Landholders' Choice to Adopt Improved Watershed Management in the Lower Blue Nile Basin, Ethiopia

By: Befikadu A. Legesse [a]* and Osei-Agyeman Yeboah [b]

[a] *Environmental Economist (Ph.D.), Research Associate, L.C. Cooper, Jr. International Trade Center, College of Agricultural and Environmental Sciences, North Carolina A&T State University, A-29, C.H. Moore Agricultural Research Station, 1601 East Market Street, Greensboro, NC, 27411-1011, USA*
[b] *Professor Ph.D., Director of L.C. Cooper, Jr. International Trade Center, College of Agricultural and Environmental Sciences, North Carolina A&T State University, A-25, C.H. Moore Agricultural Research Station, 1601 East Market Street, Greensboro, NC, 27411-1011, USA*
* *Author for correspondence:* blegesse@ncat.edu/ legesbef@gmial.com

Abstract

Watersheds are tremendously degraded worldwide, largely in developing countries especially in the Blue Nile Basin in Ethiopia. The degradation is due to several factors including pressure from land use and economic development. The degradation might be characterized by poor water quality, irregularity in water quantity, heavy floods that destroy life and property, sediment deposition in streams and irrigation canals; and sediment deposition on dams etc. Several researchers have suggested different watershed management interventions to end these problems, especially in developing countries. They include reforestation; construction of stone terrace; soil bunds; water harvesting technologies; and crop residue management. However, most landholders are not adopting these recommended technologies mainly due to socio-economic, institutional and policy-related issues. This paper empirically examines existing factors that are perceived to affect landholders' decisions for adopting improved watershed management intervention technologies in the Blue Nile Basin in Ethiopia. A multi-stage probability sampling techniques was used to sample 300 respondents and a binary Logit model was applied to the data. Results indicate that education, farm size, fertilizer, tropical livestock unit, traditional local institutions, land security and distance to nearest market are found to be significant factors that influence downstream landholders' decision to adopt improved watershed management technologies.

Keywords: Adoption behavior, improved watershed management, Blue Nile basin, downstream landholders, binary logit model.

1. Introduction

Watershed encompasses environmental and natural resources, which sustain diversified ecosystem services (Randhir *et al*., 2001) as well as economic and recreational benefits (Alemayehu *et al*., 2008; Legesse 2014). Studies show that watersheds have been extremely degraded in developing countries (Kosoy *et al*., 2006; Engel *et al*., 2008; Legesse, 2014) due to erosion, changes in farming systems, overgrazing, deforestation, pollution etc. (Alemayehu *et al*., 2008; Darghouth *et al.*, 2008; Wunder *et al*., 2008). The degradation has caused adverse impact on water quality, irregularity of water quantity, heavy floods, sediment deposition etc. especially in developing countries like Ethiopia (Pagiola *et al*., 2007; Wunder and Albán, 2007; Setegn, 2008; Darghouth *et al.*, 2008; Asquith *et al.*, 2008; Ashagre, 2009; Legesse, 2009; Mengstie, 2009). The Blue Nile Basin is one of the endangered Basins in Ethiopia due to the degradation. Studies suggest various watershed management[1] interventions to end these problems. These include soil conservation practices, preservation of hydrologic services, rehabilitation of degraded lands through physical and biological measures etc. (World Bank, 2006; Alemayehu *et al*., 2009; MOA-SLM, 2013). Also exist, are various improved watershed management technologies recommended for the downstream stratum that differ from the upper stratum of the Basin (BOA, 2012; MOA-SLM, 2013). These practices include construction of soil bunds, grass strips plantation, crop rotation, intercropping, strip cropping, manure/compost, inorganic fertilizer application, multi-storage gardening and farm ponds construction (Alemayehu *et al*., 2009; BOA, 2012; MOA-SLM, 2013). Among these measures, soil bund has been practiced for a couple of decades in the lower stratum of the Basin. However, this measure is not adopted by downstream landholders due to various reasons (Legesse, 2014; BOA, 2012). This paper examines determinants of landholders' adoption behavior towards soil bunds as a management practice that contributes to a pollution-free watershed. This study was done in the lower stratum of Koga watershed of the Blue Nile Basin through interviewing 300 respondents. The sampled respondents were selected using multi-stage probability sampling techniques. We employed a binary logit model to the data.

2. The study area

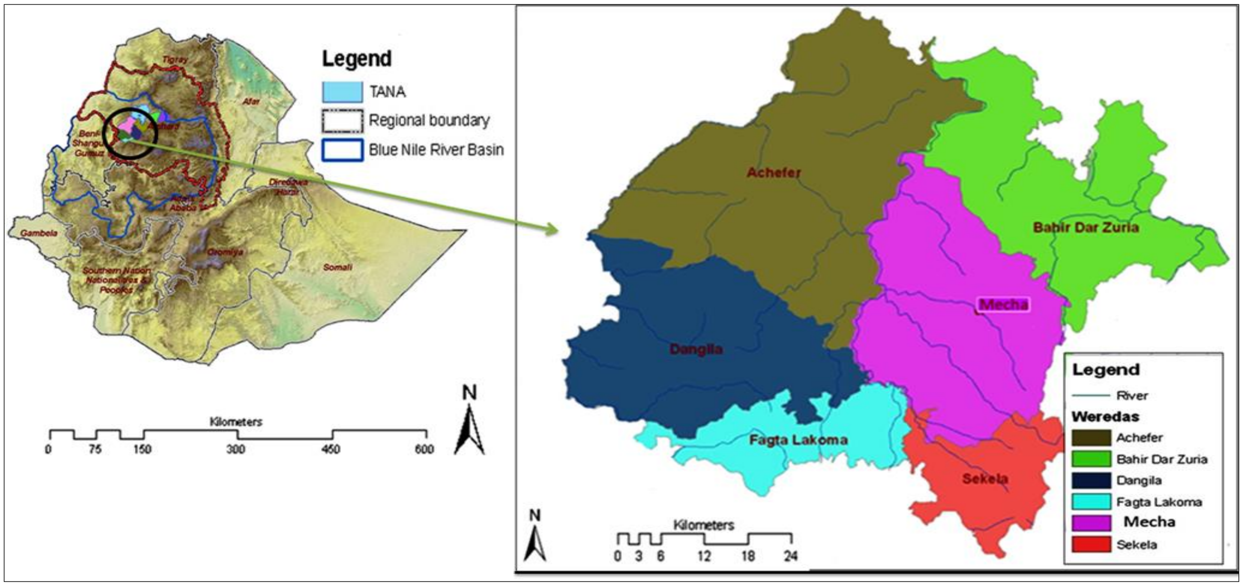
Kog watershed is located in eastern part of the Blue Nile Basin, Ethiopia, between 11°8' North to 11°25' North latitude and 37°2' East to 37°20' East longitude with a total drainage area of 299 km^2 (Bitew and Gebremichael, 2011; Legesse, 2014) (see Figure 1). The watershed's elevation ranges from 1,800 to 3,200 m. a. s. l. with an average annual rainfall of 1,560 mm and average daily temperature between 16°C to 20°C (Alemie, 2009; Kassahun, 2009; Legesse, 2014). According to the district agro-ecological[2] zones classification, the downstream part is characterized by wide flat to gently sloping topographies (Legesse, 2014). The watershed has high rainfall during July to September with highest mean monthly rainfall in July and highest evapotranspiration in May (Alemayehu *et al*., 2008).

---

[1] Watershed management refers to integrated measures that have been put in to practice to secure sustainable provisions of watershed services (Kaledhonkar *et al*., 2007).

[2] Agro-ecological zones classified based on rainfall patterns, temperature, soil types, altitude and other physical landscapes (Alemu *et al*., 2009).

Figure 1: Map of the study area



Source: ILRI – IPMS, 2012 and adopted by Legesse, 2014

3. Methodology

3.1 Data collection and sampling techniques

Data was collected from sampled farmers by employing structured questionnaires. The questionnaires were used to collect socio-economic, demographic, behavioral and institutional information. Experienced enumerators administered the data collection with close supervision. The survey data was augmented with secondary data from Central Statistical Agency, Ministry of Agriculture and District Bureau of Agriculture to obtain general information about the study area.

The study employed multi-stage sampling techniques to select respondents: in the first stage, *Koga* watershed was selected purposively. In the second stage, five *Kebeles* (the lower local administrative region next to district) were selected based on simple random sampling procedure. In the third stage, *Gottes* (the lower local administrative region next to *Kebele*) were selected based on proportional random sampling procedure. In this stage, the *Gottes* in each sampled *Kebele* were stratified into three groups depending on their distance (nearby, moderate, far away) from the center of local administration office. Following, six *Gottes* from each *Kebele* (at the rate of two *Gottes* from each stratified groups) were selected based on random sampling procedures. Finally, the sampled farmers were selected from sampled *Gottes* based on systematic random sampling procedures. The lists of farmers and *Gottes* were obtained from development centers and local administrative offices of the respective *Kebeles*. A total of 300 downstream farmers were selected for this study.

3.2 Theoretical Framework

Binary logit and Probit models are quite comparable and have the same S-shaped curves that bound in an interval from 0 to 1 (Pindyck and Rubinfeld, 1981; Gujarati, 1995; Alemayehu, 2007). The logit model has slightly flatter tails and assumes cumulative logistic probability function. Whereas, Probit model is associated with cumulative normal distribution (Pindyck and Rubinfeld, 1981; Gujarati, 1995; Alemayehu *et al.* 2010; Legesse, 2014). This study employs binary logistic regression over Probit due to the following advantages: binary logit model transforms problem of predicting probabilities within (0, 1) interval to problem of predicting the odds of an event occurring within actual condition (Pindyck and Rubinfeld, 1981), simple to work, flexible and straightforward (Hosmer and Lemeshew, 1989; Alemayehu 2007).

The dependent variable in the binary logit is a dummy variable (binary), which takes a value zero or one depending on whether downstream farmers adopt soil bunds. However, explanatory variables are either continuous or dummy variables. According to Pindyck and Rubinfeld (1981) and Alemayehu *et al*. (2010), the cumulative binary logistic probability function is specified below:

$$P_i = F(Z_i) = F\left[\alpha + \sum_{i=1}^{m} \beta_i \chi_i\right] = \left[\frac{1}{1+e^{-\left[\alpha + \sum_{i=1}^{m} \beta_i \chi_i\right]}}\right] \tag{1}$$

$$Z_i = \alpha + \sum_{i=1}^{m} \beta_i \chi_i \tag{2}$$

Where: e represents the base of natural logarithms,

X_i represents the ith explanatory variable,

P$_i$ represents the probability that downstream landholders' choice to implement soil bunds, and

α and β_i are parameters to be estimated

Interpretation of coefficients could be easier if the binary logistic model reformulates in terms of the odds and log of odds (Hosmer and Lemeshow, 1989; Gujarati, 1995). The odds ratio implies a ratio of the probability that an individual would choose an alternative (P$_i$) to the probability that she/he would not choose it (1- P$_i$), which is defined below:

$$[1 - P_i] = \left[\frac{1}{1+e^{Z_i}}\right] \tag{3}$$

Using equations (1) and (3), the odds ratio presented by equation 4.

$$\left[\frac{P_i}{1-P_i}\right] = \left[\frac{1+e^{Z_i}}{1+e^{-Z_i}}\right] = e^{Z_i} \tag{4}$$

Alternatively,

$$\left[\frac{P_i}{1-P_i}\right] = \left[\frac{1+e^{Z_i}}{1+e^{-Z_i}}\right] = e^{\left[\alpha + \sum_{i=1}^{m} \beta_i \chi_i\right]} \tag{5}$$

Taking the natural logarithms of equation 4 and 5 give the binary logit model that can be presented as below:

$$Z_i = \ln\left[\frac{P_i}{1-P_i}\right] = \alpha + \beta_1\chi_{1i} + \beta_2\chi_{2i} + --- + \beta_m\chi_{mi} \qquad (6)$$

The binary logit model can be presented as follows if the disturbance term, u_i, is considered.

$$Z_i = \alpha + \beta_1\chi_{1i} + \beta_2\chi_{2i} + --- + \beta_m\chi_{mi} + u_i \qquad (7)$$

Equation (7) was estimated using iterative maximum likelihood estimation procedure, which is consistent with utility maximization theory. This estimation procedure yields unbiased, efficient and consistent parameter estimates, particularly for large sample size (Legesse, 2014). We employed SPSS for Windows (version 19) to estimate the logit model.

Prior to the model estimation, Variance Inflation Factor[3] (VIF) and Contingency Coefficients[4] (C) techniques were employed to detect multi-collinearity among continuous and dummy explanatory variables respectively. The mathematical form of VIF and C are given by equation 8 and 9, respectively (Gujarati, 2004; Andren, 2007; Alemayehu *et al*, 2010; Legesse, 2014).

$$VIF(X_i) = (1 - R_i^2)^{-1} \qquad (8)$$

Where: R_i^2 is the squared multiple correlation coefficient and X_i is the i^{th} explanatory variable.

$$C = \sqrt{\frac{\chi^2}{n + \chi^2}} \qquad (9)$$

Where: χ^2 is Chi-square and n is total sample size.

4. Results and discussions

Results show that about 34 percent of downstream landholders are likely to be adopters of soil bund practice. The explanatory variables used in the model are *Age, Education, Farm Size, Field Visit, Fertilizer Application, Distance to Nearest Market, Tropical Livestock Unit*[5]*, Informal Local Institution (Debo*[6]*), Cooperative and Land security*.

---

[3] Researchers recommend to omit variables with a VIF value of 10 and more from the analysis in order to avoid serious multicollinearity problem (Healy, 1984; Adugna, 2005; Alemayehu *et al*., 2010; Beshir *et al*., 2012; Beshir, 2014; Legesse, 2014).

[4] C values, which ranges between 0 to 1, measures the degree of correlation between discrete variables based on chi-square measure of association. C value with 0.75 or more shows a strong degree of association between discrete variables, C value close to zero indicts absence of series association between discrete variables (Healy, 1984; Adugna, 2005; Alemayehu *et al*., 2010; Beshir *et al*., 2012; Beshir, 2014; Legesse, 2014).

[5] TLU is commonly taken to be an animal of 250 kg live weights (Storck *et al*. 1991), TLU conversion factors that used in this study which is presented in Appendix Table 1.

[6] Informal local institutions employ traditional rules and customs that govern human behavior but not codified by state law (Joireman 2001 cited in Degefa, 2010). "Debo" is one of traditional local institutions in the study area that established by the community as labor sharing pulling system, where the person requiring labor typically provides food and drink in exchange for labor.

The VIF values for continuous explanatory variables were found to be small, which were less than 10. The C values for dummy explanatory variables were found to be small, which were less than 0.75. The chi-square value of the result shows the overall goodness of fit of the model at less than 1% probability level (Table 1). The R^2 goodness of fit employed is based on the theory that an event may not occur if estimated probability of an event is less than 0.5 and otherwise it may occur (Maddala, 1989; Alemayehu *et al*., 2010; Legesse, 2014). Hence, the ith respondent was considered to be adopter if and only if the computed probability value greater or equal to 0.5 otherwise non-adopter of soil bund intervention. The binary logit model correctly predicts 83 percent of the total observed values. The sensitivity of the model shows the proportion of correctly predicted downstream landholders as adopters of improved soil bund practice is 93.90 percent. The specificity of 91.20 percent indicates the proportion of correctly predicted downstream landholders as non-adopter of improved soil bund measures. Therefore, the model predicts both groups adequately.

As presented in Table 1, seven explanatory variables included in the analysis are found to have statistically significant impact on farmers' adoption behavior with less than 10% probability level. These variable include education, farm size, fertilizer application, distance to nearest market, informal local institution, tropical livestock unit, and land security. A brief discussion on the statistically significant explanatory variables is provided below:

Education: Studies show that farmers' educational level influences their adoption behavior (Dasgupta, 1989; Chomba, 2004; Yehzbalem, 2005). This variable is significant at (P<0.01) and has a positive association with landholders' choice to adopt improved soil bund practice. Educated farmers incline to spend more time and money in soil conservation measures (Shiferaw, 2002, Abdulai and Huffman, 2014). This result coincides with Okoye (1998), Gould *et al*. (1989) Bekele and Drake (2003), Anley *et al*. (2006), Bienabe and Hearne (2006), Ojeda *et al*. (2007), Chukwuone and Okorji (2008), Yoo *et al*. (2008), Deressa *et al*. (2009) and Stithou and Scarpa (2012) who reported the positive influence of education on farmers' adoption behavior. The odds ratio of this variable indicates that farmers' decision to adopt the measure will increase by the factor of 5.70 for a unit increase in this variable, ceteris paribus.

Farm size: Farm size is a wealth indictor and a proxy for social status (Zegeye *et al.*, 2001; Asfaw *et al*., 2011; Beshir *et al*., 2012). Framers who have large farm size are more likely to adopt the technology (Norris and Batie, 1987). This variable affects farmers' adoption behavior positively and found to be significant at (P<0.01). The odds ratio of the variable implies that farmers' choice to adopt the measure will increase by a factor of 1.40 for an additional unit increase in farm size, ceteris paribus. Sureshwaran *et al*. (1996), Sangkapitux *et al*. (2009), Adugna (2005), Ndetewio *et al*. (2013), Oladele (2008), Abu *et al*. (2011) and Kwayu *et al*. (2013) also reported that farm size highly and positively correlated with farmers' choice to adopt watershed management interventions.

Fertilizer application: Fertilizer application is one of the biological management technologies used to minimize runoff through infiltration of rainfall and also improves crop yields (Nkonya *et al*., 2005; Alemayehu et al., 2008; Zelleke, *et al*., 2010; Spielman *et al*., 2011; MOA, 2012; Getnet and MacAlister, 2012; Minot and Sawyer, 2013). Studies revealed that farmers who apply fertilizers are adopters of the technologies as compared to those who do not apply (Schmidt and Tadesse, *et al*., 2012; Legesse, 2014). This variable correlates positively with farmers' adoption behavior and found to be significant at (P<0.01). The probability of downstream landholders' choice to adopt the measure will increase by 0.99 as compared to those who do not use fertilizer, ceteris paribus. Alemayehu *et al*. (2009) and Schmidt and Tadesse *et al*. (2012) also reported the positive association between fertilizer application and adoption of watershed management interventions.

Distance to the nearest market: Studies revealed that the nearest market distance saves time, reduces transportation costs and increases access to information (Beshir *et al.*, 2012; Legesse, 2014). This variable is a proxy indicator for market accessibility and it is found to be significant at (P<0.01) but associate negatively with farmers' adoption behavior. This suggests that farmers' decision to adopt the measure most likely declines with distant from the central market. The reason is that farmers' chance of accessing information about improved watershed management measures reduces the further away from the central market. This result agrees with what is stated in Chirwa (2005), Langyintuo and Mekuria (2005), Maddison (2006), Mariara (2007), Bittinger (2010), Cavatassi *et al*. (2011) and Tedla (2011). The odd ratio of the variable implies that farmers' decision to adopt the measure will decline by a factor of 0.75 for an increase in distance.

Table 1: Parameter estimates for binary logit model

Explanatory Variables	Coefficients	Odds Ratio	Wald Statistic	Significance Level
Education	1.748	5.743	9.328	0.002***
Farm size	0.334	1.396	7.693	0.006***
Field visit	0.825	2.281	2.118	0.146
Fertilizer	4.685	108.29	49.980	0.000***
Distance to nearest market	-0.295	0.745	10.135	0.001***
Tropical livestock unit	0.213	1.237	3.443	0.064*
Informal institution	1.523	4.587	4.434	0.035**
cooperatives	0.153	1.165	0.031	0.861
Land security	1.706	5.505	3.565	0.059*
Age	-0.043	0.958	2.640	0.104
Constant	-7.294	0.001	13.234	0.000***
-2 Log likelihood				110.6
Nagelkerke R Square [a]				0.83
Overall prediction				93.0
Sensitivity [b]				93.9%
Specificity [c]				91.2%
Sample size				300

***,** and * Shows significance at 1%, 5% and 10% probability levels

[a] Based on a 50-50 probability classification scheme

[b] Correctly predicted adopters

[c] Correctly predicted non-adopters

Source: Model analysis, 2016

Membership in informal local institution: Informal local institutions[7] are participatory local social institutions, which are established by the local community (Degefa, 2010; Legesse 2014). This variable is significant at ($P<0.05$) and correlates positively with farmers' adoption behavior. This implies that downstream landholders incline to adopt soil bund measure as compared to those who are not the member of informal institutions. The reason is that farmers considered traditional institutions as means to address their need (Nyangena, 2008). This result coincides with findings of Sangkapitux *et al*. (2009), Ayuya, *et al*. (2011), and Sebhatu (2012) and Legesse (2014). The odds ratio suggests that farmers' choice to adopt the measure will increase by a factor of 4.60 as they acquire additional service from informal institutions, ceteris paribus.

Tropical livestock unit: This variable is significant at ($P<0.10$) and has a positive association with farmers' adoption behavior. Livestock serves for income or wealth, wealthy landholders are less risk averse and are more likely to adopt first than less wealthy ones. Sambrook and Akhter, (2001), Tesfaye *et al*. (2001), Alemayehu *et al*. (2008) and Banks and Dagher (2012) also reported the positive influence of TLU on farmers' adoption behavior. Downstream landholders' choice to adopt the measure will increase by a factor of 1.20 as this variable increases by one additional unit, ceteris paribus.

Land security: Farmers' sense of tenure security correlates positively with their adoption behavior and found to be significant at ($P<0.10$). This implies that security in land rights encourages farmers to invest in improved watershed management (Southgate, 1988; Yehzbalem, 2005; Legesse, 2014). This might be due to the fact that downstream farmers opt to adopt the measure when they have the confidence to use their parcel at least during their lifetime. This result is in accordance with findings of Illukpitiya and Gopalakrishnan (2004), ORGUT (2010), Juana *et al*. (2013), Banks and Dagher (2012) and Legesse (2014) who reported positive effects of land tenure on farmers' choice to participate in watershed management interventions. The odds ratio suggests that farmers' adoption behavior most likely will increase by a factor of 5.50, ceteris paribus, as their sense of tenure security improve by an additional unit.

5. **Conclusions and policy implications**

The results of the study show that education, farm size, fertilizer application, distance to nearest market, informal local institution, tropical livestock unit, and land security are found to be influence a landholder's decision to adopt the technologies. Farmers' level of education has a positive and significant impact on their decision to opt the measures. This implies that educated farmers understand the problems and are more likely first to adopt the measures. This result suggests providing education and training services to farmers to improve adoption of the technologies. Farm size is one of the important factors that has a positive influence on farmers' adoption behavior. Farmers with large farms are more likely to adopt the technology than small farms. This implies that policy makers should give attention to large farmers so that the technologies can reach other farmers through a farmer-to-farmer way of information dissemination. It is also found a positive significant impact of fertilizer application on farmers' adoption behavior. This indicates that farmers who use fertilizers are adopters of the technologies. This result suggests enhancing the provision and accessibility of fertilizers to improve adoption of the technologies. The study shows that membership in informal local institution directly correlates

---

[7] Traditional institutions refer to traditional rules and customs that govern human behavior but not codified by state law (Joireman 2001 cited in Degefa, 2010).

with farmers' adoption behavior. The reason is that local institutions have high level of trust, acceptance and recognition by farmers. Tropical livestock unit has significant positive association with farmers' adoption behavior. The reason is that livestock serves for income and wealthy farmers are more likely to adopt the technologies.

Farmers' sense of tenure security has a significant positive correlation with their adoption behavior. This might be due to the fact that farmers adopt the measure when they have the confidence to use their parcel at least during their lifetime. Distance to the nearest market has a significant negative impact on farmers' adoption behavior. The reason is that farmers' chance of accessing information reduces the further away from the central market.

Based on the findings of the study, the following points need to be considered by policy makers in order to improve adoption of improved watershed management interventions: (i) there is a need to incorporate educational and training components in watershed management policies to promote the conservation, management and sustainable use of watersheds; (ii) improving farmers' income is an essential element to boost their capacity to invest in improved watershed management measures. To achieve this responsibility, all concerned stakeholders such as the Ministry of Agriculture, Agricultural Research Centers, NGOs, informal local institutions and others need to collaborate through designing appropriate systems to raise farmers' income; (iii) there is also a need to increase the number of local markets, improve existing rural marketing system and integrate farmers with the existing marketing system; and (iv) there is a need to consider farmers' land ownership rights in watershed management policies and strategies.

6. References

Abdulai A. and Huffman, W., 2014. The Adoption and Impact of Soil and Water Conservation Technology: An Endogenous Switching Regression Application. Land Economics, vol. 90 no. 1 pp, 26-43.

Adugna, G., 2005. Determinants of Land Degradation in the Lake Tana Basin and its Implications for Sustainable Land Management: The Case of Angereb and Gish-Abbay Watersheds. Thesis Presented to the School of Graduate Studies of Alemaya University, Ethiopia, pp 134.

Alemayehu, B., 2007. Policy and Institutional Analysis of Smallholder Cattle Production in Dano District of Western Showa, Ethiopia: Thesis Presented to the School of Graduate Studies of Alemaya University, pp 116.

Alemayehu, B., Bogale, A., Wollny, C., and Tesfahun, G., 2010. Determinants of choice of market-oriented indigenous Horo cattle production in Dano district of western Showa, Ethiopia. Tropical Animal Health Production, 42, pp 1723–1729.

Alemayehu, B., Hagos, F. and Haileslassie, A., 2008. Prospect of Payments for Environmental Services in the Blue Nile Basin: Examples from Koga and Gumera Watersheds, Ethiopia, pp 27.

Alemayehu, F., Taha, N., Nyssen, J., Girma, A. Zenebe, A., Behailu, M., Deckers,S and Poesen J., 2009. The impacts of watershed management on land use and land cover dynamics in Eastern Tigray (Ethiopia). Resources, Conservation and Recycling, Volume 53, Issue 4, pp 192–198.

Alemie, T.C., 2009. The Effect of Eucalyptus on Crop Productivity and Soil Properties in the Koga Watershed, Western Amhara Region, Ethiopia. Thesis Presented to the School of Graduate Studies of Cornell University, pp 48.

Alemu, B.A, Nuppenau, E.A. and Bolland, H., 2009. Technical Efficiency across agro-ecological zones in Ethiopia: The Impact of Poverty and Asset Endowments. Agricultural Journal, Volume 4, 202-207.

Andren, T., 2007. Econometrics. Ventus Publishing ApS, pp 141.

Asfaw, S., Shiferaw, B., Simtowe, F. and Haile, M.G., 2011. Agricultural technology adoption, seed access constraints and commercialization in Ethiopia. Journal of Development and Agricultural Economics, Volume 3 (9), pp 436-447.

Ashagre, B.B., 2009. SWAT to Identify Watershed Management Options: (Anjeni Watershed, Blue Nile Basin, Ethiopia). Thesis Presented to the Faculty of the Graduate School of Cornell University, pp 103.

Asquith, N.M., Vargas, M.T. and Wunder, S., 2008. Selling two environmental services: In-kind payments for bird habitat and watershed protection in Los Negros, Bolivia. Ecological economics, pp 675-684.

Banks, K. and Dagher, A., 2012. Valuation of Soil Conservation Practices in Adwa Woreda, Ethiopia: A Contingent Valuation Study. American Journal of Soil and Water, Volume 2 (3), pp 2568-5457.

Beshir, H., 2014. Factors Affecting the Adoption and Intensity of Use of Improved Forages in North East Highlands of Ethiopia. American Journal of Experimental Agriculture 4 (1), pp 12-27.

Beshir, H., Emana, B., Kassa, B. and Haji, J., 2012. Determinants of chemical fertilizer technology adoption in North eastern highlands of Ethiopia: the double hurdle approach. Journal of research in economics and international finance, Volume 1 (2), pp 39-49.

Bienabe, E. and Hearne, R.R., 2006. Public preferences for biodiversity conservation and scenic beauty within a framework of environmental services payments. Forest Policy and Economics, 9, pp 335–348.

Bitew, M.M. and Gebremichael, M., 2011. Assessment of satellite rainfall products for streamflow simulation in medium watersheds of the Ethiopian highlands. Hydrology and Earth System Science, 15, pp 1147–1155.

BOA, 2012. Socio economics and demographic characteristics of Amhara region. District bureau of agriculture, (Amahric version) unpublished, Merhawe, Ethiopia, pp 60.

Chen, H., 2010. Ecosystem Services from Low Input Cropping Systems and the Public's Willingness to pay for them. A thesis submitted to Michigan State University in partial fulfillment of the requirements for the degree of Master of Science. Agricultural, Food and Resource Economics, pp 154.

Chomba, G.N., 2004. Factors Affecting Smallholder Farmers' Adoption of Soil and Water Conservation Practices in Zambia. Thesis Presented to Michigan State University, USA, pp 118.

Chukwuone, N.A. and Okorji, C.E., 2008. Willingness to pay for Systematic Management of Community Forests for Conservation of Non-Timber Forest Products in Nigeria's Rainforest Region. Implications for poverty alleviation. Springer, pp 21.

Darghouth, S., Ward, C., Gambarelli, G., Styger, E. and Roux, J., 2008. Watershed Management Approaches, Policies, and Operations: Lessons for Scaling Up. World Bank: Water Sector Board Discussion Paper Series Paper no.11, pp 164.

Dasgupta, S., 1989. Diffusion of Agricultural Innovations in Village India. Department of Sociology and Anthropology, University of Prince Edward Island. Canada. 74-86p

Degefa, M.Y., 2010. How Informal Institutions Strengthen Sustainable Management of Common Pool Resources in Tigray, Ethiopia? A Thesis Submitted in Partial Fulfilment of the Requirements for the Doctorate in Agricultural Sciences. Centre for Development Research, University of Natural Resources and Applied Life Sciences, Vienna, pp 140.

Engel, S., Pagiola, S., Wunder, S., 2008. Designing payments for environmental services in theory and practice: an overview of the issues. Ecological Economics 65, pp 663–674.

FDRE, 2005. Federal Democratic Republic of Ethiopia: Rural Land Administration and Land Use Proclamation, Addis Ababa, Ethiopia, pp 12.

Getnet, K. and MacAlister, C., 2012. Integrated innovations and recommendation domains: Paradigm for developing, scaling-out, and targeting rainwater management innovations. Ecological Economics 76, pp 34–41.

Gould, B.W., W.E. Kangasniemi and R.M. Klemme, 1989. Conservation tillage: the role of farm and operator characteristics and the perception of soil erosion, Land Econom., 65 (2): 167-182.

Gujarati, D.N., 1995. Basic Econometrics. 3rd Edition. McGraw-Hill, Inc., pp 1001.

Gujarati, D.N., 2004. Basic Econometrics. 4th Edition. McGraw-Hill, Inc., pp 1002.

Healy, F.J., 1984. Statistics: a tool for social research. Wadsworth Publishing Company, California, USA, pp 21.

Hosmer, D.W. and Lemeshew, S., 1989. Applied Logistic Regression. A Wiley-Inter Science Publication, New York, pp 375.

ILRI – IPMS, 2012. GIS Section: International Livestock Research Institute, Improving productivity and Market success project, Addis Ababa, Ethiopia.

Kaledhonkar, M.J., Gupta, S.K., Bundela, D.S. and Singh, Gurbachan (2007), On-Farm Land and Water Management. Central Soil Salinity Research Institute, Karnal, India, pp 178.

Kassahun, H.T., 2009. Payment for Environmental Service to Enhance Resource Use Efficiency and Labor Force Participation in Managing and Maintaining Irrigation Infrastructure, the Case of Upper Blue Nile Basin. Thesis Presented to the School of Graduate Studies of Cornell University, pp 13.

Kosoy, N., Martinez-Tuna, M., Muradian, R., Martinez-Alier, J., 2006. Payments for environmental services in watersheds: insights from a comparative study of three cases in Central America. Ecological Economics 61 (2–3), pp 446–455.

Legesse, B.A., 2014. Payments for improved watershed services for improved watershed management in the Blue Nile Basin, Ethiopia. A dissertation submitted to the Faculty of Environmental Sciences and Process Engineering at the Brandenburg University of Technology in Cottbus-Senftenberg in partial fulfillment for the award of the academic degree of Doctor of Philosophy (Ph.D) in Environmental Sciences, pp 234.

Legesse, E.S., 2009. Modeling Rainfall-Runoff Relationships for Anjeni Watershed in the Blue Nile Basin. A Thesis Presented to the Faculty of the Graduate School of Cornell University in Partial Fulfillment of the Requirements for the Degree of Master of Professional Studies, pp 54.

Maddala, G.S., 1989. Limited Dependant and Qualitative Variables in Econometrics. Cambridge University press, United States of America, pp 401.

Mengstie, F.A, 2009. Assessment of Adoption Behavior of Soil and Water Conservation Practices in the Koga Watershed, Highlands of Ethiopia: Master of Professional Studies Thesis Presented to the Faculty of the Graduate School of Cornell University, pp 75.

Minot, N., and Sawyer, B., 2013. Input use in Ethiopia: Results of the 2012 ATA Baseline Survey. International Food Policy Research Institute, Washington, DC, pp 27.

MOA-SLM, 2013. Sustainable Land Management (SLM) Knowledge: Technologies. Monistry of Agriculture Ethiopia. (http://www.slmethiopia.info.et/slmknowledge/)

Nkonya, E., Kaizzi, C. and Pender, J., 2005. Determinants of nutrient balances in a maize farming system in eastern Uganda. Agricultural Systems, 85, pp 155–182.

Noma, D., 2012. What are the main drivers behind Ethiopian farmers' soil and water conservations practices? Leuven-La-Neuve, Belgium: Catholic University of Leuven.

Norris, P.E., Batie, S.S., 1987. "Verginia Farmers' Soil Conservation Decisions". An Application of Tobit Analysis. *Southern Journal of Economics* 19, 79-90.

Ojeda, M.I., Mayer, A.S. and Solomon, B.D., 2007.Economic valuation of environmental services sustained by water flows in the Yaqui River Delta. Ecological Economics 65, pp 155-166.

Okoye, C., 1998. Comparative analysis of factors in the adoption of traditional and recommended soil erosion control practices in Nigeria. Soil and Tillage Res., 45: 251-263

Oostendorp, R.H. and Zaal, F., 2011. Understanding Adoption of Soil and Water Conservation Techniques: The role of new owners. CSAE Working Paper WPS/2011-05, pp 36.

Pagiola, S., Ramírez, E., Gobbi, J., de Haan, C., Ibrahim, M., Murgueitio, E., Ruíz, J.P., 2007. Paying for the environmental services of silvopastoral practices in Nicaragua. Special Issue on Ecosystem Services and Agriculture, Ecological Economics 64 (2), pp 374–385.

Pindyck, R.S. and Rubinfeld, D.C., 1981. Econometric Models and Econometric Forecasts, 2nd Edition, Mcgraw-Hill Book Co. New York, pp 292.

Randhira, T.O., Connorb, R.O., Pennerc, P.R. and Goodwin, D.W., 2001. A watershed-based land prioritization model for water supply protection. Forest Ecology and Management 143 (2001), pp 47-56.

Sambrook, B. and S. Akhter, 2001. Social and gender analysis: Findings from the inception phase. Domestic Roofwater Harvesting Research Program, RN-RWH02. Hambantota, Srilanka. 34-36p.

Sangkapitux, C., Neef, A. and Polkongkaew, W., 2009. Willingness of upstream and downstream resource managers to engage in compensation schemes for environmental services. International Journal of the Commons. Volume 3 (1), pp 41–63.

Setegn, S.G., 2008. Hydrological and Sediment Yield Modelling in Lake Tana Basin, Blue Nile Ethiopia. Trita-Lwr.Lic 2042, pp 44.

Shiferaw, P.A., 2002. Determinants of Farmers' Willingness to Participate in Soil Conservation Practices in The Highlands of Bale: The Case of Dinsho Farming System Area. Thesis Presented to the School of Graduate Studies of Alemaya University, Ethiopia, pp 131.

Southgate, D. 1988. The Economics of Land Degradation. Environmental Department. Working Paper, No. 2, World Bank, Washington, D.C.

Spielman, D.J., Kelemwork, D. and Alemu, D., 2011. Seed, Fertilizer, and Agricultural Extension in Ethiopia. Ethiopia Strategy Support Program II (ESSP II). ESSP II Working Paper 020, pp 40.

Stithou, M. and Scarpa, R., 2012. Collective versus voluntary payment in contingent valuation for the conservation of marine biodiversity: An exploratory study from Zakynthos, Greece. Ocean & Coastal Management, 56, pp 1-9.

Storck, H., Emana, B., Adnew, B., Borowiecki, A. and Woldehawariate, S., 1991. Farming systems and farm management practices of small holders in the hararghe highlands: Farming systems and resources economics in the tropics. Wssenshaftsver lag vauk, Kiel, Germany. 11, pp 41-48.

Sureshwaran, S. R. Londhe and P. Franzier, 1996. "A Logit Model for Evaluating Farmer Participation in Soil Conservation Programs": Slopping Agricultural Land Technology on Upland Farms in the Philippines. *Journal of Sustainable Agriculture*, 7(4), pp 52-69.

World Bank, 2006. Watershed Management Approaches, Policies, and Operations: Lessons for Scaling Up. Water Sector Board Discussion Paper, 11. Washington, DC, pp 164.

Wunder, S and Albán, M, 2007. Decentralized payments for environmental services: The cases of Pimampiro and PROFAFOR in Ecuador. Ecological Economics 65, pp 685-698.

Wunder, S., Engel, S. and Pagiola, S., 2008. Taking stock: A comparative analysis of payments for environmental services programs in developed and developing countries. Ecological Economics, 65, pp 834 – 852.

Yehzbalem, M.T., 2005. Farmers' Response and Willingness to Participate in Water Harvesting Practices: A Case Study In Dejen District / East Gojam Zone

Yoo, S.H., Kwak, S.J. and Lee, J.S., 2008. Using a choice experiment to measure the environmental costs of air pollution impacts in Seoul. Journal of Environmental Management, 86, pp 308–318.

Zegeye, T., Taye, G., Tanner, D., Verkuijl, H., Agidie, A., and Mwangi, W., 2001. Adoption of Improved Bread Wheat Varieties and Inorganic Fertilizer by Small-scale Farmers in Yelmana Densa and Farta Districts of Northwestern Ethiopia. International Maize and Wheat Improvement Center (CIMMYT), Mexico, pp 29.

Zelleke, G., Agegnehu, G., Abera, D. and Rashid, S., 2010. Fertilizer and Soil Fertility Potential in Ethiopia: Constraints and opportunities for enhancing the system. International Food Policy Research Institute, pp 42.

Appendix Table 1: Conversion factors used to estimate tropical livestock unit

Animal Category	**Total TLU**	**Animal Category**	**Total TLU**
Calf	0.25	Donkey (adult)	0.70
Weaned calf	0.34	Donkey (young)	0.35
Heifer	0.75	Camel	1.25
Cow and ox	1.00	Sheep and goats (adult)	0.13
Pigs	0.20	Sheep and goats (young)	0.06
Horse	1.10	Chicken	0.013

Source: Storck *et al*. 1991; Alemayehu, 2007; Legesse, 2014.