a kind of insurance mechanism that can impact levels of transaction and protection costs (Pollak, 1985)

The spread of information through interpersonal exchange (*I*), word of mouth *(WOM)* and media (*M*) also reduces perceived risk and risk behavior of individuals (Mitra et al., 1999). Thus, membership in community agroforestry organizations, to which more than one member of a family often belongs, not only provides infrastructural support but also an adequate channel for communication of relevant information, reducing uncertainty and improving payoffs (Mercer and Pattanayak, 2003; Caveness and Kurtz, 1993; Kabwe et al., 2009). It can therefore be argued that all variables are a function of some form of information flow, i.e.:

$$C_{payment} = C_{payment}(I_M); C_{t+p} = C_{t+p}(I_{HH}); R = R(I_{I,WOM,Media}); N_c \qquad (5)$$

I_M denotes the information flow on monetary benefits of PES, I_{HH} information sharing amongst households on transaction and protection cost, $I_{I,WOM,M}$ is the interactive information

[3] However, this aspect was largely ignored in this analysis as it is beyond the scope of this article.

and communications link within formal or informal programs. The conditional utility function of agroforestry with PES therefore can be re-written as:

$$U_c = U_c(P_{\exp}(I_{M,WOM,Media;HH})N_c) + \varepsilon_c \tag{6}$$

Where ε_c is the error term is for adopting and ε_a for non-adopting smallholders while the utility function of other land use remains the same as denoted in equation 2.

The reduced form of the choice probability of participating in agroforestry with PES for each individual farmer, Y$_{Fi\,,}$ may therefore be denoted as:

$$Y_{Fi} = \begin{cases} 1: if\ U_c(P_{\exp}(I_{M,WOM,Media;HH})N_c) + \varepsilon_c > U_a(B_{\exp}(C_{opp}, R, I)N_a) + \varepsilon_a \\ 0: if\ U_a(B_{\exp}(C_{opp}, R, I)N_a) + \varepsilon_a > U_c(P_{\exp}(I_{M,WOM,Media;HH})N_c) + \varepsilon_c \end{cases} \tag{7}$$

Equation 7 defines the general condition, considering monetary and non-monetary variables, under which decision to adopt conservation i.e. agroforestry with PES may occur.

Smallholders also generate additional utility which may be unobservable if they choose either conservation or conventional farming. However, such additional utility is however conditional on certain observable features of the farm(er), y_i*. These observable features, which may proxy for additional utility, are denoted as:

$$y_i{*} = \beta_1 + \beta_2 x_{2i} + \beta_3 x_{3i} + \beta_4 x_{4i} + u_i \tag{8}$$

$$y_i{*} = \beta_1 + \beta_2\, farm\, characteristics + \beta_3 Business\, \mathrm{mod}el + \beta_4\, farmer\, characteristics + u_i \tag{9}$$

Where x_2i is function of farm characteristics – farm size, farm elevation, distance to market, x_3i is function of farm business model – labor supply, credit constraint, interest rate and x_4i is a function of farmer´s characteristics – age, education, mass media (TV).

The abundance (non-availability) of certain farm(er) features of y_i*, may lead to a higher (lower) unobservable additional utility therefore increasing (decreasing) the likelihood of adoption or membership in agroforestry with PES program.

$$Y_{Fi} = \begin{cases} 1: if\ \ y_i{*} > 0 \\ 0: if\ \ f\ y_i{*} < 0 \end{cases} \tag{10}$$

Farm(er) observable features contributing to additional utility in agroforestry with PES

Farm Characteristics

Smallholder farmers in sub-Saharan Africa may decide against adopting certain types of conservation agriculture especially when such agricultural practice or innovation requires substantial land allocation (Thangata et al., 2008; Current et al., 1995). Marenya and Barrett (2007) and Scherr (1995b) argued that in western Kenya farm size had a significant positive effect on agroforestry adoption. This may imply that only farmers with large acreage participate in agroforestry with PES and a possible exclusion of poor smallholders from PES schemes. However, Mercer and Pattanayak (2003) found that the adoption of agroforestry in Kenya was dependent on security of land ownership/rental agreement rather than the size of farmland. A prerequisite for participating in PES programs is usually a secured tenure land (Pagiola et al., 2005). Kabwe et al. (2009) and Nyangena (2008) argue that lack of land tenure reduces the adoption of conservation practices amongst smallholders in parts of Zambia and Kenya. In the case of developing countries there is no definite result for the correlation between farm size and conservation adoption amongst farmers (FAO, 2011). Pattanayak et al. (2003) argue that the sign of the correlation between farm size and agroforestry adoption in 68 per cent of the existing literature was inconsistent, with approximately 50 per cent positive and 28 per cent negative. The adoption of agroforestry with PES by smallholders in rural Kenya may depend on land tenure security rather than farm size.

Cultivating sloping land is generally cumbersome given the risk of soil erosion and degradation. Farmers with sloping land may adopt agroforestry as a strategy to control surface runoff and erosion. Some studies suggest that the grade of land significantly determines the adoption of conservation practices such as agroforestry whereby steep sloping land having a higher level of adoption (Nyangena, 2008; Mercer and Pattanayak, 2003). Conversely, adoption of conservation farming on very steep slope in Ethiopia was observed to be minimal (Gebremedhin and Swinton, 2003). Mugagga and Buyinza (2013) also argue that adoption of soil conservation on the slopes of Mount Elgon National Park in eastern Uganda is not widespread. Given the range of other inexpensive conservation techniques the influence of farm elevation on adoption of agroforestry amongst smallholders may be inconclusive.

Farm Business Model

The proximity to markets may increases opportunity cost of using agricultural land for food production since urban markets offer attractive marketing opportunities. Conversely, remotely located farms may face lower opportunity costs and a disproportional transportation costs whereas agroforestry requires only little market integration compared with cash-cropping. Consequently, a study on Ethiopia suggests that the further away farms were located from local markets the more likely that adoption of conservation would occur (Gebremedhin and Swinton, 2003). Winter et al. (2004) argue that for certain Ecuadorian smallholders, the lack of market access resulted in them embracing agricultural innovations and participating in conservation programs. The impact of distance to markets on the adoption of conservation agriculture by smallholder farmers in sub-Saharan Africa is not clear (Yesuf and Kohlin, 2006).

The adoption of conservation practices such as agroforestry may also depend on the labor intensity of a particular conservation strategy (Mercer, 2004). Adoption of agroforestry by smallholders in sub-Saharan Africa has been found to be positively correlated with labor supply within a household as it may be described as labor-intensive (Marenya and Barrett, 2007; Franzel, 1999; Mugwe et al., 2009). The low level of adoption of agroforestry by smallholders in parts of sub-Saharan Africa may, to an extent, be attributed to the labor requirements involved (Current et al., 1995; Adesina and Chianu, 2002); insufficient labor supply in rural sub-Saharan Africa may lead to the adoption of other practices aside agroforestry that are less labor-intensive.

Credit constraint plays a crucial role in early-stage decisions regarding adoption of agricultural innovation in developing countries (Feder et al., 1985; Mercer, 2004). A number of studies have found that access to credit is positively correlated to the adoption of agroforestry by farmers in developing countries especially in sub-Saharan Africa (Pattanayak et al., 2003; Kiptot and Franzel, 2011; Gladwin et al. 2002; Kiptot et al., 2007; Place et al. 2012). In Senegal, policies that promote credit accessibility to smallholders have been proposed as a means of improving the adoption of agroforestry (Caveness and Kurtz, 1993). Since certain agroforestry PES programs in Kenya provide stipends as well as credit and savings facilities to participating smallholder farmers (Shames et al., 2012), farmers that are credit constraints are more likely to participate in such PES programs. Conversely, the study by Current et al. (1995) suggests that the impact of credit accessibility on agroforestry adoption in Latin America was negligible.

Agroforestry has been found to come with a higher interest rate compared to other agricultural activities (Place et al., 2012). However, loans at reasonable interest rates are critical for the adoption of agroforestry by farmers with limited financial possibilities in sub-Saharan Africa (Lambert and Ozioma, 2011). Conversely, participants in agroforestry with PES program in rural Kenya have been observed to be charged lower interest rates by financial intermediary as compared to non- participant due to diverse benefits associated with the PES program and high interest rates, and credit constraints in general, may encourage TIST participation in order to enjoy more favorable credit conditions (Benjamin et al., 2015; Roshetko et al., 2005).

Farmer Characteristics

The age of a smallholder farmer which may serve as a proxy for experience positively influence the management decision to use tress on farmland (Adesina and Chianu, 2002; Asafu-Adjaye, 2008). Mercer and Pattanayak (2003) and Ndayambaje et al. (2013) emphasize the positive correlation between age and the probability of agroforestry adoption. Mercer (2004) argued that of the 64 percent of agroforestry adoption studies that include age as a determinant, 29 percent concluded that age was statistically insignificant while the rest suggested a significant positive correlation. As the tendency of smallholder farmers to adopt agroforestry may either increase or decrease with age, the effect of this variable on agroforestry adoption is inconsistent (Mugwe et al., 2009). Younger farmers are more likely to adopt innovative farming practices as they tend to be better informed and are typically less risk-averse than older famers (Asafu-Adjaye, 2008). Farmers tend to reduce investment required to improve farm productivity as there grow older (Mugwe et al., 2009; Marenya and Barrett, 2007). However, the influence of age on the adoption of agroforestry may therefore be project and farmer dependent.

Education and human capital have been argued to significantly influence decisions to adapt and modify innovation in agriculture (Adesina and Chianu, 2002). Human capital and technological adoption is arguably of high importance to agricultural development when access to other resources is limited (Solís et al., 2007; Silici, 2010). Feder and Umali (1993) suggest that there is no conclusive impact of education on the adoption of conservation agriculture although acknowledging its insignificance in the later stage of the diffusion cycle. Conversely, education was found not to significantly influence smallholder farmer´s decision to adopt conservation of in countries such as Kenya, Zambia and Fiji Island (Mugwe et al., 2009; Kabwe et al., 2009; Asafu-Adjaye, 2008; Mercer and Pattanayak, 2003); a potential explanation for this finding is that demonstration and learning-by-doing could outweigh formal education in the decision to adopt agroforestry with PES.

Mass media may constrains the adoption of conservation agriculture in developing countries by excluding extension services in their programs which makes strengthening of other information-sharing channels inevitable (Meena and Singh, 2012). Information and communication technology, i.e. mobile phones, in rural sub-Saharan Africa areas is increasingly been used for agriculture information sharing, therefore rendering other mass media redundant (Aker and Mbiti 2010). Introduction of mass media such as television and radio in developing countries may lead to new ideas and values which causes changes (positive and negative) in social relationship and behavior (Jensen and Oster, 2009). However, mass media may not play a role in the smallholder farmer decision to adopt conservation agriculture as the targeted audiences are usually educated medium to large scale farmers (Friedrich and Kassam, 2009). Therefore mass media can be expected to be neutral having no clear impact on smallholder farmer's decision to participate in agroforestry programs.

Table 1: Hypothesized relationship of variables and the adoption of/membership in agroforestry with PES in rural Kenya

Variable	**Measurement**	**Expected effect on adoption decision**
Neighbor is PES program member	Discrete	+
Co-operative member	Discrete	+
Farm size	Hectares	+/-
Farm slope	Discrete	+/-
Distance to market	km	+/-
Labor supply	Discrete	+
Credit constraint (yes/ no)	Discrete	+
Interest rate (in %)	%	-
Age	In years	+/-
Education	In years	+/-
Mass media (TV)	Discrete	+/-

Source: the authors

Data and variables

The small group tree planting program (TIST) is a non-government-run conservation program. Kenyan smallholder farmers receive payments for ecosystem services (PES) and for engaging in environmental-friendly practices. For example, one motive of TIST is encouraging farmers to engage in afforestation in order to mitigate the effect of climate change through capturing carbon dioxide. TIST operates in and around Meru-, Laikipia-, Embu- and Narok Counties in Kenya, whereas the majority of participating smallholder farmers are concentrated around the Mount Kenyan region especially in the rural areas. The Mount Kenyan region comprises semi-arid and arid climatic condition, therefore representing a variety of the Kenyan climatic zones. In 2013, 210 Kenyan smallholder farmers inhabiting aforementioned regions were surveyed using a structured questionnaire on their participation or non-participation in the TIST program. A sample size of 70 smallholders from each of three counties based on a random selection from group stratification of villagers based on proximity to TIST meeting point was collected resulting in total observation of 210. However, the number of observation reduces to 142 due to missing variables in the dataset as well as strictly accounting for smallholder farmers i.e. farmers with farm size of < 3 hectare.

Descriptive statistics presented in table 2 indicate that 55 percent of all farmers in our sample are members of the *Small Group Tree Planting Programme* (TIST), while 80 percent of interviewees reported to have at least one neighbor who cooperates with TIST. The study shows that 70 percent of interviewees are members of a co-operative; the degree of neighbor participation in TIST and cooperative membership ensures sufficient variation in the explanatory variables of a farmer’s likelihood to be a TIST member himself. For instance, under the farm characteristics category the average farm size was approximately 0.5 hectares while half of all farmland were located on a slope. Furthermore the average distance to the nearest market is on average two kilometers with a standard deviation of 2.4 kilometers. The variables that constitute the business model category suggests that: on average 2 – 3 household members were involved in running household farming activities; 16 per cent of smallholders were unable to the access credit markets and that for the 55 smallholders who do have credit the average interest rate is 15 percent. The variations in the interest rate for loans are quite substantial with a minimum of 4 percent and a maximum of 50 percent per annum, and a standard deviation of approximately 8 percent. In the personal characteristics category it was observed that the average age of the interviewee is approximately 47 years while average years of schooling completed by smallholder farmers was approximately 9. Moreover, 61 percent of the farmers report that they own a television set.

Table 2: Descriptive statistics (refer to model 1 in table 1)

Variable	N	Mean	Standard Deviation	Min	Max
Membership in TIST program (yes/ no)	142	0.55	0.5	0	1
Neighbor is TIST member (yes/ no)	142	0.8	0.4	0	1
Co-operative member (yes/ no)	142	0.7	0.46	0	1
Distance to market (in km)	142	2.03	2.45	0	15
Age	142	47.6	13.53	25	80
Farm size	142	0.54	0.42	0.1	2.4
Farm slope (yes/ no)	142	0.51	0.5	0	1
Labor supply	142	2.62	1.51	1	10
Education	142	8.63	3.56	0	16
Mass media (TV)	142	0.61	0.49	0	1
Interest rate (in %)	55	15.1	8.26	4	50
Credit constraint(yes/ no)	116	0.16	0.37	0	1

Source: own data compilation

Estimation techniques and empirical results

A set of logistic regression models is used to analyze the determinants of participation in TIST program. The models are based on a single dimension, i.e. cross-sectional data. In the empirical models the issue of multicollinearity is limited since the correlation matrix does not indicate excessive correlation between explanatory variables (table 3).

Table 3: Correlation matrix of explanatory variables used in table 4.

		1	2	3	4	5	6	7	8	9	10	11
1	Neighbor TIST	1										
2	Cooperative	-0.09	1									
3	Farm size	0.12	-0.35	1								
4	Distance to market	0.17	-0.58	0.16	1							
5	Mass media (TV)	-0.19	0.00	0.09	-0.09	1						
6	Age	0.02	-0.15	0.20	0.47	0.01	1					
7	Farm slope	-0.23	0.22	-0.16	-0.15	0.12	0.13	1				
8	Labor supply	0.12	-0.20	0.55	0.25	-0.01	0.33	-0.09	1			
9	Education	-0.12	-0.04	0.09	-0.20	0.14	-0.34	-0.08	0.00	1		
10	Interest rate	0.00	-0.11	-0.03	-0.29	-0.17	-0.29	-0.27	-0.20	0.12	1	
11	Credit constraint	0.03	-0.10	-0.06	-0.05	-0.11	-0.19	0.03	0.32	0.12	0.01	1

Given these considerations, the following model has been specified to empirically examine the determinants of participation in TIST, the latter being defined as a binary variable that is a function of a set of personal characteristics, characteristics of the neighboring farmer and features of the credit market. The choice of variables has been derived in line with the hypotheses specified in the model section and aligned to equation 9.

TIST member (yes/no) = β_0 + β_1 Neighbor is TIST participant (yes/no) + β_2 Cooperative member (yes/no) + β_3 Distance to market (km) + β_4 Farm size (hectares) + β_5 Age (years)+ β_6 Labor supply (head count)+ β_7 Education (years)+ β_8 Mass media (TV)+β_9 Interest rate (%)+β_{10} Credit constraint (yes/no) + ε_{it} (11)

Table 4 shows the relationship and signs of the independent variables with respect to participation in TIST program. A set of logistic regression models were used to estimate the correlation of these variables with the likelihood of participation in the TIST program. In all models tested a minimum of one and maximum of four variables were omitted from the regression to test for the robustness of the regression results. The variable(s) omitted were chosen carefully to comply with the necessity to limit omitted variable bias and collinearity; omitted variables include: distance to market; education; access to credit; interest rate.

Results of each set of logistic regressions are presented in table 4. Based on these results we can identify two potential determinants for the variation in TIST membership: neighbors' participation in the TIST program and the farmer's membership in a cooperative. We find that having a neighbor who is a TIST member increases the probability that the interviewee is also a participant by the factor three to four. Unfortunately, we do not know if the neighbor or the interviewee joined the TIST program first. Therefore, we cannot precisely identify who convinced whom to join the program, but we results suggest information spillovers between neighbors. Our results are similar to those of Scholz (2009) who argued social capital is an important variable in the adoption of small-scale agroforestry in Tanzania. Therefore, we are not able to identify whether our interviewee was motivated by the neighbor, or whether our interviewee encouraged his neighbor to join TIST. The correlation, however, indicates an information flow between neighbors, suggesting that word of mouth is an important channel for the exchange of experiences and opportunities. Conversely, we do not find possession of television or mobile phones (the latter is not shown in regression tables) to be correlated with TIST participation, indicating that spillover effects occur mainly through word-of-mouth.

Table 4: Determinants of small-scale forestry adoption among smallholder farmers (farmland < 3 hectares) in the Mount Kenyan region

	(1)	(2)	(3)	(4)	(5)
Neighbor is TIST participant (yes/no)	3.11***	3.66***	3.11***	2.36***	3.06***
	(3.81)	(4.67)	(3.85)	(2.77)	(3.66)
Cooperative member (yes/no)	1.39**	1.40***	1.41**	1.69	2.58***
	(2.39)	(3.11)	(2.44)	(1.25)	(3.40)
Distance to market (km)	0.07		0.08	0.24	0.14
	(0.77)		(0.82)	(0.60)	(0.99)
Farm size (hectares)	0.69	0.71	0.71	0.84	0.92
	(1.41)	(1.62)	(1.42)	(0.63)	(1.26)
Age	0.02	0.03**	0.02	0.05	0.04
	(1.09)	(2.40)	(1.08)	(1.22)	(1.60)
Farm slope (yes/no)	-0.10	-0.06	-0.09	0.07	0.22
	(-0.25)	(-0.15)	(-0.21)	(0.08)	(0.44)
Labor supply	0.11	0.09	0.12	0.94**	0.00
	(0.66)	(0.68)	(0.70)	(2.21)	(0.00)
Education	-0.11*		-0.10	0.08	-0.07
	(-1.76)		(-1.50)	(0.50)	(-0.97)
Mass media (TV)		-0.33	-0.32	-0.99	-0.32
		(-0.82)	(-0.73)	(-1.30)	(-0.59)
Interest rate (in %)				-0.05	
				(-0.87)	
Credit constraint (yes/no)					1.25*
					(1.69)
Constant	-4.18***	-5.84***	-4.14***	-8.30**	-6.24***
	(-3.39)	(-5.30)	(-3.33)	(-2.08)	(-3.50)
Observations	142	165	142	55	116

Note: Robust z-statistics in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Similarly, cooperative membership is associated with an increased likelihood of joining TIST. This coefficient is statistically significant in four out of five models; only in model four, where the number of observations drops substantially due to the inclusion of a new variable, statistical significance cannot be observed. We also cannot identify an unambiguous causal direction going from co-operative membership and TIST participation, but we know that co-operatives have existed in Kenya for many decades while TIST activities started only in 2005, suggesting that preexisting co-operative structures fostered information flow about TIST, and TIST membership did not play a role at advertising the advantages of a cooperative membership. To a certain extent, our results suggest that age and labor supply are positively correlated to participation in TIST program, but low levels of statistical significance do not indicate that these effects are reliable. Similarly, coefficients reflecting the effects of farm size and distance to market indicate a positive, but statistically insignificant relationship between these variables and TIST participation. As for farm size, we may hypothesize that this coefficient possibly indicates a benefit from economies of scale. Remote farms may face high transaction costs with conventional farming; in these cases, agroforestry is an attractive alternative since revenues may be generated without the necessity of bringing crops to local markets. Also, remoteness to markets seems to reduce the opportunity cost and reduce the necessity to use land primarily for transport-intensive and therefore costly food exports to urban markets. Interestingly, school education seems to have a negative effect on TIST participation; we abstain from interpreting this coefficient in the light of inconsistent expectations suggested by aforementioned literature, but use this variable as a control to avoid omitted variable bias. We also tested whether an individual's experience with formal credit markets is an incentive for participation. Benjamin et al.'s (2015) results suggest that the relationship between 'access to credit' and 'interest rate' on the one hand, and TIST membership on the other hand might be endogenous: TIST membership may help overcoming credit constraints and lowering interest rates, but sub-optimal credit market conditions may also encourage smallholder farmers to join TIST to address this disadvantage. Whereas the effect of credit constraint on TIST membership by assumption is positive, the reverse effect is likely to reduce the likelihood of being credit constraint, possibly reducing the size of the observed coefficient and underestimating the effect size. In model 4, we investigated determinants of TIST membership among clients of a formal credit institution and found no correlation between paid interest rates and TIST membership. Model 5 extends the analysis performed in model 4 and investigates all *potential* clients of a credit institution. We use the information on credit constraints as another proxy for the incentive to participate in TIST. The corresponding coefficient indicates that credit constraints serve as an incentive to participate in TIST. This confirms the considerations discussed above: smallholders with limited credit market access may anticipate beneficial effects of TIST membership and participation in ecosystem services with respect to their ability to access formal credit markets, and join TIST in order to benefit from credit and savings infrastructure provided within this program. This is a potentially important finding since participation in TIST and the accompanying income from ecosystem services have been found to be a successful business strategy for smallholders, granting them favorable credit contract terms and providing a collateral substitute (Benjamin et al., 2015).

Conclusion

We analyzed the determinants of participating in agroforestry with PES programs using TIST, an agroforestry with PES program in Kenya, as a case study; emphasis is put on the influence of the farmer's personal characteristics as well as farm and household characteristics. Participation in TIST is conceptualized as an inclusive rather than an exclusive undertaking, i.e. it is a voluntary program open to any interested party, including smallholders without access to conventional sources to innovations and agricultural technology. Therefore, our results help for understanding hurdles faced by smallholder farmers to accessing existing networks and infrastructure and benefiting from knowledge, innovations, and technology spillovers.

Notable drivers influencing participation in the TIST program are formal and informal networks such as membership in a co-operative and a neighbor's participation in TIST. This finding is statistically significant and robust for a series of model adjustments. Furthermore, our findings suggest that households with high labor supply and those that are credit constrained are more likely to participate in agroforestry with PES programs such as TIST. Although these results are in line with existing literature, the interpretation should be made with caution given the limited number of observations in our models. We also found, like in most of the literature, a consistent but rather weak positive correlation between the adoption of agroforestry with PES and a smallholder's age. Participation of smallholder farmers in agroforestry with PES program (TIST) appears uninfluenced by farm size, level of education or presence of mass media.

Our main conclusion is that participation in small-scale agroforestry with PES programs in certain parts of sub-Saharan Africa, to a large extent, do not exclude smallholder farmers due to their status, thus, they do not run the risk of becoming a "*club"* only for the privileged. Designing sustainable agriculture policy with a bottom–up approach may help speed up adoption of conservation amongst smallholder farmers in rural sub-Saharan African. Incorporating existing networks and institutions into outreach plans should also be considered as a plausible alternative. However, given the limited number of observations (n = 210) used in this analysis, more research is needed to verify the aforementioned evidence.

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