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Assessing smallholder farmers' motivation to adopt agroforestry using a multi-group structural equation modeling approach

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Abstract This study applied the multi-group structural equation modeling technique to identify differences in farmer motivations to adopting agroforestry practices in the Mt. Elgon region of Uganda. Data were collected from interviews with 400 smallholder coffee farmers belonging to four categories which included: (1) those actively participating in an Australian-funded trees for food security (T4FS) project from phase 1 (2014); (2) farmers neighbouring those actively participating in the T4FS project; (3) farmers actively participating in the T4FS project from phase 2 (2017) and; (4) farmers living distant and unaware of the T4FS project. We used the theory of planned behaviour framework to assess the adoption behaviour of these farmer categories resulting from project interventions. About 40% of the variation in farmer motivation to integrate trees in their coffee plantations was explained by the significant variables of 'attitude' and 'perceived behavioural control' among farmers actively participating in the T4FS project from phase 1. However, the neighbors of participating farmers and farmers who had never interacted with the project were only motivated by 'attitude' and 'social norms' respectively. Farmer motivation resulting from social pressure was strongest among farmers who had never interacted with the project, and in the absence of project interventions, rely on existing social structures to drive change in their community. Farmers' perceived behavioural control to overcome tree planting barriers and their attitude to the economic benefits of shaded coffee were significantly different among the four farmer categories ($p < 0.05$). The findings indicate that psychological factors are key drivers to the farmers' internal decision-making process in agroforestry technology adoption and can be context-specific. The adoption behaviour of smallholder farmers is mainly shaped by existing community social norms and beliefs that tend to promote knowledge exchange, as opposed to the conventional knowledge transfer extension approaches. Norms are therefore an inherent part of social systems and can create distinct farming practices, habits and standards within a social group. Researchers and extension agents can act upon these identified positive attitudes,

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norms and perceived behavioural controls to guarantee adoption and sustainability of agricultural technologies.

Keywords Coffee agroforestry · Psychological drivers · Motivation · Adoption · Uganda

Introduction

Population growth in Sub-Saharan Africa has greatly contributed to the ever increasing intensive agriculture and related land use pressures (Meijer et al. 2015). Many smallholder farmers in Sub-Saharan Africa must deal with low and unpredictable crop yields and incomes. There is an urgent need for sustainable agricultural practices that can address these issues. However, most options to improve productivity involve the use of expensive inputs that inherently increase risks that farmers are often unable to bear. Agroforestry is a cheaper option that offers a wide range of benefits to farmers including increasing crop yield and food security (Garrity et al. 2010). Farming systems with fertilizer trees are inexpensive and significantly increase crop yields and food security while enhancing associated environmental services (Akinnifesi et al. 2010; Ajayi et al. 2011). Although the benefits of agroforestry are well known and various innovations are being used by farmers, there has not been widespread adoption (Meijer et al. 2015). There are also cases where some agroforestry technologies have been adopted, and later abandoned in some communities (Kiptot et al. 2007).

Although several studies have documented the extrinsic factors influencing agroforestry adoption (Mukadasi et al. 2007; Barungi et al. 2013; Gram et al. 2018; Rahn et al. 2018), the reasons for the relatively low adoption rates are still not fully understood. There is a general concern that researchers need to pay more attention to the internal decision-making process, and look beyond the mere characteristics of agricultural innovations and the household to include psychological factors in technology uptake (Sood and Mitchell 2006; Mekoya et al. 2008; Borges et al. 2014; Senger et al. 2017). However, these studies have rarely been applied to agroforestry adoption, especially in the Mt. Elgon region of Uganda.

This study applied the multi-group structural equation modeling technique to identify the differences in farmer psychological drivers to adopt shaded coffee across four farmer categories in the Mt. Elgon region of Uganda. The selection of farmer categories was based on the duration of implementation of an Australian government funded project in the Mt. Elgon region of Uganda. The T4FS is an Australian Centre for International Agricultural Research (ACIAR) funded project aimed at improving household food security and smallholder livelihoods through widespread adoption of appropriate locally adapted agroforestry practices in key agricultural landscapes in Ethiopia, Rwanda and Uganda. The project has been reaching out to smallholder farmers in rural regions where an estimated 10 million people are facing acute food security problems since 2012. It has demonstrated the importance of trees in fields and farming landscapes for enhancing and sustaining crop yield and food security in Eastern Africa. In Uganda, the T4FS project started in 2014 and currently in its second phase of implementation in the Mt. Elgon region of Uganda (www.worldagroforestry.org/project/trees-food-security-2-developing-integrated-options-and-accelerating-scaling-agroforestry).

The importance of trees in fields has been demonstrated among smallholder coffee farmers through participatory on-farm trials involving planting of trees in coffee farming systems in Eastern Uganda. Coffee is shade tolerant and traditionally grown under shade trees in complex agroforestry systems (Franck and Vaast 2009). However, there has been a general transformation of coffee farming by eliminating shade trees, increasing agrochemical inputs and selecting genotypes—all to increase short-term income (Jezeer and Verweij 2015). The question of whether coffee provides benefits from shade trees has been widely disputed where yield potential, competition for water and nutrients and pest and disease incidence are central issues in this controversy (Beer et al. 1997; Damatta 2004; DaMatta and Ramalho 2006). Nonetheless, there is substantial evidence that unshaded coffee plantations generally require high levels of external inputs to maximize yield (Damatta 2004; Jezeer et al. 2018), a cost smallholder farmers in the Mt. Elgon region can seldom afford. The cheaper alternative available to smallholder coffee farmers is the integration of shade trees, facilitated by the T4FS project, to sustain their coffee production. The study addresses the extent to which project interventions influenced smallholder farmers' motivations to integrate trees in their coffee farming systems.

Theoretical background of the study

To investigate smallholder farmers' motivation to adopt shaded coffee on their farms, this study employed the Theory of Planned Behaviour (TPB), which suggests that behavioural intentions are shaped by attitude, subjective norms and perceived behavioural control (Ajzen 2011). This study adopted the Theory of Planned Behaviour (TPB) due to the limitations associated with other theories such as Theory of Diffusion of Innovations (DIT) (Rogers 2003), Theory of Reasonable Action (TRA) (Fishbein and Ajzen 2010) and the Technology Acceptance Model (TAM) (Venkatesh and Davis 1996). For example, while the DIT has been reported to be market focused (Lai 2017), rendering it vital for organization implementation, TRA ignores the perceived behavioural control construct, which was reported to be vital by Buyinza et al. (2020). The final version of TAM eliminates the need for the attitude construct (Lai 2017), a key social aspect among smallholder farmers.

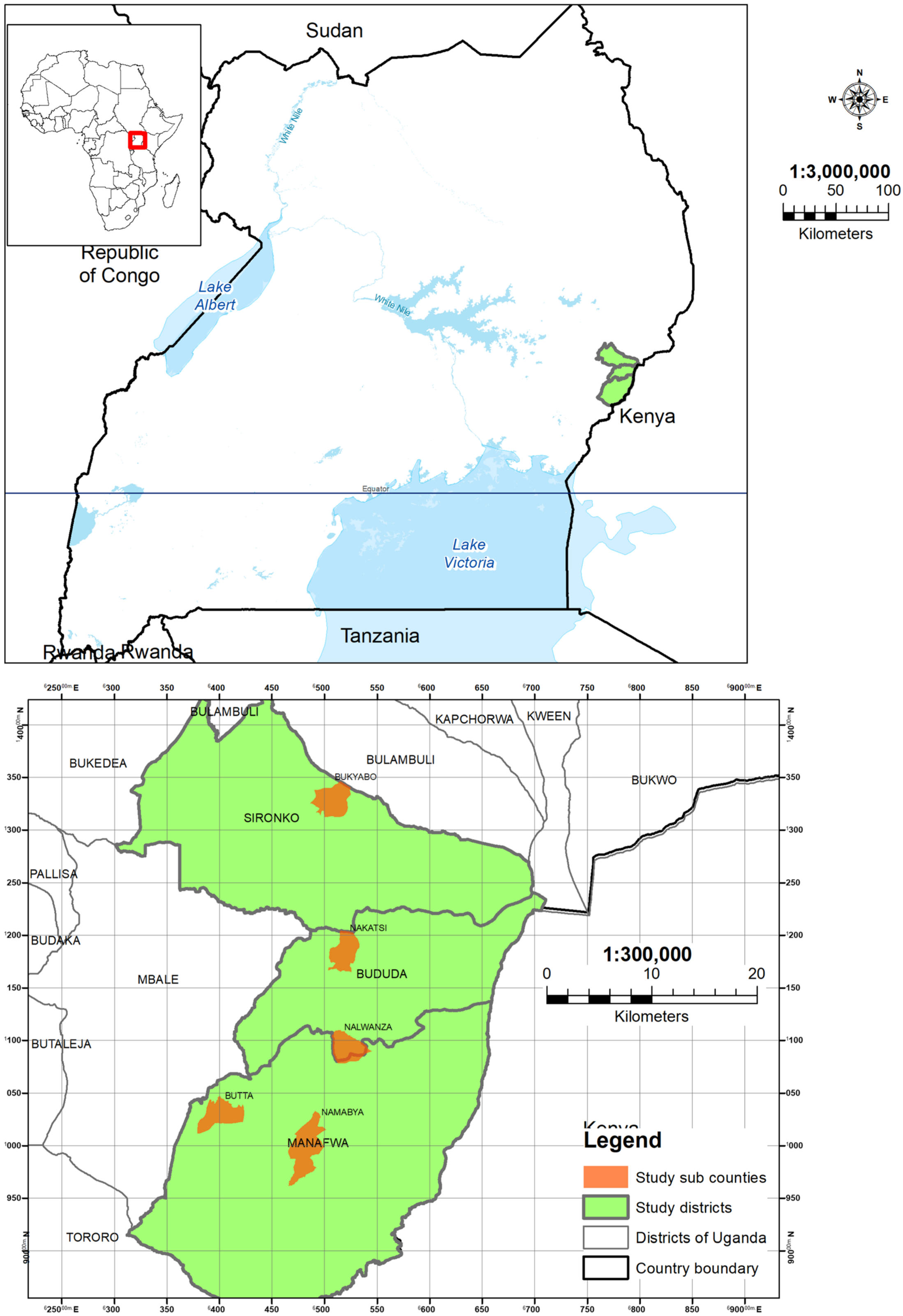
The TPB used in this study is an expectancy-value model that provides a useful framework for understanding the correlation between attitude and the underlying beliefs (Meijer et al. 2015). It offers a theoretical foundation for studying psychological factors that influence people's intentions and behaviours. The components of the TPB (attitude, subjective norm and perceived behavioural control) relate to the key aspects influencing smallholder farmers' decision-making on integration of trees in their coffee plantations in the Mt. Elgon region of Uganda (Buyinza et al. 2020). Attitude is the degree to which execution of a behaviour is positively or negatively evaluated (Wauters et al. 2010). Subjective norm refers to a person's perception of the social pressure upon them to perform or not perform a behaviour, and perceived behavioural control is the perceived personal capability (perceptions of difficulties and possibilities) to successfully perform the behaviour (Borges and Lansink 2016).

Methods

Study area

The study was conducted in three districts including Manafwa, Bududa and Sironko, located in Mt. Elgon region of Uganda (Fig. 1). The study was conducted in three districts including Manafwa, Bududa and Sironko, located on the slopes of Mt. Elgon in Eastern Uganda (Fig. 1). In terms of climate, the area receives a bimodal pattern of rainfall with an average annual rainfall of 1500 mm. The region has peak rainy seasons that occur in the months of April-May and September-November, occasionally characterized by landslides (Atuyambe et al. 2011; Broeckx et al. 2019; Nakileza et al. 2017). However, a pronounced dry period occurs from December to February, with a mean annual temperature of 23 °C. The soils are generally classified as inorganic clays of high plasticity (Mugagga et al. 2012) and local farming communities live between 1000 m.a.s.l. at the foothill and 2200 m.a.s.l. close to the protected Mt. Elgon National Park. Due to the relatively high population density of approximately 250–300 inhabitants per km^2 (Gram et al. 2018), the landscape mainly consists of smallholder farms (< 2 acres) with intensive and mixed coffee (*C. arabica*) agricultural systems. However, coffee productivity has been reported to be substantially lower than its potential due to low soil fertility and poor land and coffee tree management practices (Wang et al. 2015).

In terms of the general social setting of the community, participation in farmer group activities has been reported to be generally dominated by male farmers and coffee has been categorized as a male-controlled crop (Ochago 2017). Women have been reported to have limited access to and control over coffee management inputs and benefits (Ochago 2017), a key barrier to their coffee farming decision making. However, local knowledge on agroforestry has been reported to be gender blind in the region, with no differences observed in ranking of tree species and ecosystem services between men and women (Gram et al. 2018). Communities close to the National Park are reluctant to invest in long term conservation techniques due to the land tenure insecurity (Mugagga and Buyinza 2013).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Districts of Uganda
Country boundary

◀**Fig. 1** Map showing study sites

Sampling and survey

In this study, four respondent categories were purposively selected and these were: (1) farmers actively participating in the T4FS project from phase one beginning in 2014; (2) farmers neighbouring those actively participating in the T4FS project; (3) farmers actively participating in the T4FS project from phase 2 beginning in 2017; and (4) farmers who have never participated in the T4FS project and living far from project participating farmers. The farmers actively participating in the project since its inception and those neighbouring active project participants, were selected from Manafwa district, the only area where the T4FS project has been operating since 2014. Farmers actively participating in the second phase of the project and those who had never participated in the T4FS project were selected from Bududa and Sironko districts respectively. While Bududa district is among the districts where the second phase of the project is being implemented (since 2017), there are no T4FS project interventions in Sironko district. However, the farming systems, ethnicity and culture are identical across the three districts.

Prior to the main survey, a pre-test was carried out with 15 farmers to ensure that the questions could be clearly understood. The final version of the survey tool consisted of three groups of questions: socio-demographic characteristics; farmers' opinions and assessment of existing agroforestry practices; and questions based on TPB. This paper only addresses socio-demographic characteristics and TPB questions in relation to the four respondent categories. A sample of 100 respondents was randomly selected for each respondent category, giving a total of 400 respondents for the entire study. While a random sample of farmers actively participating in the project since its inception and farmers actively participating in phase 2 of the project was obtained from the list of project beneficiaries, farmers who had never participated in the project were randomly selected from a list of households from the local council leaders. A list of farmers neighbouring project beneficiaries was generated with the help of local leaders, from which a random sample was obtained. A simple random sampling technique was used to select random samples. The data collection took place from May to July 2018.

Data analysis

Model estimation

Structural equation modeling (SEM) quantifies the underlying relationships between latent constructs. SEM is a series of models that are combined in a single platform (Hair et al. 2010). However, two fundamental models are included in SEM: (1) a measurement model, which is a linear model that generates the latent constructs as a function of the observed variables; and (2) a structural model (also known as a path analysis), that quantifies the relationships between the latent constructs (Hair et al. 2010; Fonseca 2013). Multi-group SEM provides a simultaneous estimation of different interdependent multiple regressions (Hair et al. 2010) that allows analysis of several groups of data from a population. While SEM can be conducted with each separate subset of data individually, simultaneous analysis is preferred because it allows testing of the significance of any differences among groups. Simultaneous analysis also provides a more accurate estimation of the group parameters, whether there are group differences or not.

The structural model validated by Buyinza et al. (2020) was used to proceed with the multi-group analysis in this paper (Fig. 2). The four groups of data were the farmer sample groups mentioned above. Multi-group SEM aims to identify the differences in farmer psychological motivations to adopt agroforestry practices across these farmer categories in

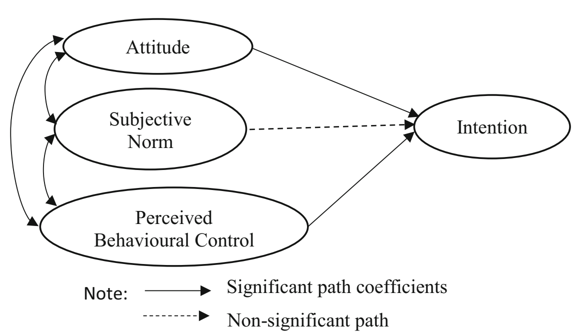

Fig. 2 Structural model for farmers' intention to adopt trees on-farm. (Adapted from Buyinza et al. 2020)

the Mt. Elgon region of Uganda. The differences concern whether farmers at different levels of interaction with the T4FS research project differ from each other in psychological factors that influence their intention to incorporate trees in coffee plantations. The results address to what extent project interventions influence smallholder farmers' adoption of agroforestry practices. The four TPB latent constructs (attitude, subjective norm, perceived behavioural control and intention) are used in the structural model. The variables that represent the constructs are shown in Table 1.

Estimation was run by IBM SPSS Amos 25. Although goodness-of-fit (GOF) indices have four categories, (including Chi-square test, absolute fit indices, incremental fit indices and parsimonious fit indices), using the Chi-square test and at least one index from each of the other groups is the rule of thumb (Hair et al. 2010). This approach has also been seen in other SEM studies (McKenzie and Gow 2004; van Der Veen and Song 2014; Dang et al. 2018). Other model fit indices estimated include the Ratio of Confirmatory Fit Index to degrees of freedom (CMIN/DF), Incremental Fit Index (IFI), Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA) and the Probability of getting a sample RMSEA as large as its calculated value in the given model (PCLOSE). The structural model in Fig. 1 shows an acceptable model fit ($\chi^2 = 141.631$, df = 59, $p = 0.000$, CMIN/DF = 2.401, IFI = 0.933, TLI = 0.910, CFI = 0.932, RMSEA = 0.059 and PCLOSE = 0.107).

Multi-group structural equation analysis

Using the validated structural model, two structural models were estimated as meeting the requirements of the multi-group SEM technique. The first was the unconstrained structural model in which all parameters were to be estimated for each of the four groups. The second model was estimated with selected controlled path coefficients. In this study, the controlled path coefficient was the subjective norm, which was insignificant in the structural model (Fig. 2). This second model assumes that some parameters in one group are equal to those in the other groups. The two models were then assessed using the Chi-square test to decide which model was better to address factors that influenced the adaptation intentions across the four farmer categories at different levels of interaction with the T4FS project in the Mt. Elgon region of Uganda.

Results

Socio-economic characteristic of the sample

Overall, out of the 400 respondents interviewed, 228 (57%) were males and there was a uniform distribution of male and female respondents across the four farmer categories. Over 50% of the respondents were aged between 31 and 50 years and the majority had only attained primary education and owned less than 2 acres of land. While most of the households had 4–7 family members, active farm work was mostly done by less than 3 male and female household members.

Descriptive statistics for the attitudinal statements stratified by farmer category are presented in Table 1. Farmers generally displayed a high intention to plant shade trees in their coffee plantations. Farmers evaluated planting of trees in coffee as being highly favorable, expressed by means above 6 out of 7 for all variables measuring attitude across all farmer categories. However, farmers perceived relatively low social pressure to plant trees in coffee plantations, especially among farmers actively participating in the project activities (group 1 and 3). Generally, farmers displayed a moderate perception of control on planting scattered trees on their farms. The main limiting factors appear to be resources (including seedlings, labour and land) and the technical skills involved in planting and managing trees on farm.

The analysis of variance between the construct variables and farmer categories showed significant differences in farmer perceptions of social pressure to plant trees from their peers and extension workers across the farmer categories ($p < 0.01$) (Table 1). Farmers' perceived own capability (perceived behavioural control) to overcome tree planting barriers and their evaluation of the economic benefits of shaded coffee (attitude) were significantly different among the four farmer categories ($p < 0.05$).

Model estimates based on groups

Following validation of the proposed model conducted to obtain an appropriate model fit, an unconstrained structural model was developed based on four groups

Table 1 Group-specific descriptive statistics "mean (standard deviation)" of attitudinal measurable variables on a scale of 1–7 and Analysis of variance (ANOVA) between TPB construct variables and farmer categories (*p* value)

Statement/question	Overall	Group1[a]	Group2[a]	Group3[a]	Group4[a]	*P*-Value
Intention	6.21 (0.82)	6.35 (0.72)	6.19 (0.79)	6.01 (0.96)	6.29 (0.72)	
INT1: Do you intend to plant trees for shade in at least part of your farm in the next 5 years?	6.37 (0.81)	6.50 (0.73)	6.36 (0.80)	6.17 (0.97)	6.44 (0.70)	0.024*
INT2: How likely is it that you will plant trees for shade in at least part of your farm in the next 5 years?	6.07 (0.78)	6.17 (0.70)	6.09 (0.73)	5.93 (0.96)	6.08 (0.72)	0.180
INT3: How strong is your intention to plant trees for shade in coffee in at least part of your farm in the next 5 years?	6.20 (0.85)	6.37 (0.76)	6.12 (0.84)	5.94 (0.98)	6.35 (0.74)	0.001**
Attitude	6.17 (0.80)	6.20 (0.92)	6.26 (0.79)	6.11 (0.73)	6.13 (0.75)	
ATT1: Planting trees in my coffee garden reduces the amount of inputs (e.g., fertilizers) into the farm	6.17 (0.88)	6.18 (1.10)	6.26 (0.84)	6.12 (0.73)	6.11 (0.82)	0.608
ATT2: Planting trees in my coffee garden provides more economic benefits compared to unshaded gardens	6.19 (0.76)	6.28 (0.87)	6.29 (0.77)	6.02 (0.72)	6.16 (0.63)	0.039*
ATT3: I need to use shade trees on my coffee farm to maximize production	6.17 (0.77)	6.14 (0.79)	6.23 (0.76)	6.20 (0.73)	6.12 (0.81)	0.725
Subjective norm	5.08 (1.49)	4.98 (1.66)	5.21 (1.47)	4.83 (1.71)	5.31 (0.94)	
SN1: Most people who are important to me think I should plant shade trees on my coffee farm	5.21 (1.47)	5.04 (1.60)	5.45 (1.43)	4.86 (1.72)	5.48 (0.90)	0.004**
SN2: Extension workers think I should plant shade trees on my coffee farm	5.07 (1.58)	4.87 (1.80)	4.85 (1.69)	4.85 (1.66)	5.69 (0.85)	0.000**
SN3: Other farmers whom I regularly interact with would approve that I should plant shade trees on my coffee farm	5.32 (1.42)	5.32 (1.57)	5.52 (1.33)	5.02 (1.69)	5.40 (0.93)	0.079
SN4: I feel under social pressure from fellow farmers to plant shade trees on my coffee farm	4.75 (1.51)	4.70 (1.65)	5.03 (1.46)	4.58 (1.78)	4.67 (1.06)	0.168
Perceived behavioural control	5.13 (1.16)	5.08 (1.12)	5.18 (1.19)	5.02 (1.22)	5.22 (1.07)	
PBC1: I feel that I have sufficient knowledge on planting shade trees in my coffee farm	5.28 (1.05)	5.25 (1.03)	5.38 (1.14)	5.08 (1.15)	5.41 (0.83)	0.105
PBC2: I have all the resources (e.g. seedlings, labour and land) I need to plant shade trees in my coffee farm.	4.66 (1.29)	4.68 (1.27)	4.82 (1.22)	4.60 (1.29)	4.54 (1.41)	0.458
PBC3: How confident are you that you could overcome barriers that prevent you from using scattered trees in at least part of your farm within the next 5 years?	5.44 (1.36)	5.31 (1.05)	5.35 (1.23)	5.38 (1.23)	5.72 (0.98)	0.040*

[a]Group 1 = farmers actively participating in the T4FS project from phase 1 (2014); Group 2 = farmers neighbouring those actively participating in the T4FS project; Group 3 = farmers actively participating in the T4FS project from phase 2 (2017) and; Group 4 = farmers living distant and unaware of the T4FS project. N = 400; df = 3; *significant at 5% significance level; **significant at 1% significance level

representing the study farmer categories. The constrained model was obtained by controlling the subjective norm path coefficient, which was insignificant in the structural model (see Fig. 2). The corresponding model fit indices for the unconstrained and constrained models are shown in Table 2. All indices for the unconstrained and constrained models indicate an acceptable fit.

Table 2 Model fit indices for the unconstrained and constrained models

Statistic	Threshold	Unconstrained model	Constrained model
CMIN/DF	1–3	1.517	1.511
IFI	$\geq$ 0.900	0.910	0.907
CFI	$\geq$ 0.900	0.904	0.905
RMSEA	$\leq$ 0.06	0.036	0.036
PCLOSE	$\geq$ 0.05	0.999	0.999
χ^2, df, *p*	–	χ^2 = 358.012, df = 236, p = 0.000	χ^2 = 358.136 df = 237, p = 0.000

Multi-group analysis model parameter outputs

The model parameter outputs in Tables 3 and 4 show the structural relations of attitude, subjective norms, and perceived behavioural control on farmers' intention to plant shade trees among the four farmer categories of the study. The estimation results of the unconstrained structural model show that there are differences across the four groups (farmer categories) regarding factors that influence farmers' intentions to integrate trees in their coffee plantations (Table 3). The intention of farmers actively participating in the T4FS project from phase 1 to plant trees in coffee is significantly influenced by their attitude and perceived behavioural control. Only the attitude construct influences farmers neighbouring those actively participating in the T4FS project to plant trees in coffee plantations, and none of the TPB constructs influences the intentions of the farmers who have never participated in the T4FS project and who are living far from the farmers participating in the project, to plant trees in coffee plantations. There was also an insignificant negative influence of perceived behavioural control to plant trees in coffee among farmers who had never participated in the T4FS project and living far from project participating farmers.

The results of the constrained model are similar to the unconstrained model but with an additional positive subjective norm coefficient for the group of farmers who have never participated in the T4FS project and are living far from project participating farmers (Table 4). The constrained model also shows an improvement in the variation of farmer intentions that can be explained by the significant variables (attitude and perceived behavioural control) among farmers actively participating in the T4FS project from phase 1 (R^2 = 0.398).

The Chi-square test to compare the two models shows an insignificant result (*p*-value = 0.725), indicating that the four groups are not different at model level but may differ at path level (Table 5). This further implies that the constrained structural model is better able to reflect the influences of TPB constructs on farmers' intentions to adopt agroforestry practices across the four farmer categories.

Table 3 Multi-group analysis: unconstrained model standardized parameter estimates

Group/ farmer category	Endogenous TPB construct variable	Exogenous TPB construct variables			Structural equation fit (R^2)
		ATT	SN	PBC	
Farmers actively participating in the T4FS project from phase 1	INT	0.180*	– 0.001	0.260*	0.371
Farmers neighbouring those actively participating in the T4FS project	INT	0.414**	– 0.025	0.132	0.284
Farmers actively participating in the T4FS project from phase 2	INT	0.378	0.045	0.190*	0.166
Farmers who have never participated in T4FS project and living far from project participating farmers	INT	0.162	0.343	– 0.034	0.144

*Significant at 5% significance level; **Significant at 1% significance level

Table 4 Multi-group analysis: constrained model standardized parameter estimates, with the subjective norm path coefficient controlled for the four groups or farmer categories

Group/ farmer category	Endogenous TPB construct variable	Exogenous TPB construct variables			Structural equation fit (R^2)
		ATT	SN	PBC	
Farmers actively participating in the T4FS project from phase 1	INT	0.190*	− 0.018	0.251*	0.398
Farmers neighbouring those actively participating in the T4FS project	INT	0.415**	− 0.018	0.133	0.282
Farmers actively participating in the T4FS project from phase 2	INT	0.378*	0.045	0.190*	0.166
Farmers who have never participated in the T4FS project and living far from project participating farmers.	INT	0.162	0.343*	− 0.034	0.144

*Significant at 5% significance level; **Significant at 1% significance level

Table 5 Chi-square test for comparison between the constrained and unconstrained model

Model	Chi-square	df	*p* value
Unconstrained model	358.012	236	
Constrained model	358.136	237	
Difference	0.124	1	0.725

Discussion

Farmers' motivation to adopt shaded coffee farming systems.

The results of this study indicate that there are differences in farmer motivations to integrate trees in their coffee plantations across the four farmer categories. The squared multiple correlation (R^2) for farmers' intention to plant trees in coffee plantations shows 39.8%, 28.2%, 16.6% and 14.4% variation of farmer intentions among the 4 respective farmer groups. This can be explained by the corresponding significant constructs in each farmer category. The constrained model estimates show that the constructs of 'attitude' and 'perceived behavioural control' had a positive significant influence on farmers' intentions among project participating farmers (Table 4). This implies that the motivation of project participating farmers (phase 1 and 2) to adopt shaded coffee was a result of their positive evaluation of shaded coffee as being more favorable and their own perceived capability to implement the practice of integrating trees in their coffee plantations. A related agroforestry adoption study in Southern Bahia, Brazil revealed that perceived behavioural control proved to have the most significant correlation with farmers' intentions to adopt or maintain agroforestry (McGinty et al. 2008). They expected support from government, non-governmental organizations and research institutions in addressing their hindrances (such as lack of seedlings, labour and land) when making land use decisions. Farmers often argue that adopting agroforestry practices on their farms is out of their control without extensive support from such agencies and organizations. It is therefore not surprising that perceived behavioural control is an important motivation among project beneficiaries (phase 1 and 2) who often receive free seedlings and capacity building trainings from the T4FS project.

However, the neighbors of project participating farmers and farmers that had never interacted with the project were only motivated by 'attitude' and 'social norms' respectively. Norms are an inherent part of social systems and structures (such as smallholder farming communities), typically developed through a process of socialisation within a given social context and can create distinct farming practices, habits and standards within a social group. Social norms can influence farmer behaviours through the process of diffusion (Mankad 2016), where an innovation is communicated through social channels within a social structure (Rogers 2004). Early research in the agricultural context found that the process of diffusion exerted social pressure on farmers to adopt innovative farming practices championed by early adopters in the neighbourhood. The rationale was that evidence of implementation and success of innovative practices was the most effective way to change farmers' behaviours. A potential reason why social norms do not seem to play a key psychological influence on farmer decisions among farmers interacting with researchers (category 1 and 3 farmers) and their neighbors (category 2) could be because some research outputs may undermine or conflict with the pre-existing social cultural attachments among communities. This could explain why social norms are predominant in Sironko, where farmers have never interacted with the T4FS research project.

Underlying farmer motivations across farmer categories

Each of the four constructs (intention, attitude, perceive behavioural control, social norms) had at least three subsidiary construct variables that also demonstrated significant differences across the four farmer categories (see Table 1). For example, there were clear differences in attitude based on their evaluation of the economic benefits that can be accrued from shaded and unshaded coffee ($p < 0.05$, Table 1, ATT2). Economic benefits from shaded coffee were more positively perceived by farmers actively participating in the project from phase 1, and their neighbors. This category of farmers had interacted with the project and project neighbors for a longer period than the other farmer categories. It is likely that these farmers had learnt from project interventions such as training, tree seedling distribution and participatory trial establishment. The neighbors may have learnt through observations and knowledge sharing with project beneficiaries.

The study revealed differences in farmer perceptions of the social pressure from other important people and extension workers across the four farmer categories ($p < 0.05$, Table 1, SN1 & SN2). Farmer motivation resulting from social pressure was strongest among farmers who had never interacted with the project and lived far from project beneficiaries. This could indicate that these farmers have stronger social structures that drive change in their community compared with other farmer categories. The lack of any project intervention in the area could have resulted in the use of existing norms and government extension systems among communities as the only source of information regarding agroforestry. Conventionally, extension has assumed that innovations originate from science and are transferred to farmers who adopt them (Black 2000). However, extension theory and practice has seen a paradigm shift from knowledge transfer approaches to knowledge exchange approaches (Blackstock et al. 2010). The expression of social norms as drivers towards integration of trees in coffee systems among farmers who had never interacted with the project and lived far from project beneficiaries seems to demonstrate this theory. Rural people tend to rely more on indigenous knowledge when engaging in tree planting and less on formal knowledge (Meijer et al. 2015; Ofoegbu and Speranza 2017). While knowledge transfer approaches promote the adoption of predetermined practices, knowledge exchange approaches emphasise the need for people to develop their own solutions to problems. Therefore, the relationship between farmers and researchers, and extension workers should shift from knowledge transfer to knowledge exchange.

Knowledge exchange involving communication within a social group is an important process in articulating, sharing and exchanging ideas amongst farmers. Although knowledge exchange fails to recognise the difficulties and dangers in working with multiple forms of knowledge (Morgan and Murdoch 2000), there are implications for how science underpinning agroforestry in smallholder farming systems should be conceptualised, conducted and communicated. The role of social norms in agricultural technology adoption should not be underestimated and should be integrated into agricultural research and extension. This is because social norms are instrumental in building social pressure among local communities towards a behaviour.

The Theory of Planned Behaviour framework and multi-group SEM analytical technique demonstrated potential for understanding the complex behaviour of smallholder farmers towards agroforestry adoption. However, to improve their predictive power, we recommend inclusion of additional constructs in the TPB framework. Ajzen (1991) accepts that additional variables may be required but argues that they should contribute significantly to the explanation provided by the model. On this basis, future applications of the TPB and multi-group SEM should include additional constructs such as environmental concern by farmers (e.g. willingness to protect existing trees, plant new trees on bare landscapes) and incentives from having shaded coffee (e.g. government support towards tree management, carbon trade initiatives, premium prices for shade coffee). Incorporation of background factors such as age, education, land size and sex could also provide a more comprehensive analysis of the motivations of smallholder farmers to adopt agroforestry practices. However, a related study on farmers' response to rural development policy challenges found that the influence of background factors on behavioural intentions was less pronounced (Martinovska et al. 2016). Nonetheless, background factors can be context-specific, thus there is a need to include them in future related studies, especially in developing countries.

Conclusions

Sustainable agricultural technology adoption requires that researchers and development agencies pay more attention to the internal decision-making processes, and look beyond the mere characteristics of agricultural innovations and the household to include psychological factors in technology uptake. The Theory of Planned Behaviour provides a useful model for exploring the psychological factors that influence smallholder farmers' tree planting decisions. Multigroup Structural Equation Modeling employed by this study provides a simultaneous estimation of different interdependent multiple regressions (Hair et al. 2010) which allows analysis of several groups of data from a population. The findings indicate that psychological factors are key drivers to the farmers' internal decision-making processes in agroforestry technology adoption. However, the psychological factors vary among different groups of farmers, usually shaped by the existing community social norms and beliefs. These norms tend to promote knowledge exchange, as opposed to the traditional knowledge transfer approaches. The TPB collectively explained about 40% of the variance in farmers' intensions to integrate trees in coffee plantations with attitude and perceived behavioural control being the statistically significant predictors. Future applications of the TPB and multigroup SEM should include additional constructs such as environmental concern by farmers and incentives to farmers for having shaded coffee. This would provide a more comprehensive analysis of the motivations of smallholder farmers to adopt agroforestry practices.

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