Kassie, Geremew Worku

Article

The Nexus between livelihood diversification and farmland management strategies in rural Ethiopia

Cogent Economics & Finance

Provided in Cooperation with:
Taylor & Francis Group

Suggested Citation: Kassie, Geremew Worku (2017) : The Nexus between livelihood diversification and farmland management strategies in rural Ethiopia, Cogent Economics & Finance, ISSN 2332-2039, Taylor & Francis, Abingdon, Vol. 5, Iss. 1, pp. 1-16, https://doi.org/10.1080/23322039.2016.1275087 cogent economics & finance

GENERAL & APPLIED ECONOMICS | RESEARCH ARTICLE

The Nexus between livelihood diversification and farmland management strategies in rural Ethiopia

Geremew Worku Kassie[1]*

Received: 04 August 2016
Accepted: 09 December 2016
Published: 05 January 2017

*Corrsopnding author: Geremew Worku Kassie, Department of Economics, Business & Economics College, Debre Markos University, Debre Markos, Ethiopia
E-mails: geremew_worku@dmu.edu.et, geremewworku@yahoo.com

Reviewing editor:
Goodness Aye, University of Agriculture Makurdi Benue State, Nigeria

Additional information is available at the end of the article

Abstract: The purpose of this study was to determine whether or not livelihood diversification strategies are significant predictors of rural households' farmland management practices. To this end, the two-limit Tobit econometric model was employed to analyse the nexus between livelihood diversification and farmland management. The study incorporated 151 farm households in Gozamin District, East Gojjam, in Ethiopia. A survey questionnaire was used to gather data. Both descriptive and inferential statistics were used as methods of data analysis. The result indicated that livelihood diversification, measured by the inverse Herfindahl–Hirschman diversity index, has a positive and significant effect on sustainable land management activities. Besides, farm households who participated in agricultural extension packages and those engaged in farm cooperatives and in non-farm wage employment activities joined significantly more in sustainable rural land management practices. The integrated rural livelihood and sustainable land management strategy that can help jointly maximise the farm household livelihood and the land management practices is required. Rural livelihood development policies need to promote and adapt rural institutions like farm cooperatives and comprehensive agricultural extension services.

Geremew Worku Kassie

ABOUT THE AUTHOR

Germew Worku is a full-time lecturer in the Department of Economics at Debre Markos Univesity, Ethiopia. Currently, he is teaching several economics courses and has engaged in the supervision of research projects for the students in the same department. Geremew owns two master's degrees: one in Development Economics (MSc) in Ethiopia and the other is in International Cooperation Policy (MSc), in Japan. His research interests focus on rural livelihood and farm income diversification, with particular inclination to the South-east Asia and East Africa's comparative Economic Growth Analysis.

PUBLIC INTEREST STATEMENT

Ethiopia strives to ensure sustainable agricultural development as more than 78% of its population depends on agriculture. To this end, each household has to be engaged in good farmland management practice that enhances agricultural productivity. This is because sustainable agricultural development requires environmentally friendly land management practices. Furthermore, households in rural districts of Ethiopia use different livelihood diversification strategies primarily to ensure their livelihood security. This scenario, in one way or the other, may have its own impact on their farmland management practice in particular and on the environment in general. Therefore, this study will be of public interest since it attempts to determine whether or not livelihood diversification strategies are significant predictors of rural households' farmland management practice. The study showed that farm household livelihood diversification activities have positive effect on farmland management practices. Besides, the two-limit Tobit econometric model developed in this study may be applicable in other developing nations with similar characteristics as north-east central Ethiopia.

cogent • economics & finance

Subjects: Sustainable Development; Development Policy; Rural Development; Development Theory; Economics and Development; Environment & the Developing World; International Trade (incl.trade agreements & tariffs); Development Economics

Keywords: farm household; livelihood diversification; sustainable land management; Tobit model

1. Introduction

Livelihood diversification is defined by several scholars in different ways. It is the scope and combination of activities and choices (Liu & Liu, 2016); a means of gaining a living (Loison & Loison, 2016); comprises the capabilities, assets and activities required for a way of living (Farrington, Carney, Ashley, & Turton, 1999; Scoones, 1998). It is also defined as the course by which households establish progressively diverse livelihood portfolios (Niehof, 2004); adequate stocks and flows of cash to meet basic needs (Hilson, 2016), and it is a form of self-insurance (Barrett, Reardon, & Webb, 2001). Livelihood diversification is a major means by which many individuals reduce risk. It is widely understood as a form of self-practice in which people exchange some foregone expected earnings for reduced income variability achieved by selecting a portfolio of assets and activities (Abdulai & CroleRees, 2001; Adesina, Mbila, Nkamleu, & Endamana, 2000; Barrett, Reardon, et al., 2001). Farm household diversification refers to income strategies of rural individuals in which they increase their number of activities, regardless of the sector or location (Brandth & Haugen, 2011; Loison & Loison, 2016; Martin & Lorenzen, 2016).

In situations of high-risk agricultural sector and poverty incidences, poorer farm households with constraints of critical assets will be forced to engage in alternative incomes by participating in low-yield and sometimes risky non-farm activities (Barrett, Reardon, et al., 2001; Makita, 2016; Martin & Lorenzen, 2016; Loison & Loison, 2016). Farm households in sub-Saharan Africa strongly rely on farming and exploitation of natural resources. Specifically, in Ethiopia, the complex inter-linkages of poverty, population growth and environmental degradation cause decline in farm plot sizes, lead to landlessness and expansion of farming to marginal lands (Belay & Bewket, 2015; Bezabih, Gebreegziabher, Gebremedhin, & Köhlin, 2010; Pender & Gebremedhin, 2008). Therefore, rural households in sub-Saharan African countries usually need to cope with poverty and income variability (Abdulai & CroleRees, 2001). As a result, diversification is usually connected with livelihood survival and distress under abating conditions, as well as with livelihood security under improving economic conditions (Niehof, 2004).

Different scholars mentioned several types of livelihood diversification activities. There are four distinct rural livelihood strategies, namely: on-farm agricultural production, unskilled on-farm or off-farm wage employment and non-farm earnings from trades, commerce and skilled employment and the fourth mixed strategy combines all the three strategies (Gebru & Beyene, 2012; Hilson, 2016; Sherren, Loik, & Debner, 2016). The components of rural livelihood diversification are also classified by sector as farm or non-farm, by function as wage employment or self-employment or by location as on-farm or off-farm (Bowen & De Master, 2011; Loison & Loison, 2016). It is also argued that rural people establish their livelihoods via three main strategies: agricultural intensification; livelihood diversification; and migration (Barrett, Bezuneh, & Aboud, 2001). The types of livelihood diversification activities by the farm households may have either positive or negative effects to the rural land management system. In addition, the rural land management practice is also determined by the socio-economic characteristics of farm households. Therefore, it is pertinent to examine the effect of households' livelihood diversification strategies on farmland management practice in Gozamin Rural District in East Gojjam, Ethiopia.

2. Literature review

Africa as a continent is mainly identified by subsistence farm households; non-farm income sources already account for as much as 40–45% of average household income (Author & Fahy Bryceson, 2002; Bezabih et al., 2010). Empirical studies in Ethiopia also indicated that 20–35% of total farm household income was found to be generated from non-farm livelihood diversification activities (Gebru & Beyene, 2012). Non-farm activities have the potential to help households reduce poverty by granting them with a form of insurance against the threats of farming and minimising reliance on natural resources (Davis, 2003; Deininger & Jin, 2006; Hilson, 2016; Lanjouw & Lanjouw, 2001; Martin & Lorenzen, 2016; Neupane & Thapa, 2001; Reardon, 1997).

There are theories that explained why farm households diversify, instead of specialising their livelihood activities. The major justifications for diversification as summarised by (Sherren et al., 2016) are attribute to (i) self-insurance against risk, (ii) an ex-post coping strategy, (iii) inability to specialise due to incomplete factor markets and (iv) consumption diversification where there are incomplete product markets. In addition, there are incentives for allocating labour to the non-farm activities including: better comparative returns, inadequate farm output, a need for non-farm income sources to purchase for farm inputs and risky returns to farming (Barrett, Reardon, et al., 2001; Gebru & Beyene, 2012; Marenya & Barrett, 2007; Martin & Lorenzen, 2016; Reardon, 1997). The extent of risk-taking or aversion behaviour of the farm household also positively determines the necessity for diversification as a form of insurance, and conversely may also determine negatively the degree of access to other ways of settling and coping with shocks and risks (Ellis, 2000). Generally, these drivers have been divided along a spectrum of "necessity versus choice", on the one extreme, "push factors", and on the other extreme, "pull factors" (Hilson, 2016; Makita, 2016; Orenstein & Hamburg, 2009; Sherren et al., 2016; Van Hulst, Helena, & Posthumus, 2016). The dwarf productivity growth of agriculture, the declining soil mineral content of the farmland and the ever-continuing population growth push farm households in the north-east central Ethiopia of Gozamin District to diversify their livelihood strategy, so as to minimise risk, maximise their personal income and to guarantee and smooth consumption expenditure.

There are conflicting scholarly debates about the nexus between environment and livelihood diversification (Ellis, 2000; Scoones, 1998, 2009). Some argued that the livelihood diversification of the poor may be towards the production and exhaustive trading activities of natural resources, including overfishing and mineral overexploitation that aggravates environmental degradation (Ashley & Carney, 1999; Neefjes, 2000). Farm households may deforest frontier forests for charcoal and fuelwood purposes, and further degrading the soil nutrient by expanding cropland (Djalilov, Khamzina, Hornidge, & Lamers, 2016; Mirzabaev, Nkonya, & von Braun, 2015; Rahman, Sunderland, Roshetko, Basuki, & Healey, 2016). In contrast, other scholars (Chien, 2015; Guzmán, González de Molina, & Alonso, 2011; Haiguang, Jiping, Xiubin, Huiyuan, & Qiang, 2015; Jepsen et al., 2015; López-i-Gelats, Milán, & Bartolomé, 2011; Pandey, Bajpai, & Singh, 2016; Zhang, Podlasly, Feger, Wang, & Schwärzel, 2015; Zhang et al., 2011) divergently argued that livelihood diversification and resource conservation may mutually reinforce each other. Taking the relationship between off-farm employment and ecosystem as an example, some researchers believe that labourers leaving the rural areas alleviate the pressures on farmland, and thereby contribute to deforestation reduction, biodiversity conservation and local environment protection (Delden et al., 2015; Haiguang et al., 2015; Ito, Bao, & Ni, 2016; Reardon, 1997; Tai-yang, Xian-jin, Xiu-ying, & Ke, 2011; Zhang et al., 2011). The practical experiences in some areas, especially in the mountainous parts of North America and some parts of Europe, indicated that off-farm employment of rural labourers contributed to forest transition and regrowth (Pandey et al., 2016). Some other researchers believe that rural labourers are no longer dependent on natural resources, and non-farm activities do not have any effect on ecosystem (Haiguang et al., 2015).

For instance, a poor farm household's labour input allocation may be transited from natural resource-dependent livelihood activities to other environmentally non-harmful off-farm and non-farm income generating activities, such as trade, and rural small-scale manufacturing practices. Subsequently, the adverse impact on natural resources caused by firewood and charcoal production is expected to decline (Davis, 2003; Farrington et al., 1999). In addition, smallholder farmers use a variety of activities to adapt to climate variability and change. These practices include diversification activities like planting trees that could minimise the pressures of natural capital and diversification of livelihood strategies and land use management (Delden et al., 2015; Ito et al., 2016; Reardon, 1997; Tai-yang et al., 2011). The growth of non-farm income sources if accessible in remote rural areas might reduce the need for landless dwellers to carry out extractive practices in local environments for their livelihood. This has been called the "substitution of employment for the environment" (Delden et al., 2015). In addition, livelihood diversification is an effective way of solving the problem caused by poverty and environmental degradation (Delden et al., 2015; Ito et al., 2016). For instance, in China, livelihood diversity helps minimise households' dependence on environmental resources, thereby helping environment rehabilitation (Zhang et al., 2011). Off-farm employment sometimes demands the outflow of the rural population and reduces regional population and environmental stresses, which are beneficial for keeping sustainable achievements (Ito et al., 2016; Tai-yang et al., 2011; Zhang et al., 2011). As an external "pull" factor, the rapid development of China's overall economy effectively promotes the non-agricultural transfer of the rural labour force and improvement of household livelihoods, so as to indirectly promote the restoration of the ecological environment (Wang, Gao, Wang, & Li, 2016).

The effect of livelihood diversification on environment is one of the integral issues in any agrarian countries. Eradication of extreme poverty and hunger will be successfully attained if the country could promote sustainable livelihood and agriculture (World Bank Group, 2012). In countries such as Ethiopia, diversification in agriculture sector is highly related to using and exploiting natural resources; conversely, it may help rehabilitate farmland from degradation as far as it is undertaken in an environmentally sustainable manner. For instance, in north-east central Ethiopia, small-scale farmers continue to diversify their income bases to non-farm and off-farm activities to maximise their income and livelihood sources. However, previous empirical studies did not try to examine the effect of farm household livelihood diversification activities on sustainable land management practices particularly in the context of developing countries. This study attempted to examine the nexus between livelihood diversification strategies and farmland management practices at farm household level by employing data compiled from the survey of 151 farm households in Gozamin District of north-east central Ethiopia.

3. The model

This study developed the econometric model to estimate the effects of livelihood diversification strategies of farm households on sustainable land management practices. The extent of household's livelihood diversification is measured by the inverse Herfindahl–Hirschman Diversity *(IHHD)* index using the formula:

$$\text{IHHD}_i = [1/\sum y_j^2]_i \tag{1}$$

where y_j represents the proportional contribution of each livelihood activity *j* to household *i*'s overall income. Farm livelihood activity consists of three broad categories of farm household income sources, namely: on-farm, off-farm and non-farm practices (Ellis, 2000; Ellis & Freeman, 2004), that indicate the maximum value of the IHHD index is limited to be three. In this model, all sample farm households are assumed to be engaged in at least one farm activity, on-farm activities, which mainly may include the production of crops and livestock. Thus, the IHHD lies between one and three. Similarly, the sustainable land management (SLM) index, the dependent variable, is constructed from eight different sustainable land management indicators and practices, which are performed in the study area. These indicators include tree plantation, terracing, fallowing, manure and compost, soil-bund, gully check, shelterbelt and strip cropping by the farm household's own farmlands. Based on the institutional and socio-economic characteristics of the individual farm households, some of them adapt these sustainable land management practices in various extents while others do not. All scores are added and divided by eight to find a Sustainable Land Management *(SLM)* index for individual farm household *(i)* as illustrated below:

$$\text{SLM}_i = \left(\sum_{n=1}^{8} s_n/8\right)_i \tag{2}$$

where s_n represents eight different sustainable land management practices notably conducted in the study area. The *SLM* index lies between zero and one, inclusive.

The farm household may allocate the food crop land for more environmentally sustainable livelihood activities like tree planting and perennial cropping purposes. On the other hand, depending on the household characteristics and institutional set-up, some livelihood strategies may have adverse effects on the farmland management systems. As a rational economic agent, the farm household is expected to adapt land management techniques for sustainable agricultural practices if the benefit gained from adopting them is higher than otherwise.

If the dependent variable is censored, i.e. having a lower limit and/or upper limit, then the least squares estimators of the regression parameters are biased and inconsistent. This study employs a censored regression model (Greene, 2012; Maddala, 1992), which is a generalisation of the standard Tobit model. It is censored since some proportion of farmers from the sample did not participate in sustainable land management practices, and a dependent variable will take a limit value for some proportion of the observations, which is zero from below. As the dependent variable, sustainable land management index has a lower limit of zero and an upper limit of one; the two-limit Tobit model is found to be a more reliable measure.

$$Y_i^* = X_i'\beta + \varepsilon_i \tag{3}$$

$$Y_i = \begin{cases} \gamma \text{ if } y_i^* \le \gamma \\ y_i^* \text{ if } \gamma < y_i^* < \varphi \\ \varphi \text{ if } y_i^* \ge \varphi \end{cases} \tag{4}$$

where γ is the lower limit, that is zero, and φ is the upper limit, which is one in the dependent variable of this model. The study estimated this model using the Maximum Likelihood (ML) procedure. The log-likelihood function can be presented as follows, assuming the disturbance term, ε, follows a normal distribution with mean 0 and constant variance σ^2,

$$\log = \sum_{i=1}^{N} \left[I_i^{\gamma} \log \Phi\left(\frac{\gamma - X_i'\beta}{\sigma}\right) + I_i^{\phi}\left(\frac{X_i'\beta - \phi}{\sigma}\right) + \left(1 - I_i^{\gamma} - I_i^{\phi}\right)\left(\log \theta\left(\frac{y_i - X_i'\beta}{\sigma}\right) - \log \sigma\right)\right] \tag{5}$$

where $\Phi(\cdot)$ and $\phi(\cdot)$ represent the cumulative distribution function and the probability density function of the standard normal distribution, respectively, and I_i^{γ} and I_i^{φ} are indicator functions with:

$$I_i^{\gamma} = \begin{cases} 1, & \text{if } y_i = \gamma \\ 0, & \text{if } > \gamma \end{cases} \tag{6}$$

$$I_i^{\varphi} = \begin{cases} 1, & \text{if } y_i = \varphi \\ 0, & \text{if } > \varphi \end{cases} \tag{7}$$

For a standard Tobit model, for each observation (i), where i, 1, … , n, the dependent variable is defined by:

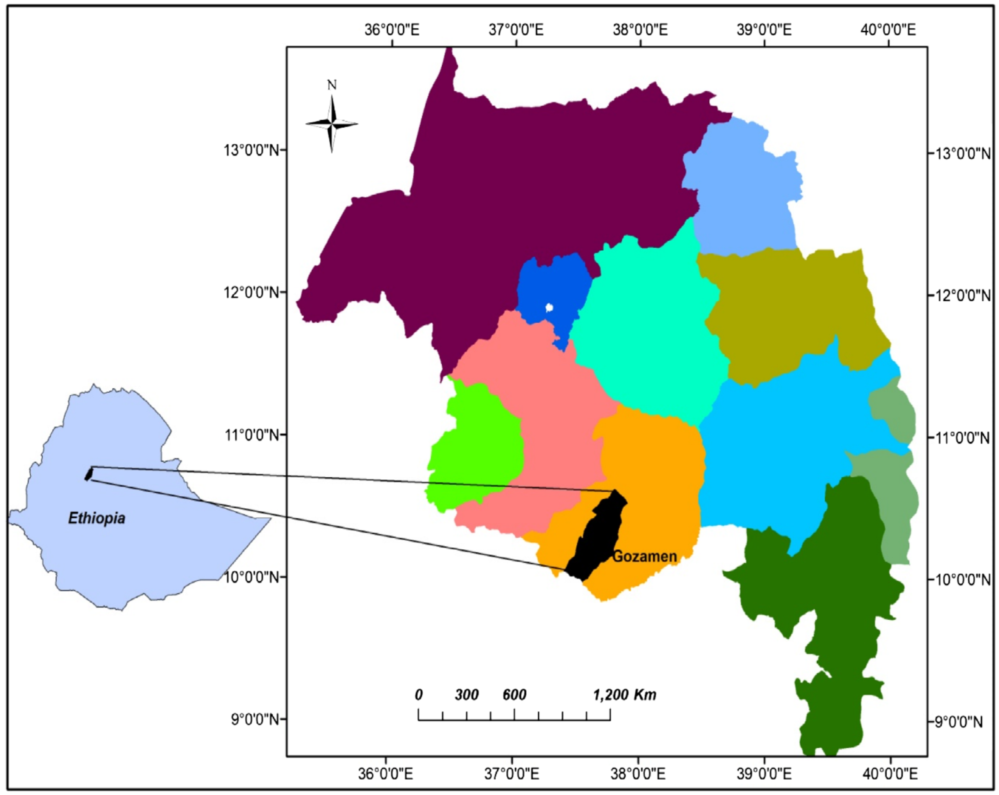
$$y_i^* = x_i'\beta + \in_i$$

$$y_i = \begin{cases} 0, & y_i^* \le 0 \\ y_i^*, & y_i^* > 0 \end{cases} \tag{8}$$

The log-likelihood function of the censored regression model can be maximised with respect to the parameter vector $(\beta',\ \sigma)'$ using standard non-linear optimisation algorithms.

cogent • economics & finance

Figure 1. Map of Gozamin District.



4. Data and variables

The data for this study were collected from a survey of 151 farm households in Gozamin District located in north-east central Ethiopia. First, the study area was selected purposefully so as to find the representative farm households of rural Ethiopia. Second, a survey questionnaire was used by employing simple random sampling technique to select sampled farm households (Figure 1).

As indicated in Table 1 below, farm households do not use sustainable land management practices with equal extent and efforts. Some adopt all sustainable land management practices, others partly, while others do not adopt any of the practices.

As seen in Table 2, out of the total 151 farm households, 71.52% of them are engaged in off-farm and non-farm livelihood activities. Similarly, 75.4% of them are found to actively participate in sustainable land management activities.

During the survey season, the farm households' average income was 23371 ETB and from on-farm income, off-farm income and non-farm income diversification activities, the farm households earned on average 20177 ETB, 1235 ETB and 1971 ETB, respectively.

cogent • economics & finance

Table 1. Descriptive summary statistics of sustainable land management

Variable	Description	Mean	Standard deviation (SD)
FALLOW	Dummy land management, 1 if there is fallow; 0 otherwise	0.549	0.499
MANU&COMPO	Dummy land management, 1 if manure and compost; 0 otherwise	0.629	0.484
TERRACE	Dummy land management, 1 if terrace; 0 otherwise	0.437	0.497
SOIL_BUND	Dummy land management, 1 if soil-bund; 0 otherwise	0.516	0.501
GULLY_CHECK	Dummy land management, 1 if gully check; 0 otherwise	0.490	0.502
TREE_PLANT	Dummy land management, 1 if tree-planted; 0 otherwise	0.503	0.504
SHELTERBELT	Dummy land management, 1 if shelter-belt; 0 otherwise	0.562	0.497
STRIP_CROP	Dummy land management, 1 if strip-cropping; 0 otherwise	0.496	0.501

Table 2. Descriptive summary statistics of sample farm households

Variable	Description	Mean	Standard deviation (SD)
HHSEX	Dummy of gender, 1 if male; 0 otherwise	0.72	0.45
HHAGE	Age of the farm household head	44.36	12.39
NOFORMAL_EDU	Dummy of education, 1 if no formal education	0.68	0.47
ELEM_EDUC	Dummy education, 1 if elementary education	0.20	0.40
SECON_EDUC	Dummy education, 1 if secondary education	0.11	0.32
STUD_PROP	Proportion of students in the household	0.35	0.24
MRKT_DIS	Distance of home from the nearest market (km)	16.73	1.56
LAND_HA	Land size owned by the household	1.16	0.45
LABOR	Number of labour (between age of 15 and 65)	2.40	0.76
LAND_RIGHT	Dummy, 1 if a household secured for his land	0.89	0.30
COOP_MEM	Dummy, 1 if a household is a member of the cooperative	0.64	0.47
CREDIT_SERV	Dummy, 1 if a household has access to credit	0.49	0.50
EXTEN_SERV	Dummy, 1 if household participated in agri-extension	0.72	0.44
WAGE	Wage of labour (Annual wage)	4,663	1,398
CROPY	On-farm income	20,177	9,798.9
OFFARMY	Off-farm income	1,235	1,355
NONFARMY	Non-farm income	1,971	2,519
TOTAL_INCO	Total income	23371	11191
VILL_LEQLEQ	Location dummy, 1 if Leqleqit	0.33	0.47
VILL_WEYNMA	Location dummy, 1 if Weynmager	0.33	0.47
VILL_ADDISGULT	Location dummy, 1 if Addis-gulit	0.33	0.47
IHHD_INDEX*			

$$IHHD\_INDEX^{*} = \frac{1}{(\text{on-farm income}/\text{total income})^{2}} + \frac{1}{(\text{non-farm income}/\text{total income})^{2}} + \frac{1}{(\text{off-farm income}/\text{total income})^{2}}$$

cogent • economics & finance

5. Empirical results

Table 3 reveals coefficient and marginal estimates of the two-limit Tobit model. Since the Tobit model is non-linear, the estimated coefficients cannot result in a correct measure of the effect of the explanatory variables on the dependent variable. Therefore, the most fitting method is to use marginal effects rather than their coefficients. For comparison, the multivariate probit result has already been computed and seen in Appendices 1 and 2.

On the margin, farmers who become members of the cooperatives are more likely to participate in sustainable land management practices by more than 15.6% units than the non-member counterparts. As farmers organise themselves through cooperatives, it is more likely that their knowledge about farmland protection could be enhanced. Furthermore, the government development agencies in Ethiopia use cooperatives as a channel to give technology and environmental protection awareness for farm households. This result is in line with (Bravo-Monroy, Potts, & Tzanopoulos, 2016) who found that being a member of community organisations stimulated adoption of organic coffee management practices. Similarly, Wang et al. (2016) found out that being a member of regional environmental cooperatives and having membership in farmers' organisations led to the improvement in farm households' perceptions towards agricultural environmental schemes and to adopt

Table 3. Two-limit Tobit estimation of sustainable farmland management index

SLM_INDEX	COEFFICIENTS	MARGINAL EFFECTS (DY/DX)
HHSEX	0.022(0.047)	0.016(0.044)
LNHHAGE	−0.045(00.087)	−0.042(0.082)
LNMRKT_DIS	−0.019(0.443)	−0.087(0.419)
LAND_HA	0.015(0.049)	0.014(0.047)
LAND_RIGHT	0.009(0.077)	0.010(0.073)
COOP_MEM	0.159***(0.053)	0.156***(0.050)
CREDIT_SERV	−0.035(0.044)	−0.036(0.041)
EXTEN_SERV	0.364***(0.068)	0.352***(0.064)
LABOR	0.014(0.027)	0.011 (.025)
LNAGRI_TECH	0.038(0.037)	0.034(0.035)
LNWAGE	0.231**(.122)	0.227*(0.120)
ELEM_EDUC	−0.109**(0.054)	−0.105**(0.051)
SECON_EDUC	0.066(0.068)	0.061(0.064)
VILL_LEQLEQ	−0.082(0.108)	−0.088(0.102)
VILL_WEYNMA	0.006(0.082)	−0.001(0.077)
IHHD_INDEX	0.592***(.062)	0.569***(0.057)
_CONS	−2.408 (10.714)	-
σ	0.2210637	0.015856	0.189699	0.2524283
Observation summary	37 left-censored observations at slm_index ≤ 0	
	107 uncensored observations	
	4 right-censored observations at slm_index ≥ 1	
Log likelihood =	Number of Observations	=148
	LR $\chi^2(16)$	=196.95
	Prob. > χ^2	=0.0000
	−14.609788 Pseudo R^2	=0.8708

Notes: Standard errors are in parentheses.

For dummy variables, dy/dx denotes a change from 0 to 1. Addisgult is used as the reference village and household head having no formal education is used as the reference for educational level.

*Statistical level of significance at 10%.

**Statistical level of significance at 5%.

***Statistical level of significance at 1%.

eco-friendly soil management practices. Other researchers (Ahn et al., 2016; Bank, Dc, Savastano, Bank, & Dc, 2012; Bell, Zhang, & Nou, 2016; Chien, 2015; Dang, Yuan, & Kong, 2016; Demir, Inan, Biyik, & Uzun, 2015; Hawthorne et al., 2015; Ito et al., 2016; Ma & Abdulai, 2016; Mosadeghi, Warnken, Tomlinson, & Mirfenderesk, 2015; Steinhäußer, Siebert, Steinführer, & Hellmich, 2015) on their various studies about the importance of cooperatives also reached the same conclusion.

Agricultural extension service users are more likely to participate in sustainable land management practices; keeping other factors constant, farm households who have access to agricultural extension services are found to be 35.2% units more likely to participate in sustainable land management practices. More importantly, extension services are supposed to enhance the knowledge of farm households in better farming that includes the adoption of environmentally sustainable farming techniques. As farm households get access to agricultural extension services, they can protect their land and will engage themselves in land management practices to increase their land productivity. Similarly, previous studies revealed that contact with extension workers and getting technical assistance helped farm households improve their land management and soil conservation practices (Delden et al., 2015; Fraser, Dougill, Mabee, Reed, & McAlpine, 2006; Grace et al., 2016; Kondylis, Mueller, Sheriff, Zhu, & Bank, 2016; Kotzé, Sandhage-Hofmann, Meinel, du Preez, & Amelung, 2013; Mirzabaev et al., 2015; Nyanga, Kessler, & Tenge, 2016; Onduru, de Jager, Gachini, & Diop, 2016; Reed, 2008; Reed, Fraser, & Dougill, 2006; Reed et al., 2009; Sherren et al., 2016; Tittonell, 2014; Zhang et al., 2015).

Wage collected from non-farm income sources has also a positive effect on sustainable land management practices. On the margin, as a farm household head gets employed in non-farm activities, the land management practices increased by 22.7% units. The justification on this econometric result is that the intensity of on-farm farming may be declining, while sustainable land management practices such as fallowing and tree plantations, which are less labour-intensive, would increase. Various international studies also supported this result (Bhandari & Grant, 2007; Gautam, Webb, Shivakoti, & Zoebisch, 2003; Holden, Shiferaw, & Pender, 2004; Paudel & Gopal, 2004; Robalino, 2007; Scherr, 2000; Templeton & Scherr, 1999; Thapa, 1996).

Farm households who have primary education show less engagement in sustainable land management activities by 10.5% units than those who have no formal education. Perhaps this is because instead of being engaged in sustainable land management practices, farm households with better education may be engaged more in specialisation and higher productive activities. Education could also take away labour time from the land management practices. Some previous studies also found out similar findings (Kilgore & Snyder, 2016; McLaren, Parkhill, Corner, Vaughan, & Pidgeon, 2016; Pender & Gebremedhin, 2008; Schulze et al., 2015; Yesilonis, Szlavecz, Pouyat, Whigham, & Xia, 2016). However, some other previous studies (Ersado, Amacher, & Alwang, 2004; Pender & Kerr, 1998; Pender, Nkonya, Jagger, Sserunkuuma, & Ssali, 2004) found out that education has affected positively the land management conservation practices.

Finally, livelihood diversification that is measured by Inverse Herfindahl–Hirschman Diversity index reveals statistically significant and positive effects on the adoption decision of sustainable land management practices. Keeping other factors constant, as farm households' measure of livelihood diversification increased by one unit, the marginal effect of sustainable land management index was found to increase by 56.9% units. This result may be justified; first, some livelihood diversification activities in the study area such as vegetable and tree plantations on farm plots can be reinforced with enhancing the sustainable land management practices. Second, as farm households diverge their livelihood strategies, their personal income is likely to be maximised, and that will motivate farmers to invest in better farmland management practices like protecting their land from erosion and any other potential land degradation effects. Finally, farm households allocate their labour to livelihood diversification activities that will help smooth their annual consumption expenditure through non-farm and off-farm income sources that may help reduce the intensity of on-farm agricultural practices. Using Ordinary Least Square and quantile regression techniques, Mishra and Moss (2013) brought consistent results.

There exist contradicting results in the previous literature about the effect of livelihood diversification on land management. For instance, the empirical study (Sim et al., 2003) in India concluded that the livelihood of the rural poor households highly depends on forest resources and products that support them economically, socially and even culturally. The other study (Sheng, Fan, & Ma, 2006) with 946 sample peasant farm households in the Zhaotong and Yunnan Province of China indicated that, mainly due to the population pressure, farm households were forced to expand agriculture to marginal lands through deforestation and depletion of biodiversity. Several studies brought consistent result that farm households with higher non-farm income were found to be greater adopters of better land management practices (Flannery, Lynch, & Ó Cinnéide, 2015; Franzén, Hammer, & Balfors, 2015; Garibaldi et al., 2016; Hua & Squires, 2015; Kohler, Marchand, & Negrão, 2015; Marull, Font, & Boix, 2015; Mikulcak, Haider, Abson, Newig, & Fischer, 2015; Oppio, Corsi, Mattia, & Tosini, 2015; Page, Ridoutt, Creeper, & Bellotti, 2015; Tan & Li, 2015; Tang & Ho, 2015; Travers, Winney, Clements, Evans, & Milner-Gulland, 2015; Vincent & Fleury, 2015; Zhu & Simarmata, 2015). Similar studies illustrated that farm households with greater income from non-farm activity participate more intensively in sustainable land management practices (Pender, Gebremedhin, Benin, & Ehui, 2001). On the other hand, the study (Holden, Shiferaw, & Pender, 2001) in Ethiopia found that non-farm income diversification activities affect negatively the land conservation practices.

In conclusion, livelihood diversification, as measured by Inverse Herfindahl–Hirschman Diversity index, reveals an upbeat and significant effect on sustainable land management index of a farm household. Besides, participating in agricultural extension packages and being members of farm cooperatives have significant effects on households' sustainable land management practices. On the other hand, farm households who have completed a primary education participate less in sustainable land management practices compared to those without formal education.

6. Implications

Comprehensive rural development policy needs to be designed and implemented in order to empower farm households. Off-farm and non-farm rural livelihood diversification strategies need to be incorporated in the rural development policies. Most importantly, the off-farm and non-farm rural development strategies will help farm households to employ their labour hour efficiently throughout the year; consequently, there will not be wasted idle labour hours. Besides, in Ethiopia, the integrated rural livelihood–sustainable land management strategy that can help maximise both the rural livelihood and the land management practices of farm households needs to be formulated. Finally, rural development institutions like cooperatives and agricultural extension packages have to be incorporated in rural development strategies so as to improve the capacity of farm households to participate in livelihood diversification and sustainable land management practices. The rural development policy towards livelihood diversification needs to incorporate farm households in institutionalising cooperatives like tree plantation, and other environmental cooperatives that can enhance farmland management practices shall be mainstreamed.

Funding
The authors received no direct funding for this research.

Author details
Geremew Worku Kassie[1]
E-mails: geremew_worku@dmu.edu.et, geremewworku@yahoo.com
ORCID ID: http://orcid.org/0000-0002-9736-1747
[1] Department of Economics, Business & Economics College, Debre Markos University, Debre Markos, Ethiopia.

Citation information
Cite this article as: The Nexus between livelihood diversification and farmland management strategies in rural Ethiopia, Geremew Worku Kassie, *Cogent Economics & Finance* (2017), 5: 1275087.

References

Abdulai, A., & CroleRees, A. (2001). Determinants of income diversification amongst rural households in Southern Mali. *Food Policy, 26*, 437–452. doi:10.1016/S0306-9192(01)00013-6

Adesina, A. A., Mbila, D., Nkamleu, G. B., & Endamana, D. (2000). Econometric analysis of the determinants of adoption of alley farming by farmers in the forest zone of southwest Cameroon. *Agriculture, Ecosystems & Environment, 80*, 255–265. doi:10.1016/S0167-8809(00)00152-3

Ahn, J., Li, S., Wang, Q., Lee, W., Lee, E., Horstmann, N., ... Vang, S. (2016). Assessing rice productivity and adaptation strategies for Southeast Asia under climate change through multi-scale crop modeling. *AGSY, 143*, 14–21. doi:10.1016/j.agsy.2015.12.001

Ashley, C., & Carney, D. (1999). *Sustainable livelihoods: Lessons from early experience issues DFID Department for International Development* (Vol. 7, No. 1). London: Department for International Development.

Author, E., & Fahy Bryceson, D. (2002). Multiplex livelihoods in Rural Africa: Recasting the terms and conditions of gainful multiplex livelihoods in rural Africa: Recasting the terms and conditions of gainful employment. *The Journal of Modern African Studies Journal of Modern African Studies, 40*, 1–28. doi:10.1017/S0022278X01003792

Bank, W., Dc, W., Savastano, S., Bank, W., & Dc, W. (2012). Land fragmentation, cropland abandonment, and land market operation in Albania. *World Development, 40*, 2108–2122. doi:10.1016/j.worlddev.2012.05.010

Barrett, C. B., Bezuneh, M., & Aboud, A. (2001). Income diversification, poverty traps and policy shocks in Côte d'Ivoire and Kenya. *Food Policy, 26*, 367–384. doi:10.1016/S0306-9192(01)00017-3

Barrett, C. B., Reardon, T., & Webb, P. (2001). Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. *Food Policy, 26*, 315–331. doi:10.1016/S0306-9192(01)00014-8

Belay, M., & Bewket, W. (2015). Enhancing rural livelihoods through sustainable land and water management in northwest Ethiopia. *Geography, Environment, Sustainability, 8*, 79–100.

Bell, A., Zhang, W., & Nou, K. (2016). Pesticide use and cooperative management of natural enemy habitat in a framed field experiment. *Agricultural Systems, 143*, 1–13. doi:10.1016/j.agsy.2015.11.012

Bezabih, M., Gebreegziabher, Z., Gebremedhin, L., & Köhlin, G. (2010). *Participation in off-farm employment, rainfall patterns, and rate of time preferences: The case of Ethiopia* (No. dp-10-21-efd). Retrieved from http://www.rff.org/RFF/documents/EfD-DP-10-21.pdf

Bhandari, B. S., & Grant, M. Ã. (2007). Analysis of livelihood security: A case study in the Kali-Khola watershed of Nepal. *Journal of Environmental Management, 85*, 17–26. doi:10.1016/j.jenvman.2006.07.010

Bowen, S., & De Master, K. De (2011). New rural livelihoods or museums of production? Quality food initiatives in practice. *Journal of Rural Studies, 27*, 73–82. doi:10.1016/j.jrurstud.2010.08.002

Brandth, B., & Haugen, M. S. (2011). Farm diversification into tourism – Implications for social identity? *Journal of Rural Studies, 27*, 35–44. doi:10.1016/j.jrurstud.2010.09.002

Bravo-Monroy, L., Potts, S. G., & Tzanopoulos, J. (2016). Drivers influencing farmer decisions for adopting organic or conventional coffee management practices. *Food Policy, 58*, 49–61. doi:10.1016/j.foodpol.2015.11.003

Chien, S. (2015). Local farmland loss and preservation in China—A perspective of quota territorialization. *Land Use Policy, 49*, 65–74. doi:10.1016/j.landusepol.2015.07.010

Dang, S., Yuan, D., & Kong, W. (2016). Land cooperatives as an approach of suburban space construction: Under the reform of Chinese land transfer market. *Frontiers of Architectural Research*. doi:10.1016/j.foar.2016.09.002

Davis, J. R. (2003, July). The rural-non-farm economy, livelihoods and their diversification: Issues and options. *Livelihoods and their diversification: Issues and options*. doi:10.2139/ssrn.691821

Deininger, K., & Jin, S. (2006). Tenure security and land-related investment: Evidence from Ethiopia. *European Economic Review, 50*, 1245–1277. doi:10.1016/j.euroecorev.2005.02.001

Delden, L. V., Dominiak, M., Fouch, H. J., Van Der Westhuizen, H. C., Oomen, R. J., Preez, C. C., & Amelung, W. (2015). Rangeland management effects on soil properties in the savanna biome, South Africa: A case study along grazing gradients in communal and commercial farms. *Journal of Arid Environments, 120*, 14–25. doi:10.1016/j.jaridenv.2015.04.004

Demir, O., Inan, H., Biyik, C., & Uzun, B. (2015). Land management for erosion prevention: A case study for a Turkish nature reserve. *Land Use Policy, 47*, 394–400. doi:10.1016/j.landusepol.2015.01.036

Djalilov, B. M., Khamzina, A., Hornidge, A.-K., & Lamers, J. P. A. (2016). Exploring constraints and incentives for the adoption of agroforestry practices on degraded cropland in Uzbekistan. *Journal of Environmental Planning and Management, 59*, 142–162. Retrieved from http://www.tandfonline.com/doi/full/10.1080/09640568.2014.996283 http://dx.doi.org/10.1080/09640568.2014.996283

Ellis, F. (2000). The determinants of rural livelihood diversification in developing countries. *Journal of Agricultural Economics, 51*, 289–302. doi:10.1111/j.1477-9552.2000.tb01229.x

Ellis, F. & Freeman, H. A. (2004). Rural livelihoods and poverty reduction strategies in four African countries. *Journal of Development Studies, 40*, 1–30. doi:10.1080/00220380410001673175

Ersado, L., Amacher, G., & Alwang, J. (2004). Productivity and land enhancing technologies in Northern Ethiopia: Health, public investments, and sequential adoption. *American Journal of Agricultural Economics, 86*, 321–331. doi:10.1111/j.0092-5853.2004.00581.x http://dx.doi.org/10.1111/j.0092-5853.2004.00581.x

Farrington, J., Carney, D., Ashley, C., & Turton, C. (1999). *Sustainable livelihoods in practice: early applications of concepts in rural areas* (Vol. 42, pp. 1–2). London: ODI. Retrieved from http://hdl.handle.net/10535/4235

Flannery, W., Lynch, K., & Ó Cinnéide, M. Ó. (2015). Consideration of coastal risk in the Irish spatial planning process. *Land Use Policy, 43*, 161–169. doi:10.1016/j.landusepol.2014.11.001

Franzén, F., Hammer, M., & Balfors, B. (2015). Institutional development for stakeholder participation in local water management—An analysis of two Swedish catchments. *Land Use Policy, 43*, 217–227. doi:10.1016/j.landusepol.2014.11.013

Fraser, E. D. G., Dougill, A. J., Mabee, W. E., Reed, M., & McAlpine, P. (2006). Bottom up and top down: Analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. *Journal of Environmental Management, 78*, 114–127. doi:10.1016/j.jenvman.2005.04.009

Garibaldi, L. A., Gemmill-herren, B., Annolfo, R. D., Graeub, B. E., Cunningham, S. A., & Breeze, T. D. (2016). Farming approaches for greater biodiversity, livelihoods, and food security. *Trends in Ecology & Evolution, xx*, 1–13. doi:10.1016/j.tree.2016.10.001

Gautam, A. P., Webb, E. L., Shivakoti, G. P., & Zoebisch, M. A. (2003). Land use dynamics and landscape change pattern in a mountain watershed in Nepal. *Agriculture, Ecosystems & Environment, 99*, 83–96. doi:10.1016/S0167-8809(03)00148-8

Gebru, G. W., & Beyene, F. (2012). Rural household livelihood strategies in drought-prone areas: A case of Gulomekeda District, eastern zone of Tigray National Regional State, Ethiopia. *Journal of Development and Agricultural Economics, 4*, 158–168. doi:10.5897/JDAE12.026

Grace, K., Anderson, S., Gonzales-chang, M., Costanza, R., Courville, S., Dalgaard, T., … Wratten, S. (2016). A review of methods, data, and models to assess changes in the value of ecosystem services from land degradation and restoration. *Ecological Modelling, 319*, 190–207. doi:10.1016/j.ecolmodel.2015.07.017

Greene, W. H. (2012). *Econometric analysis* (7th Eds). London: Pearson Education.

Guzmán, G. I., González de Molina, M., & Alonso, A. M. (2011). The land cost of agrarian sustainability. An assessment. *Land Use Policy, 28*, 825–835. doi:10.1016/j.landusepol.2011.01.010

Haiguang, H. A. O., Jiping, Z., Xiubin, L. I., Huiyuan, Z., & Qiang, Z. (2015). Impact of livelihood diversification of rural households on their ecological footprint in agro-pastoral areas of northern China. *Journal of Arid Land, 7*, 653–664. doi:10.1007/s40333-015-0049-5

Hawthorne, T. L., Elmore, V., Strong, A., Bennett-Martin, P., Finnie, J., Parkman, J., … Reed, J. (2015). Mapping non-native invasive species and accessibility in an urban forest: A case study of participatory mapping and citizen science in Atlanta, Georgia. *Applied Geography, 56*, 187–198. doi:10.1016/j.apgeog.2014.10.005

Hilson, G. (2016). Farming, small-scale mining and rural livelihoods in Sub-Saharan Africa: A critical overview. *The Extractive Industries and Society, 3*, 547–563. doi:10.1016/j.exis.2016.02.003

Holden, S., Shiferaw, B., & Pender, J. (2001). Market Imperfections and Land Productivity in the Ethiopian Highlands. *Journal of Agricultural Economics, 52*, 53–70. Retrieved from http://doi.wiley.com/10.1111/j.1477-9552.2001.tb00938.x

Holden, S., Shiferaw, B., & Pender, J. (2004). Non-farm income, household welfare, and sustainable land management in a less-favoured area in the Ethiopian highlands. *Food Policy, 29*, 369–392. doi:10.1016/j.foodpol.2004.07.007

Hua, L., & Squires, V. R. (2015). Managing China's pastoral lands: Current problems and future prospects. *Land Use Policy, 43*, 129–137. doi:10.1016/j.landusepol.2014.11.004

Ito, J., Bao, Z., & Ni, J. (2016). Land rental development via institutional innovation in rural Jiangsu, China. *Food Policy, 59*, 1–11. doi:10.1016/j.foodpol.2015.12.005

Jenkins, A., Velandia, M., Lambert, D. M., Roberts, R. K., Larson, J. A., English, B. C., & Martin, S. W. (2011). Factors influencing the selection of precision farming information sources by cotton producers. *Agricultural and Resource Economics Review, 40*, 307–320. http://dx.doi.org/10.1017/S106828050000808X

Jepsen, M. R., Kuemmerle, T., Müller, D., Erb, K., Verburg, P. H., Haberl, H., … Björn, I. (2015). Transitions in European land-management regimes between 1800 and 2010. *Land Use Policy, 49*, 53–64. doi:10.1016/j.landusepol.2015.07.003

Kilgore, M. A., & Snyder, S. A. (2016). Lake States natural resource managers' perspectives on forest land parcelization and its implications for public land management. *Land Use Policy, 59*, 320–328. doi:10.1016/j.landusepol.2016.07.035

Kim, S., Gillespie, J. M., & Paudel, K. P. (2005). The effect of socioeconomic factors on the adoption of best management practices in beef cattle production. *Journal of Soil and Water Conservation, 60*, 111–120.

Kohler, F., Marchand, G., & Negrão, M. (2015). Local history and landscape dynamics: A comparative study in rural Brazil and rural France. *Land Use Policy, 43*, 149–160. doi:10.1016/j.landusepol.2014.11.010

Kondylis, F., Mueller, V., Sheriff, G., Zhu, S., & Bank, W. (2016). Do female instructors reduce gender bias in diffusion of sustainable land management techniques? Experimental evidence from Mozambique. *World Development, 78*, 436–449. doi:10.1016/j.worlddev.2015.10.036

Kotzé, E., Sandhage-Hofmann, A., Meinel, J., du Preez, C. C., & Amelung, W. (2013). Rangeland management impacts on the properties of clayey soils along grazing gradients in the semi-arid grassland biome of South Africa. *Journal of Arid Environments, 97*, 220–229. doi:10.1016/j.jaridenv.2013.07.004

Lanjouw, J. O., & Lanjouw, P. (2001). The rural non-farm sector: issues and evidence from developing countries. *Agricultural Economics, 26*, 1–23. doi:10.1111/j.1574-0862.2001.tb00051.x

Liu, Z., & Liu, L. (2016). Characteristics and driving factors of rural livelihood transition in the east coastal region of China: A case study of suburban Shanghai. *Journal of Rural Studies, 43*, 145–158. doi:10.1016/j.jrurstud.2015.12.008

Loison, S. A., & Loison, S. A. (2016). Rural livelihood diversification in Sub-Saharan Africa: A literature review rural livelihood diversification in Sub-Saharan Africa: A literature review. *The Journal of Development Studies, 51*, 1125–1138. doi:10.1080/00220388.2015.1046445

López-i-Gelats, F., Milán, M. J., & Bartolomé, J. (2011). Is farming enough in mountain areas? Farm diversification in the Pyrenees. *Land Use Policy, 28*, 783–791. doi:10.1016/j.landusepol.2011.01.005

Ma, W., & Abdulai, A. (2016). Does cooperative membership improve household welfare? Evidence from apple farmers in China. *Food Policy, 58*, 94–102. doi:10.1016/j.foodpol.2015.12.002

Maddala, G. (1992). *Introduction to econometrics* (2nd ed.). New York, NY: Macmillan Publishing Company.

Makita, R. (2016). Livelihood diversification with certification-supported farming: The case of land reform beneficiaries in the Philippines. *Asia Pacific Viewpoint, 57*, 44–59. doi:10.1111/apv.12106

Marenya, P. P., & Barrett, C. B. (2007). Household-level determinants of adoption of improved natural resources management practices among smallholder farmers in western Kenya. *Food Policy, 32*, 515–536. doi:10.1016/j.foodpol.2006.10.002

Martin, S. M., & Lorenzen, K. A. I. (2016). Livelihood diversification in rural laos. *World Development, 83*, 231–243. doi:10.1016/j.worlddev.2016.01.018

Marull, J., Font, C., & Boix, R. (2015). Modelling urban networks at mega-regional scale: Are increasingly complex urban systems sustainable? *Land Use Policy, 43*, 15–27. doi:10.1016/j.landusepol.2014.10.014

McLaren, D., Parkhill, K. A., Corner, A., Vaughan, N. E., & Pidgeon, N. F. (2016). Public conceptions of justice in climate engineering: Evidence from secondary analysis of public deliberation. *Global Environmental Change, 41*, 64–73. doi:10.1016/j.gloenvcha.2016.09.002

Mehar, M., Mittal, S., & Prasad, N. (2016). Farmers coping strategies for climate shock: Is it differentiated by gender? *Journal of Rural Studies, 44*, 123–131. doi:10.1016/j.jrurstud.2016.01.001

Mikulcak, F., Haider, J. L., Abson, D. J., Newig, J., & Fischer, J. (2015). Applying a capitals approach to understand rural development traps: A case study from post-socialist Romania. *Land Use Policy, 43*, 248–258. doi:10.1016/j.landusepol.2014.10.024

Mirzabaev, A., Nkonya, E., & von Braun, J. Von (2015). Economics of sustainable land management. *Current Opinion in Environmental Sustainability, 15*, 9–19. doi:10.1016/j.cosust.2015.07.004

Mishra, A. K., & Moss, C. B. (2013). Modeling the effect of off-farm income on farmland values: A quantile regression approach. *Economic Modelling, 32*, 361–368. doi:10.1016/j.econmod.2013.02.022

Mosadeghi, R., Warnken, J., Tomlinson, R., & Mirfenderesk, H. (2015). Comparison of Fuzzy-AHP and AHP in a spatial multi-criteria decision making model for urban land-use planning. *Computers, Environment and Urban Systems, 49*, 54–65. doi:10.1016/j.compenvurbsys.2014.10.001

Neefjes, K. (2000). *Environments and livelihoods*. London: Oxfam GB. http://dx.doi.org/10.3362/9780855987152

Neupane, R. P., & Thapa, G. B. (2001). Impact of agroforestry intervention on soil fertility and farm income under the subsistence farming system of the middle hills, Nepal. *Agriculture, Ecosystems & Environment, 84*, 157–167. doi:10.1016/S0167-8809(00)00203-6

Niehof, A. (2004). The significance of diversification for rural livelihood systems. *Food Policy, 29*, 321–338. doi:10.1016/j.foodpol.2004.07.009

Nyanga, A., Kessler, A., & Tenge, A. (2016). Key socio-economic factors influencing sustainable land management investments in the West Usambara Highlands, Tanzania. *Land Use Policy, 51*, 260–266. doi:10.1016/j.landusepol.2015.11.020

Onduru, D., de Jager, A., Gachini, G., & Diop, J. (2016). *Exploring new pathways for innovative soil fertility management in Kenya*. International Institute for Environment and Development. Retrieved from http://hdl.handle.net/10919/65392

Oppio, A., Corsi, S., Mattia, S., & Tosini, A. (2015). Exploring the relationship among local conflicts and territorial vulnerability: The case study of Lombardy Region. *Land Use Policy, 43*, 239–247. doi:10.1016/j.landusepol.2014.11.006

Orenstein, D. E., & Hamburg, S. P. (2009). To populate or preserve? Evolving political-demographic and environmental paradigms in Israeli land-use policy. *Land Use Policy, 26*, 984–1000. doi:10.1016/j.landusepol.2008.12.003

Page, G., Ridoutt, B., Creeper, D., & Bellotti, B. (2015). A framework for assessing local PES proposals. *Land Use Policy, 43*, 37–41. doi:10.1016/j.landusepol.2014.10.023

Pandey, V. C., Bajpai, O., & Singh, N. (2016). Energy crops in sustainable phytoremediation. *Renewable and Sustainable Energy Reviews, 54*, 58–73. doi:10.1016/j.rser.2015.09.078

Pender, J., & Gebremedhin, B. (2008). Determinants of agricultural and land management practices and impacts on crop production and household income in the highlands of Tigray, Ethiopia. *Journal of African Economies, 17*, 395–450. doi:10.1093/jae/ejm028

Paudel, G. S., & Gopal, B. T. (2004). Impact of social, institutional and ecological factors on land management practices in mountain watersheds of Nepal. *Applied Geography, 24*, 35–55. doi:10.1016/j.apgeog.2003.08.011

Pender, J. L., & Kerr, J. M. (1998). Determinants of farmers' indigenous soil and water conservation investments in semi-arid India. *Agricultural Economics, 19*, 113–125. doi:10.1016/S0169-5150(98)00026-7

Pender, J., Gebremedhin, B., Benin, S., & Ehui, S. (2001). Strategies for sustainable development of less-favoured areas: Strategies for sustainable agricultural development in the Ethiopian highlands. *American Journal of Agricultural Economics, 83*, 1231–1240. Retrieved from http://www.jstor.org/stable/1244813
http://dx.doi.org/10.1111/ajae.2001.83.issue-5

Pender, J., Nkonya, E., Jagger, P., Sserunkuuma, D., & Ssali, H. (2004). Strategies to increase agricultural productivity and reduce land degradation: Evidence from Uganda. *Agricultural Economics, 31*, 181–195. Retrieved from http://doi.wiley.com/10.1111/j.1574-0862.2004.tb00256.x.
http://dx.doi.org/10.1111/agec.2004.31.issue-2-3

Rahman, S. A., Sunderland, T., Roshetko, J. M., Basuki, I., & Healey, J. R. (2016). Tree culture of smallholder farmers practicing agroforestry in Gunung Salak Valley, West Java, Indonesia. *Small-scale Forestry, 15*, 433–442. doi:10.1007/s11842-016-9331-4

Reardon, T. (1997). Using evidence of household income diversification to inform study of the rural nonfarm labor market in Africa. *World Development, 25*, 735–747.
http://dx.doi.org/10.1016/S0305-750X(96)00137-4

Reed, M. S. (2008). Stakeholder participation for environmental management: A literature review. *Biological Conservation, 141*, 2417–2431. doi:10.1016/j.biocon.2008.07.014

Reed, M. S., Fraser, E. D. G., & Dougill, A. J. (2006). An adaptive learning process for developing and applying sustainability indicators with local communities. *Ecological Economics, 59*, 406–418. doi:10.1016/j.ecolecon.2005.11.008

Reed, M. S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., … Stringer, L. C. (2009). Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal of Environmental Management, 90*, 1933–1949. doi:10.1016/j.jenvman.2009.01.001

Robalino, J. A. (2007). Land conservation policies and income distribution: who bears the burden of our environmental efforts? *Environment and Development Economics, 12*, 521–533. doi:10.1017/S1355770X07003671
http://dx.doi.org/10.1017/S1355770X07003671

Scherr, S. J. (2000). A downward spiral? *Research evidence on the relationship between poverty and natural resource degradation*. doi:10.1016/S0306-9192(00)00022-1

Schulze, J., Martin, R., Finger, A., Henzen, C., Lindner, M., Pietzsch, K., … Seppelt, R. (2015). Design, implementation and test of a serious online game for exploring complex relationships of sustainable land management and human well-being. *Environmental Modelling and Software, 65*, 58–66. doi:10.1016/j.envsoft.2014.11.029

Scoones, I. (1998). *Sustainable rural livelihoods: A framework for analysis* (No. 72). Retrieved from http://opendocs.ids.ac.uk/opendocs/handle/123456789/3390

Scoones, I. (2009). Livelihoods perspectives and rural development. *The Journal of Peasant Studies, 36*, 171–196. Retrieved from http://www.tandfonline.com/doi/full/10.1080/03066150902820503.
http://dx.doi.org/10.1080/03066150902820503

Sheng, K., Fan, J., & Ma, H. (2006). Sustainable rural livelihood and ecological shelter construction in upper reaches of changjiang river. *Chinese Geographical Science, 16*, 32–40. Retrieved from http://link.springer.com/10.1007/s11769-006-0020-7
http://dx.doi.org/10.1007/s11769-006-0020-7

Sherren, K., Loik, L., & Debner, J. A. (2016). Climate adaptation in "new world" cultural landscapes: The case of Bay of Fundy agricultural dykelands (Nova Scotia, Canada). *Land Use Policy, 51*, 267–280. doi:10.1016/j.landusepol.2015.11.018

Sim, H. C., Appanah, S., & Durst, P. B. (2003). Bringing back the forests. *Policies and Practices for Degraded Lands and Forests*, Bangkok.

Steinhäußer, R., Siebert, R., Steinführer, A., & Hellmich, M. (2015). National and regional land-use conflicts in Germany from the perspective of stakeholders. *Land Use Policy, 49*, 183–194. doi:10.1016/j.landusepol.2015.08.009

Tai-yang, Z., Xian-jin, H., Xiu-ying, Z., & Ke, W. (2011). Temporal and spatial variability of agricultural land loss in relation to policy and accessibility in a low hilly region of southeast China. *Land Use Policy, 28*, 762–769. doi:10.1016/j.landusepol.2011.01.004

Tan, M., & Li, X. (2015). Does the green great wall effectively decrease dust storm intensity in China? A study based on NOAA NDVI and weather station data. *Land Use Policy, 43*, 42–47. doi:10.1016/j.landusepol.2014.10.017

Tang, B., & Ho, W. K. O. (2015). Land-use planning and market adjustment under de-industrialization: Restructuring of industrial space in Hong Kong. *Land Use Policy, 43*, 28–36. doi:10.1016/j.landusepol.2014.10.022

Templeton, S. R., & Scherr, S. J. (1999). Effects of demographic and related microeconomic change on land quality in hills and mountains of developing countries. *World Development, 27*, 903–918. doi:10.1016/S0305-750X(99)00037-6

Thapa, G. B. (1996). Land use, land management and environment in a subsistence mountain economy in Nepal. *Agriculture, Ecosystems & Environment, 57*, 57–71.
http://dx.doi.org/10.1016/0167-8809(96)88021-2

Tittonell, P. (2014). Ecological intensification of agriculture—sustainable by nature. *Current Opinion in Environmental Sustainability, 8*, 53–61. doi:10.1016/j.cosust.2014.08.006

Travers, H., Winney, K., Clements, T., Evans, T., & Milner-Gulland, E. J. (2015). A tale of two villages: An investigation of conservation-driven land tenure reform in a Cambodian Protection Forest. *Land Use Policy, 43*, 186–196. doi:10.1016/j.landusepol.2014.11.007

Van Hulst, F., Helena P., & Posthumus, H. (2016). Understanding (non-) adoption of Conservation Agriculture in Kenya using the Reasoned Action Approach. *Land Use Policy, 56*, 303–314. Retrieved from doi:10.1016/j.landusepol.2016.03.002

Vincent, A., & Fleury, P. (2015). Development of organic farming for the protection of water quality: Local projects in France and their policy implications. *Land Use Policy, 43*, 197–206. doi:10.1016/j.landusepol.2014.10.020

Wang, N., Gao, Y., Wang, Y., & Li, X. (2016). Adoption of eco-friendly soil-management practices by smallholder farmers in Shandong Province of China. *Soil Science and Plant Nutrition, 62*, 185–193. Retrieved from http://www.tandfonline.com/doi/full/10.1080/00380768.2016.1149779 http://dx.doi.org/10.1080/00380768.2016.1149779

World Bank Group (Ed.). (2012). *World development indicators 2012*. Washington DC: World Bank Publications.

Yesilonis, I., Szlavecz, K., Pouyat, R., Whigham, D., & Xia, L. (2016). Historical land use and stand age effects on forest soil properties in the Mid-Atlantic US. *Forest Ecology and Management, 370*, 83–92. doi:10.1016/j.foreco.2016.03.046

Zhang, T., Zeng, S., Gao, Y., Ouyang, Z., Li, B., Fang, C., & Zhao, B. (2011). Assessing impact of land uses on land salinization in the Yellow River Delta, China using an integrated and spatial statistical model. *Land Use Policy, 28*, 857–866. doi:10.1016/j.landusepol.2011.03.002

Zhang, L., Podlasly, C., Feger, K., Wang, Y., & Schwärzel, K. (2015). Different land management measures and climate change impacts on the runoff – A simple empirical method derived in a mesoscale catchment on the Loess Plateau. *Journal of Arid Environments, 120*, 42–50. doi:10.1016/j.jaridenv.2015.04.005

Zhu, J., & Simarmata, H. (2015). Formal land rights versus informal land rights: Governance for sustainable urbanization in the Jakarta metropolitan region, Indonesia. *Land Use Policy, 43*, 63–73. doi:10.1016/j.landusepol.2014.10.016

Appendix 1

Multivariate probit model

Farm households mostly supposed to adopt more than one land management systems simultaneously so as to protect their farmlands from degradation and erosion to maximise land productivity. In this case, one can have two alternatives, multivariate and multinomial regression models. However, one of the assumptions of the multinomial regression model is the possible land management systems are mutually exclusive so that error terms are independent. However, the possible land management strategies are not mutually exclusive and farmers try to implement multiple land management strategies so as to protect their key resources, land; therefore, we employ multivariate probit so as to incorporate the possible correlation in the error terms. Similar researchers (Jenkins et al., 2011; Kim, Gillespie, & Paudel, 2005; Mehar, Mittal, & Prasad, 2016) employed multivariate probit estimation technique so as to improve efficiency in the case of simultaneous adoption studies.

Following (Greene, 2012), we put the empirical model as follows:

$$Y_{m1} = X'_{jm1}\beta_1 + \in_{m1}$$

$$Y_{m2} = X'_{jm2}\beta_2 + \in_{m2}$$

$$Y_{m3} = X'_{jm3}\beta_3 + \in_{m3}$$

$$Y_{m4} = X'_{jm4}\beta_4 + \in_{m4}$$

$$Y_{m5} = X'_{jm5}\beta_5 + \in_{m5}$$

$$Y_{m6} = X'_{jm6}\beta_6 + \in_{m6}$$

$$Y_{m7} = X'_{jm7}\beta_7 + \in_{m7}$$

$$Y_{m8} = X'_{jm8}\beta_8 + \in_{m8}$$

where Y_{mi} = land management strategies; and m = 1; if farm household adopts fallow land management strategy (0 otherwise) and so on and m = farm household id; X'_{jmi} = vector of explanatory variables, β_i = vector of parameter and $\in_{mi}$ is error term.

Appendix 2

Multivariate probit model of farmland management strategies

Variable	Fallow	Manu& Compost	Terrace	Soil_ bund	Gully_ check	Tree_ plant	Shelterbelt	Strip_ crop
HHSEX	−0.179	0.628*	0.057	−0.102	0.104	−0.193	−0.188	0.749**
	(0.260)	(0.332)	(0.291)	(0.286)	(0.286)	(0.260)	(0.309)	(0.328)
LNHHAGE	−0.667	−0.321	0.481	−0.097	−0.096	−0.119	−0.243	−1.274**
	(0.486)	(0.620)	(0.518)	(0.510)	(0.572)	(0.444)	(0.453)	(0.559)
ELEM_ EDUC	−0.096	−0.601**	−0.297	−0.096	0.613**	−0.468*	−0.315	−1.065***
	(0.329)	(0.304)	(0.340)	(0.308)	(0.275)	(0.277)	(0.344)	(0.375)
SECON_ EDUC	0.264	0.297	0.023	0.633	0.342	−0.135	1.030**	−0.780*
	(0.511)	(0.453)	(0.369)	(0.465)	(0.490)	(0.380)	(0.368)	(0.460)
LNMRKT_ DIS	−3.692	−0.578	6.260**	−2.290	−1.045	−2.156	−0.730	1.459
	(2.595)	(2.944)	(2.708)	(2.686)	(2.944)	(2.421)	(2.718)	(3.084)
LAND_HA	−0.093	−0.201	0.110	0.317	0.046	0.385	0.294	−0.054
	(0.288)	(0.360)	(0.294)	(0.282)	(0.328)	(0.262)	(0.288)	(0.318)
LAND_ RIGHT	0.061	−0.088	0.583	−0.521	−0.208	−0.062	−0.015	0.290
	(0.365)	(0.411)	(0.499)	(0.425)	(0.391)	(0.455)	(0.514)	(0.544)
COOP_MEM	0.201	0.600*	0.799**	0.572*	−0.073	0.224	0.515	0.565*
	(0.332)	(0.346)	(0.340)	(0.335)	(0.323)	(0.311)	(0.332)	(0.372)
CREDIT_ SERV	−0.162	−0.050	−0.151	−0.219	0.368	−0.264	−0.236	0.573***
	(0.256)	(0.266)	(0.284)	(0.262)	(0.284)	(0.240)	(0.283)	(0.313)
AGRI_EX-TEN	0.928**	1.158**	1.082**	0.256	1.610***	1.089***	0.628	1.395***
	(0.460)	(0.473)	(0.458)	(0.399)	(0.449)	(0.395)	(0.432)	(0.461)
LABOR	0.244*	0.189	0.037	−0.047	−0.108	−0.042	−0.020	−0.068
	(0.143)	(0.137)	(0.142)	(0.157)	(0.200)	(0.139)	(0.138)	(0.148)
LNAGRI_ TECH	0.171	0.197	0.257	−0.229	0.198	−0.154	0.186	−0.134
	(0.224)	(0.274)	(0.166)	(0.224)	(0.248)	(0.272)	(0.278)	(0.238)
LNWAGE	0.651	−0.065	1.491**	1.686**	0.003	0.005	0.066	1.678**
	(0.748)	(0.815)	(0.740)	(0.748)	(0.733)	(0.723)	(0.692)	(0.760)
VILL_LE-QLEQ	−1.293**	−0.064	0.272	−1.190*	−0.866	0.031	0.172	0.606
	(0.638)	(0.607)	(0.618)	(0.618)	(0.718)	(0.630)	(0.649)	(0.703)
VILL_ WEYNMA	−0.197	−0.483	0.702	−0.565	−0.155	−0.133	0.037	0.140
	(0.479)	(0.505)	(0.505)	(0.499)	(0.543)	(0.469)	(0.520)	(0.551)
IHHD_IN-DEX	1.524***	1.796***	1.678 ***	1.672***	2.058***	1.109***	1.786***	1.598***
	(0.392)	(0.399)	(0.454)	(0.420)	(0.453)	(0.344)	(0.373)	(0.359)
CONSTANT	4.241	−0.867	−38.117***	−6.486	−1.053	5.899	−1.324	−16.014
	(10.197)	(11.791)	(12.005)	(10.812)	(10.694)	(9.095)	(10.397)	(11.767)
			$\chi^2(28)$			64.0813		
			Prob. > χ^2			0.0001		
			Number of Observations			148		

Note: Standard errors are in parentheses.
*Statistical level of significance at 10%.
**Statistical level of significance at 5%.
***Statistical level of significance at 1%.