3 January 2016

Reply to interactive comment on "Determinants of farmers' tree planting investment decision as a degraded landscape management strategy in the central highlands of Ethiopia" by B. Gessesse et al.

[reply] Dear Anonymous Referee # 1,

On behalf of the co-authors, I thank you so much for your valuable comments and suggestions made on the interactive discussion paper titled *"Determinants of farmers' tree planting investment decision as a degraded landscape management strategy in the central highlands of Ethiopia"* which was published in journal of Solid Earth Discussion section. We want to express our appreciation that you recommend the paper to be published in the Journal of Solid Earth subsequent to addressing the comments. Your comments are very helpful to enhance the quality of our manuscript, and we sincerely hope that we have sufficiently addressed your concerns. The details of the revision we have made are given below.

Sincerely,
Berhan Gessesse, PhD

Details of changes made to the manuscript

We have attended the following comments suggested by the Anonymous Referee # 1.

1- Linking the discussion section (part 3) with the specific objectives is required: e.g.: Specific objective i) pp.3248, line 8-12 asserts to examine tree planting decisions of land users to reverse land degradation caused due to deforestation, gully formation and soil erosion. However, there are no evidences on the results part how deforested and gullied areas are managed or covered with trees. This indicates that the study is lacking significant focus on the specific objectives raised. The separate specific objectives should be better analyzed and be provided with temporary conclusions.

[reply] It is vivid that the Ethiopian highlands in general and our case study site in particular are some of the world's major land degradation hotspots (Hurni, 1993, Gessesse et al., 2015). As we clearly indicated in the introduction section of the present manuscript, many land management options such as physical conservation measures (soil bunds, stone bunds, hillside terraces) and biological conservation measures (afforestaion programme) were devised to counteract various forms of land degradation in the forms of splash erosion, sheet erosion and gully formation as well as the process of deforestation in the highlands of Ethiopia. Although stone terracing, check dams, diversion ditches and runoff diversion land management options are very common in the study site, the practice of tree planting as a land management strategy to reclaim deforested and gullied areas is almost scant in the case study watershed. On top of that, many studies were conducted to evaluate the effectiveness of different forms of land management options in Ethiopia. However, the adoption of tree planting land management practice as a response to deforestation and gully formation is the missing

element in all most all studies which were conducted in Ethiopia. Thus, the central focus of this study is examining the implementation status of tree planting land management strategy and with major determinants of farmers' tree planting decision at Modjo watershed to manage degraded site. Accordingly, the first objective of the manuscript is revised as follows: *"i) to examine the adoption of tree planting decision by local land users for reversing land resources degradation,"*

2. Linking the concluding remarks with the points discussed in the results part is needed: e.g.:

2.1 In the abstract, p3246, lines 17-19, "the processes of land use conversion and land degradation are serious which in turn have had adverse effects on agricultural productivity, local food security and poverty trap nexus". But here, is "land use conversion" mean "land degradation"? If not, your focus is I think on "land degradation" and there is no need to include "land use conversion". Again the sentences lines 19-21, read as "…devising sustainable and integrated land management policy options and implementing them would enhance ecological restoration and livelihood sustainability in the study watershed". But, the phrases "sustainable and integrated land management policy options" and "ecological restoration and livelihood sustainability" are not adequately analyzed in the results section. So, on what background you reached at such a conclusion?

[reply] Since land conversion is one component of land degradation process, the phrase "land conversion" is removed from this section and revised in the "authors' changes in manuscript" and in the "revised version of the manuscript". On the other hand, land degradation in the form of land cover conversion, land use alienation, soil erosion, surface runoff, vegetation degradation and others is a very critical problem in the Modjo watershed (Gessesse et al., 2015). In addition, the practice of land management implementation to counteract these various forms of environmental catastrophe is very limited in the case study site. Although as long as serious land degradation problem manifests in a given environment, it has negative implication at on-site and off-site level. Some of the on-site and off-site effects of land degradation are soil fertility loss, loss of biodiversity, disruption of ecosystem function and services, water scarcity, silitation, sedimentation, etc. Consequently, severe land degradation affects a significant portion of cultivated lands, decreasing the prosperity and economic growth of countries. On the other hand, if the land resource base becomes less productive, food security is compromised, competition for dwindling resources would be increased, and the seeds of famine, starvation and poverty and potential conflict are sown. In this connection, we stated that *"devising sustainable and integrated land management policy options and implementing them would enhance ecological restoration and livelihood sustainability in the study watershed"* in the last section of our abstract. There for, this statement is not conclusion rather we recommend as a best land management option to tackle land degradation process in the case study watershed in the future. Accordingly the following modification is applied to the last sentence of the abstract as " *Hence, the study recommended that devising sustainable and integrated land management policy options and implementing them would enhance ecological restoration and livelihood sustainability in the study watershed".*

2.2 P 3261, Section 4, lines 16-18 states: "The result of the study revealed that the challenges for sustaining the current land resources utilisation are immense in the study watershed". But, there are data supporting this suggestion. So, how did you come to such a conclusion?

[reply] This section is revised as follows: "The result of the study revealed that the challenges for sustaining the current land resources degradation and low level of land management options are very challenging in the study watershed". Even, some of the farmers have been attempted to plant trees for the purpose of reversing land degradation practices in line with the adoption of various forms of land management technologies, meaningful results are not achieved to address degraded land rehabilitation in the Modjo watershed.

2.3 Lines 21-26, the likelihood of household size, productive labour force availability; disparity of schooling age, perception of the process of deforestation and the current land tenure system have positively and significantly constrain on tree growing investment decision to combat land degradation, minimize soil fertility exhaustion and ecosystem disruption as well as to scale up ecological sustainability. The concepts "minimize soil fertility exhaustion and ecosystem disruption as well as to scale up ecological sustainability" have no supporting evidence in the analysis part (section 3) and are not directly related to the problem considered. The conclusion on pp, 3261-3262, lines 27-28; "integrated land resource management strategy option is essential" has no any supporting analysis in the results.

[reply] Regarding this comment, land degradation is the temporary or permanent lowering of the productive capacity of land resources (FAO, UNDP, UNEP, 1994). Thus, as long as land degradation is a problem for a particular geographical setting, this challenge is explained as functions of the various forms of soil degradation(like deterioration in soil physical, chemical, biological and hydrological properties), soil erosion ad wind erosion, water resources degradation, deforestation, and lowering of the productive capacity of farming lands and rangelands. Consequently, various effects of land degradation would be observed and inevitable at on-site and off-site level. Some of the observed on-site effects are the lowering of the productive capacity of the land, soil fertility exhaustion, causing either reduced outputs (crop yields, livestock yields). Contrary to this, off-site effects of land degradation in the form of soil erosion occur through changes in the water regime, decline in river water quality, and sedimentation of river beds and reservoirs. Therefore, various forms of land degradation are very critical in the case study watershed (Gessesse et al., 2015) and the present manuscript clearly revealed that land management practices mainly tree planting strategy is not yet widely used to monitor land degradation calamites in the study watershed. Thus, if tree planting land management strategy and other land management options are inhibited by various forms of bio-physical, socio-economic and demographic factors, the magnitude of the land degradation would be increased so that land users in the study watershed may face challenges such as soil fertility exhaustion and ecosystem disruption as well as to scale up ecological sustainability which would be resulted from various forms of land degradation. In this section, thus, we simply outlined the cause-effect relationships of land management options, land degradation process and the consequent impacts of land resource degradation in the study watershed. On the other hand, in the final concluding remarks section of our paper, we stated a phrase like *"integrated land resource management strategy option is essential".* This statement is not conclusion rather we forwarded this point as a recommendation for future land management strategy to combat land resource degradation in the case study watershed.

3. Specific comments:

#1. P.3250, 2nd paragraph, first line "**LULC**" should be defined at the first start. Again, (CSA) (2010), line 12 should better be written as (CSA, 2010).

[reply] The acronyms of LULC is defined in the introduction section of the manuscript as follows "Land-use and land-cover (LULC)". Similarly, the comment regarding CSA, 2010) is revised as follows: Based on the 2010 population projection of the Central Statistical Agency (CSA), about 625131 people with an average population density of 172 people per km^2 lived in and around the Modjo watershed (CSA, 2010). Accordingly, these two cases area addressed in the "authors' changes in manuscript" and in the "revised version of the manuscript".

#2. The sentence on the last paragraph (same page) line 18-24 is too long and needs rewriting. On line 20, "Rural Kebele Associations" contradicts with what is given in fig. 1, p. 3270. Change it to Rural Kebele Administrations.

[reply] This sentence is revised as follows in the "authors' changes in manuscript" and in the "revised version of the manuscript". Feedbacks from local experts about critical environmental degradation hotspot sites, the geographical distribution of the sample Rural *Kebele* Administrations (RKAs), agro-ecological zones, spatial patterns of the LULCs, and land management practices in the up, mid and downstream parts of the watershed were used as criteria for selecting sampling RKAs for household survey (Figure 1 and Table 1). Accordingly, the phrase Rural *Kebele* Associations (RKAs) is changed into Rural *Kebele* Administrations (RKAs).

#3. On p3251, line 8-9 & 13-15 indicated that "A social survey instrument" and SPSS were used in data analysis. What is "A social survey instrument"? SPSS is a supporting tool and not a model. Hence, it is better to write the name of the regression model used in data analysis.

[reply] Social survey instrument means simply "questionnaire survey." Similarly, we used 'Statistical Package for Social Scientists' (SPSS) version IBM SPSS 20 window as a tool to analyze the surveyed data. In our manuscript, we didn't consider SPSS as a model rather we considered it as a tool.

#4. P3252, last paragraph, line 20 is it that to say logit values?

[reply] Considering the comment, the error is fixed in the revised version of our manuscript as follows "logit values".

#5. P3253, last paragraph, last three lines, how was multicollinearity assessed? Can you specify the method used?

[reply] Multicollinearity statistics in regression concern the relationships among the independent variables, without considering the dependent variable. So, we run collinearity diagnostics REGRESSION under the statistics button of SPSS tool. Then after running the model, the correlation matrix output was interpreted by a method recommended by Pallant (2007). Although two values ('Tolerance Value (TV) and Variance Inflation Factor (VIF)) have recommended by the same author to check multicollinearity status of the model outputs; in our analysis, we used the computed 'tolerance value'. 'Tolerance value' is an indicator of how much of the variability of the specified independent variable is not explained by the other independent variables in the model and is calculated using the formula 1-R squared for each independent variable. According to Pallant (2007), if this value is very small (tolerance value of less than 0.10), it indicates that the multiple correlation with independent variables is high, suggesting the possibility of multicollinearity. However, the tolerance value of our model result depicts that the correlation between each of the independent variables considered for our model (multicollinearity status) was greater than 0.10; therefore, our model has not violated the multicollinearity assumption.

#6. The 2nd paragraph, p3254 should better move to p3251 (i.e. to the methods part).
[reply] The focus of this section of the manuscript is providing a general highlights regarding variables and hypothesised relationships**.** Therefore, the purpose of this paragraph is to give a clue about both dependent and independent variables which were considered for our study. Thus, we argue that this paragraph shall remain as it is in this section to highlight the relationship between dependent and independent variables for readers.

#7. Can you relate the descriptive results discussed (pp.3255-3256) like family size, farm size, etc with other similar works so that readers can evaluate the accuracy of the data?

[reply] As we can clearly understand from our manuscript, we used both descriptive and inferential statistics for our analysis. In this connection, the focus of this descriptive statistics section is simply to provide the biophysical, socioeconomic and demographic background characteristics of our respondents to evaluate the impacts of various independent variables on local land users' willingness to adopt tree planting as a land management strategies. We argue that it is indispensable to present and discuss the background characteristics of the sample population as it is before any in-depth analysis is to be done. However, we did very detailed comparative analysis in the inferential statistics sections (section 3.2, pp. 3256-3261) to evaluate our results based on the findings of others which were conducted in other areas.

#8. Source is missing for information provided in the 3rd paragraph (line 15-26), p. 3256.
[reply] The central point of this paragraph is to describe the binomial logistic regression model outputs of our surveyed data analysis. Since the paragraph is addressing the output of our data analysis, we argue that we don't need to add sources or references for this part.

#9. P.3257, 2nd paragraph, first line, there is the term "willingness". Now a question arises that what was studied, "willingness" or actual adoption behavior? See the last sentence of this paragraph, is it relevant?

[reply] Although the main focus of this study was to evaluate the major determinants of the adoption of tree planting land management decision, the study also attempted to figure out farmers willingness to plant trees from the perspective of land management strategy. In this regard, the manuscript (on pp. 3256 Ls. 7 to 9) clearly documented that most of the sample households (62 %) participated in tree growing over the past two or more decades whereas the remaining 38 % of the surveyed farmers did not participate in tree planting due to several reasons. Accordingly, the last sentence in this paragraph, is deleted in the "authors' changes in manuscript" and in the "revised version of the manuscript".

#10. P.3260, 2nd paragraph, line 19-21, states that the current land ownership policy discourages farmers' participation in tree growing activities. Is this explanation correct given the regression result (Table 4, LATENURE) remains positive?

[reply] In connection to this comment, the explanation is correct and the regression result between current land policy and discouraging people to plant trees to manage their own environment remain positive. As we can clearly understand from the manuscript (PP. 3254 Ls. 23-25) the hypothesis was formulated as follows. *"The current state-owned land tenure system might lead to decrease the confidence of land-users to have planted trees."* Accordingly, the question was structured to address the above hypothesis in our questionnaire to capture farmers' perception about the case. In response to our questionnaire, most farmers replied YES, meaning that the current land tenure system deceased the confidence of farmers to plant trees.

#11. In the summary statement pp.3261-3262, under the concluding remarks (line 23-24), is the expression "**have positively and significantly constrain** on tree growing investment decision to combat land degradation, minimize soil fertility exhaustion and ecosystem disruption as well as to scale up ecological sustainability" correct? Particularly see the term **"positively and significantly constrain".** I think this requires revision. Please try to improve these conclusions based on empirical data. Besides, soil "fertility exhaustion", "ecosystem disruption" and "ecological sustainability" are not mentioned in the results part. So, based what data you reached at such a conclusion?

[reply] Our intension in this section is to link tree planting land management-land degradation-impacts of land degradation on soil fertility exhaustion and ecosystem disruption as well as to scale up ecological sustainability. If the referee thinking that this phrase not relevant, we can remove from this section in the final version of the manuscript. In addition, the phrase **"positively and significantly constrain"** is modified as follows. *"Among others, the likelihood of household size, productive labour force availability; the disparity of schooling age, perception of the process of deforestation and the current land tenure system have highly influence the practice of tree growing investment decision."*

#12. P.3266, Table 1, how the households were selected from the three catchments? Was it based on proportion?

[reply] The household heads were selected using multistage sampling techniques and clearly discoursed in the methodology section of the manuscript (pp. 3250 Ls19-28 and pp. 3251 Ls.1-6) as follows. *The study was mainly based on a survey of farm households. Local experts and extension workers feedback about critical environmental degradation hotspot sites, the geographical distribution of the sample Rural Kebele Administrations (RKAs), agro-ecological zones, spatial patterns of the LULCs, land degradation hotspot sites and land management practices in the upstream, midstream and downstream parts of the watershed were used as criteria for selecting sampling RKAs of the household survey (Fig. 1 and Table 1). Multistage sampling design was used to select the sample households. First, as clearly shown in Fig. 1 and Table 1, the watershed was clustered into upstream, midstream and downstream parts together with the two agro-ecological zones namely Dega (temperate) and Woyna-Dega (tropical). Second, using the criteria mentioned above, three RKAs namely Adadi-Gole (from upstream part and Dega agro-ecological zone), Godino (from midstream part and Woyna-Dega agro-ecological zone) and Ouda (from downstream part and Woyna-Dega agro-ecological zone) were selected. In the third stage,* *10 % of sample households were selected from a list of registered households obtained from the respective RKA offices using a lottery randomisation approach of simple random sampling technique. One hundred twenty one respondents (of which 14.9 % were female household heads) were selected.*

#13. P.3268 (Table 3), Data are provided for the three RKAs but not discussed in the text. So, what is the use of showing such data if not discussed in the text?
[reply] We believe that information derived from household head data were directly presented and documented in section 3.1 Background characteristics of the respondents section of the manuscript (pp. 3255 to3256). Besides, these descriptive datasets are transformed into regression model outputs. Later on, all the findings discussed in the result section are based on this dataset.

#14. P.3269 (Table 4), why training and road access came-out with negative signs?

[reply] From our findings, we clearly understood that the relationship between independent variables and dependent variable are context dependent. In this regard, variables such as age, gender, access to road and participation in short term training had an unexpected sign in the model. Thus, further investigation should be needed to examine these cases and to come across conclusive arguments.

Reply to interactive comment on " Determinants of farmers' tree planting investment decision as a degraded landscape management strategy in the central highlands of Ethiopia" by B. Gessesse et al.

[reply] Dear Anonymous Referee # 2,

On behalf of the coauthors, I am delighted for your critically reading of our manuscript, valuable comments and suggestions you made on the interactive discussion paper titled "Determinants of farmers' tree planting investment decision as a degraded landscape management strategy in the central highlands of Ethiopia" which was published in journal of Solid Earth Discussion section. We want to express our gratitude that you recommend the paper to be published in the Journal of Solid Earth with minor revision. In doing so, I sincerely hope that we have sufficiently addressed your concerns.

Sincerely,
Berhan Gessesse, PhD
Details of changes made to the manuscript

We have attended the following comments suggested by the Anonymous Referee # 2.

I. Specific comments

I. The sentence in the abstract section, on p3246, line 11-17´ is too long and better to split into two sentences. The last two sentences of the´ abstract section are needed to be rephrased in order to strongly illustrate the overall conclusions of the study. This could be achieved by using better connective words or by minimizing the connective words.

[reply] The sentence is revised in the final version of the abstract section of the manuscript as follows.

The findings of the study demonstrated that the adoption of tree growing decision by local land-users' is a function of a wide range of biophysical, institutional, socioeconomic and household level factors. In this regard, the likelihood of household size, productive labour force availability, the disparity of schooling age, level of perception of the process of deforestation and the current land tenure system have a critical influence on tree growing investment decisions in the study watershed. Eventually, the processes of land use conversion and land degradation are serious which in turn have had adverse effects on agricultural productivity, local food security and poverty trap nexus. Hence, the study recommended that devising sustainable and integrated land management policy options and implementing them would enhance ecological restoration and livelihood sustainability in the study watershed.

II. In conclusion section, p3261 and p3262 the fourth, fifth and sixth sentences are needed to be coherently connected to convey the major conclusions of the study in a powerful manner.

[reply] The conclusion section of the manuscript is revised as follows:

This paper examines major determinants of smallholder farmers' tree planting decision as a land management strategy in the Modjo watershed, Ethiopia. The result of the study revealed that the challenges for sustaining the current land resource management options including tree planting decisions as a land management strategy are enormous in the study watershed. As a result, meaningful results are not achieved to address degraded land rehabilitation. In this connection, local land users' low level tree planting investment achievement is highly compromised by various determinants. Among others, the likelihood of household size, productive labour force availability; the disparity of schooling age, perception of the process of deforestation and the current land tenure system have significantly affected the practice of tree growing investment decision to combat land degradation and its consequent impacts on soil fertility exhaustion and ecosystem disruption as well as to scale up ecological sustainability. The findings of this study also contribute a lot to provide relevant policy inputs for stockholders and decision makers to ameliorate determinants of tree planting investment decisions. Thus, the study recommended that integrated watershed-based land resource management strategies are essential to: (i) take corrective measures to stabilise the determinants of land management practices as well as prioritise, rehabilitate and protect ecologically vulnerable and degraded sites; (ii) raise awareness about the negative impacts of land resources degradation process and the effect of inefficient utilization of natural resources, and (iii) secure stable land-use rights and land ownership legal enforcement. In addition to this, further studies are still needed to establish institutional, economic, livelihood and ecological sustainability principles which guide the practice of continual land management implementation in the study watershed in particular and in other similar geographical setting at large.

III. **[reply]** All other technical corrections commented and suggested by the referee # 2 are fully addressed and incorporated both in the "authors' changes in manuscript" and in the "revised version of the manuscript".

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Authors' changes in manuscript

Determinants of farmers' tree planting investment decision as a degraded landscape management strategy in the central highlands of Ethiopia

Berhan Gessesse[1234], Woldeamlak Bewket[3] and Achim Bräuning[4]
[1]Earth Observation Research Division, Entoto Observatory and Research Center, P.O. Box 33679, Addis Ababa, Ethiopia
[2]Department of Geography and Environmental Studies, Kotebe University College, Addis Ababa, Ethiopia
[3]Department of Geography and Environmental Studies, Addis Ababa University, P.O. Box 150372, Addis Ababa, Ethiopia
[4]Institute of Geography, Friedrich-Alexander University of Erlangen-Nürnberg, Erlangen 91054, Germany

Correspondence to: A. Bräuning and B. Gessesse (berhanavu@gmail.com)

Determinants of farmers' tree planting investment decision as a degraded landscape management strategy in the central highlands of Ethiopia

Abstract. Land degradation due to lack of sustainable land management practices are one of the critical challenges in many developing countries including Ethiopia. This study explores the major determinants of farm level tree planting decision as a land management strategy in a typical farming and degraded landscape of the Modjo watershed, Ethiopia. The main data were generated from household surveys and analysed using descriptive statistics and binary logistic regression model. The model significantly predicted farmers' tree planting decision (Chi-square = 37.29, df=15, P <.001). Besides, the computed significant value of the model suggests that all the considered predictor variables jointly influenced the farmers' decision to plant trees as a land management strategy. The findings of the study demonstrated that the adoption of tree growing decision by local land-users' is a function of a wide range of biophysical, institutional, socioeconomic and household level factors. In this regard, the likelihood of household size, productive labour force availability, the disparity of schooling age, level of perception of the process of deforestation and the current land tenure system have a critical influence on tree growing investment decisions in the study watershed. Eventually, the processes of land use conversion and land degradation are serious which in turn have had adverse effects on agricultural productivity, local food security and poverty trap nexus. Hence, the study recommended that devising sustainable and integrated land management policy options and implementing them would enhance ecological restoration and livelihood sustainability in the study watershed.

Key words: land degradation; household level tree planting; land management; Modjo watershed; Ethiopia

1 Introduction

Several interwoven earth's system components including the physical, chemical and biological as well as anthropogenic activities are very dynamic that are relentlessly changing. Part of the earth's environment and one of the constituents of the watershed landscape ecology, land resources give essential life support roles like provisioning, regulating and supporting functions and services. However, land uses and land covers (LULCs) have been subjected to change globally in the form of conversion or modification and their environmental functions and services have destabilised from time to time (Turner and Meyer, 1994; Turner et al., 1994; Geist et al., 2006; Angassa, 2014).

Ecological degradation including soil erosion, vegetation and/or biodiversity loss, deterioration of fresh water resources, extreme weather events, climate variability and other related environmental problems have resulted from land use changes (FAO, UNDP, UNEP, 1994; Lambin et al., 2006), and constraints on environmental resources are becoming serious to future development of agrarian nations across the globe. Accordingly, land resources such as its soils, water, forests, pastures, and wildlife management have been central to human society from its long times (Angassa, 2014). Considerable efforts have been made to monitor environmental changes and to manage as well as restore degraded environments in Ethiopia (Admassie, 2000; Gebremedhin and Swinton, 2003; Najam et al., 2007; Frankl et al., 2014). However, land resource management investment decision practices have seriously undermined and constrained by numerous factors. Among others, household level demographic characteristics, farming practices, profitability of the adopted land management technologies, agro-ecological conditions, access to roads and markets, and external factors including land-use policies, property rights, level of extension services and institutional factors are some of the critical factors affecting land management investment decisions in Ethiopia (Hoben, 1995; Pender and Kerr, 1998; Amsalu and De Graaff, 2007; Bewket, 2007; Ewnetu and Bliss, 2010; Teshome et al., 2014). Lemenih et al. (2014) also argued that the growing importance of cash crops farming system in different parts of Ethiopia is also aggravating the problem of land use conversion and consequently land resource degradation and affecting to mange land resources in the country.

Similar to many other environmentally vulnerable nations, Ethiopia has experienced rampant environmental problems over many centuries mainly land degradation in the forms of immense wide and deep gully development, soil erosion, vegetation covers alteration mainly the disturbance of herbaceous species and water resource degradation and others to mention just a few (Hurni, 1993, Angassa, 2014; Lemenih et al., 2014; Teshome et al., 2014; Gessesse et al., 2015). The massive conversion of vegetation cover, expansion of farming activities along with the dissected terrain and ecological vulnerable sites and inappropriate farming practices have serious implications for large-scale geo-environmental resource disgraceful conditions both in the lowlands and highlands of Ethiopia (Lakew et al., 2000; Tefera et al., 2002; Rahmato, 2001; Vivero et al., 2005). These environmental problems lead to deterioration of soil fertility and productivity. Consequently, the agriculture sector of the country has been hindered by this massive land resource degradation, and has further contributed to negative impact on the country's economic development at large.

In response to extensive degradation of the resource base and maximize land productivity, different types of land resource conservation technologies have been introduced by the successive governments of the country, mainly in the aftermath of the catastrophic drought and famine of the 1970s (Woldemariam, 1992; Hoben, 1995; Admassie, 2000;

Rahmato, 2001). Among the introduced land management measures, building physical structures such as stone terraces, soil bunds and agroforestry practices on cultivated fields; and area-closure and afforestation measures on degraded hillsides and barren lands were important. Increasingly focused studies were carried out in Ethiopia to examine the major challenges for the adoption and sustained use of land management strategies mainly stone terraces and soil bund technologies (Shiferaw and Holden, 1998; Bewket and Sterk, 2002; Gebremedhin and Swinton, 2003; Bekele and Drake, 2003; Hagos and Holden, 2006; Bewket, 2007; Amsalu and De Graaff, 2007) as well as use of cattle manure as a land management measure (Belay and Bewket, 2013).

Although the primary purpose of tree planting is to secure the demand of fuel wood and charcoal production, construction materials, input for farm tools, and for many other reasons across the Ethiopian highlands (Rahmato, 2001; Ewnetu and Bliss, 2010), success to date in terms of widely adopted and sustained realisation of tree planting investment decision as a land management measure has been very limited (Admassie, 2000; Rahmato, 2001; Bewket, 2007). In relation to this, detailed researches were not conducted to investigate the determinants of farm level tree planting decision as a land management strategy. As a result, there is a need to explore site-specific complexes of biophysical and socioeconomic variables affecting tree planting investment decision as a response to restore degraded lands in the highlands of Ethiopia. Therefore, the purpose of this study is to contribute in bridging this research gap through investigating the participation of local land users in tree planting investment decision in the form of agroforestry, reforestation and afforestation to recover degraded land. The specific objectives of this study were: i) to examine the adoption of tree planting decision by local land users for reversing land resources degradation, and ii) to investigate major determinants of farm level tree growing investment decision as a land management strategy in a typical rainfed farming landscape of the Modjo watershed.

2 Materials and methods

2.1 Site description

The study area, Modjo watershed (~1,478 km^2) is situated in East *Shewa* administrative zone in the *Oromiya* National Regional State of Ethiopia. It is a part of the upper *Awash* river basin in central Ethiopia, stretching from 8^0 35' 00" N to 9^0 05' 11" N and 38^0 54' 35" E to 39^0 15' 30" E (Fig. 1). It is also characterised by undulating topography with hills, mountains, plains and river valleys. The physiographic characteristic of the watershed reveals a distinct difference in elevation which ranges from 1740 m (south of Modjo town) to 3060 m asl (at *Yerer* volcanic ridge). On the basis of Hurni's (1998) and Dejene's (2003) agro-ecological classification of Ethiopia, the Modjo watershed falls under the *Weyna-Dega* (Tropical) (1740 m-2300 m) and Dega (Temperate) (2300 m-3060 m) agro-ecological zones. Considering FAO's (2006) slope classification scheme, the gradient of Modjo watershed is categorized into flat to very gently sloping (9.5% of the total watershed area), gently sloping to sloping (61.2%), strongly sloping to moderately steep (18.4%) and steep to very steep (2.9%). Based on climate data from two selected weather stations at *Chefe-Donsa* town (upstream) and *Modjo* town (downstream) parts, annual total rainfall is 932 mm and 824 mm, respectively. The mean annual long-term maximum temperature varies between 23.2^{0}C (at upstream part of the area) and 27.9^{0}C (in the downstream part), while the minimum temperature varies from 10.6^{0}C (upstream part) to 11.6^{0}C (downstream part).

Nine generalised LULC classes including bare land, cultivated land (consisting of croplands with scattered rural settlements), forest, grassland, marshland, plantation areas, shrubs, urban settlements and water bodies were identified in the study watershed based on the year 2007 SPOT image classification(Gessesse et al., 2015). Several people depended on both crop cultivation and livestock rearing livelihoods. Based on population projection, about 625131 people with an average population density of 172 people per km^2 lived in and around the Modjo watershed(CSA, 2010). Some part of the study area is inhabited by urban dwellers and densely populated areas are observed particularly in and around *Chefe-Donsa*, *Godino*, *Debre-Zeit*, *Ejeri* and *Modjo* urban landscapes.

2.2 Data sources and method

The study was mainly based on a survey of farm households. Local experts' and extension workers' feedbacks regrading critical environmental degradation hotspot sites, the geographical distribution of the sample Rural *Kebele* Associations (RKAs), agro-ecological zones, spatial patterns of the LULCs, land degradation hotspot sites and land management practices in the upstream, midstream and downstream parts of the watershed were used as criteria for selecting sampling RKAs of the household survey (Figure 1 and Table 1). Multistage sampling design was used to select the sample households. First, as clearly shown in Figure 1 and Table 1, the watershed was clustered into upstream, midstream and downstream parts together with the two agro-ecological zones namely *Dega* (temperate) and

Woyna-Dega (tropical). Second, using the criteria mentioned above, three RKAs namely *Adadi-Gole (from upstream part and Dega agro-ecological zone), Godino (from midstream part and Woyna-Dega agro-ecological zone)* and *Ouda (from downstream part and Woyna-Dega agro-ecological zone)* were selected. In the third stage, 10% of sample households were selected from a list of registered households obtained from the respective RKA offices using a lottery randomisation approach of simple random sampling technique. One hundred twenty one respondents (of which 14.9% were female household heads) were selected.

Two extension workers in each RKA were trained as data enumerators to carry out the household survey under close supervision of the researcher. A social survey instrument was used to extract information on household characteristics as well as constraints that influence farmers' decisions to plant trees in order to manage their own degraded environment. A structured questionnaire was used to explore the background information of the respondents and factors that are likely to influence the farmers' decision on tree planting for the purpose ameliorating land degradation. Finally, the surveyed data were analysed using the 'Statistical Package for Social Scientists' (SPSS) version IBM SPSS 20 window.

2.3 Model selection and specification

Household characteristics of respondents and perception of local land-users regarding the determinants of farmers' tree growing decisions were analysed using descriptive statistics and logistic regression model. The outcome variable of 'local land-users tree growing decision' is dichotomous so that a binary logistic regression model was used. This statistical model allows for predicting probabilities of tree-growing decision (the outcome variable) as a function of a set of biophysical and socioeconomic dichotomous or quantitatively measured predictor variables. The Chi-square test of independence was also employed to identify possible association between the outcome and the set of predictor variables. The outcome variable P_i is a dummy variable that equals '1' if farmers participated in tree planting as a land management measure and '0' otherwise. Considering the binary logistic regression equation, the probability of the choice to plant trees ($P_i = 1$), or not ($P_i = 0$) is then derived as follows:

$$P_i = \frac{1}{1+e^{-(\beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_n X_{ni})}} \quad (1)$$

Conceptually, this model is expected to contain linear relationships (Meyers et al., 2006). However, this assumption is violated due to the dummy nature of the dependent variable considered in the present study. Then, linearising (transforming odds ratio) the inherent non-linear relationship between explanatory variables (X_i) and the probability of the outcome variable (Pi) using the logarithmic function is one way to fix the limitation of a logistic regression model. Thus, the odds ratio address for the change in the odds of the response variable given a unit change in a predictor variable, other explanatory variables held constant in the model. Accordingly, the probability of choice not to grow trees or the odds ratio is computed as follows:

$$\ln [\text{odds}] = \frac{P_i}{1-P_i} \qquad (2)$$

To create the relationship between the predictors and odds using the logit (which is the natural logarithm of an odds ratio) function, the ln of the odds that a case belongs to the response group and rewritten as follows:

$$\ln [\text{odds}] = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots, + \beta_n X_{ni} \qquad (3)$$

Then, the ln should be part of the predicted group membership and it can be written as:

$$\text{gpred} = \text{Ln} [\text{odds}] = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_n X_{ni} \qquad (4)$$

Because of the difficulty of interpretation of the logit vales, the log odds are transformed into probabilities by taking the antilog of the above equation. The log odds (represented as gpred) are now inserted into the antilog function. Therefore, the antilog equation that transforms the log odds to probabilities is derived as follows:

$$\text{Predicted probability } (P_i) = \frac{e^{\text{gpred}}}{1 + e^{\text{gpred}}} \qquad (5)$$

where, P_i is a probability of land-users participating in tree planting decision (of the outcome being a 1) by for the i^{th} sample farmer; e is the base of natural logarithm and has a value approximately 2.718, β_0 is the intercept (constant); $\beta_1, \beta_2, \cdots, \beta_n$ are the regression coefficients of the corresponding predictor variables (Xs); $X_{1i}, X_{2i}, \cdots, X_{ni}$ are predictor (explanatory) variables for the i^{th} farmer; ln stands for the natural log; ln [odds] the natural logarithms of an odds ratio in favor of adopting planting trees as a land management strategy, 1- P_i is the probability of land-users not practicing tree planting to manage their own environment (of the outcome being a 0); The β coefficient indicates the change in log odds of membership for any 1-unit change in the predictor variables; gpred is predicted group membership and e^{gpred} is the antilog value of the natural log predicted group membership.

2.4 Variables and hypothesised relationships

Although a range of explanatory variables were identified and considered in various land management literature and the use of these variables frequently lacks consistency (Shiferaw and Holden, 1998; Gebremedhin and Swinton, 2003; Bekele and Drake, 2003; Hagos and Holden, 2006; Amsalu and De Graaff, 2007; Mekonnen and Damte, 2011; Mekonnen *et al.*, 2012; Belay and Bewket, 2013), the predictor variables of this study were identified based on the consultation with natural resource conservation experts, background information of the farming systems of the study area and literature of land resource management. Before running the model, preliminary analyses were carried out to check the presence of multicollinearity among predictor variables and the computed tolerance values of collinearity diagnostics analysis is greater than 0.1. This shows that there is no perfect multicollinearity between all the considered explanatory variables in the model (Pallant, 2007, Field, 2009).

Furthermore, for this study, the inference of the binary logistic model was undertaken by normalising one category, which is usually coded as 1 which is referred to 'response' or 'target' groups while cases or incidents coded as 0 are sometimes called 'referent' or 'control' groups (Table 2). Among other land management options, a dichotomous household level tree planting choice was taken as an "outcome" variable whereas a range of household characteristics, institutional and biophysical explanatory variables which were expected to have influence on farm level tree growing decisions were considered.

Table 2 presents a description of household level predictor variables used in the analysis. From the perspective of the existing study site, it is hypothesised that household heads characterised by older age groups, long farming experience and good literacy background would be willing to engage in planting of trees to minimise land degradation problem and enhance productivity of the environment. Male-headed households are more likely to grow trees than their female-headed counterparts. Moreover, it is also assumed that households with large family size and large productive labour force are more likely to respond to land resource degradation through tree planting. Household heads' with large landholding size are more likely to grow trees to conserve their own lands and the surrounding environment at large. Access to information through short term training and advices from extension workers is helpful to increase the probability of farmers' participation in planting trees to manage their own lands. The current state-owned land tenure system might lead to decrease the confidence of land-users to have planted trees. Land-users' perception and awareness regarding the deforestation problem is a positive stimulant to grow trees. Similarly, households which owned large livestock herds are less likely to grow trees, but rather they intend to secure more grazing lands. Access to the road is a positive stimulus for households to plant trees; because the household heads could get seedlings easily to nearby markets. Finally, households who reside in the downstream part (*Weyna-Dega* agroecological zone) are more likely to have recognised resource degradation and thus to have planted trees than those living in the upstream part (*Dega* agro-ecological zone).

3. Results and discussion

3.1 Background characteristics of respondents

The key demographic and socioeconomic characteristics of surveyed households are presented in Table 3. A large percentage of household heads, 85.1%, were males whereas females constitute the remaining proportion (14.9%). Large proportions (85.1%) of respondents were between the age range of 31 and 64 years, while 9.1% and 5.8% of them were between 21 and 30 and 65 and more years, respectively. Household size ranged from 1 to 11 persons per family with an average family size of 5.9 persons. About 37.2% of respondents had between one and 5 household members, while a majority (62.8%) of them had 6 and more members in the family. Households with productive labour force of 1-3, 4-6 and 7-10 categories accounted for 45.5%, 33.9% and 20.7% of the sample households, respectively. Economically dependent age groups (0-14) and elderly (65 and above) varied from family to family. In this regard, 66.1% of respondents had household dependency ratios between 0.0 and 0.5 while 33.9% of households had dependency ratios between 0.5 and 3. On the other hand, 23.1% of the respondents were illiterate. However, 38.9% of the respondents could read and write whereas the educational achievements of 28.1% of respondents ranged from grade 1 to grade 8. A small proportion of the household heads (9.9%) were attending grade 9 and above schooling age.

Most surveyed households were engaged in a mixed farming system (70.3%) and on crop cultivation (27.3%). Moreover, some of them (2.5%) were engaged with off-farm activities like petty trade, daily laborer and selling charcoal and wood. Besides, most of the respondents had farming experience for more than 30 years. The landholding of households in the study sites varied from 0.5 ha to 4.8 ha with an average holding size of 1.8 ha per household. A large majority of the surveyed households (62% from the three sample sites) had often involved in the planting of trees in the form of afforestation, reforestation, area closure and enrichment tree planting and/or agro-forestry systems to reverse land degradation.

3.2 Determinants of household level tree planting

The extent of major determinants of tree growing decision as a land management strategies were examined in this study. The analysis shows that most of the sample households (62%) participated in tree growing over the past two or more decades. However, 38% of the surveyed farmers did not participate in tree planting (Table 3). The effects of the various socioeconomic, demographic, institutional as well as environmental factors on the farmers' tree growing decision were evaluated using the binomial logistic regression model. The justification for the inclusion of these variables together with the hypothesised direction of relationship with tree-growing decision is explained in the preceding section.

Overall, 121 cases were analysed using the binomial logistic regression model result as presented in Table 4 depicted that the full model significantly predicted farmers' tree planting decision (Chi-square = 37.29, df= 15, P <.001). The computed significant value of the model suggests that all the considered predictor variables jointly influenced the farmers' decision to grow trees. The model as a whole explained between 27.3% (Cox and Snell R squared) and 37.1% (Nagelkerke R squared) of the variance in participation of tree growing status explained by predictor variables. The current model correctly classified 28 farmers who did not participate in tree growing activities but misclassified 18 others (it correctly classified 60.9% of cases). It also correctly classified 62 farmers who were involved in tree planting practices but misclassified 13 others (it correctly classified 82.7% of cases). The overall accuracy of classification is, therefore, the weighted average of these two values (74.4%).

Table 4 presents the regression coefficients (β), the levels of statistical significance and the marginal effects of the odds ratio [EXP (β)] together with a 95% confidence interval (CI) of the odds ratio for each of the predictor variables. The negative or positive signs of the regression coefficients (β) of the model present only the direction of the effect of the predictor variables on the dependent variable. Besides, the marginal effects of the odds ratio [Exp (β)] represent the probability of a change in the odds of being in one of the categories of outcome when the value of a predictor increases by one unit. In general, the estimated coefficients should be compared with the base category of non- participants in tree planting as a land management practice.

The regression results (Table 4) show that local land-users' willingness to adopt tree growing decision is a function of a wide range of factors. The direction of most of the predictor variables used in this model had signs that agreed with our prior expectations. Although land management decisions are constrained by several determinants, their magnitude of influence varies spatially elsewhere to operate successful resource conservation interventions (Shiferaw and Holden,1998; Herweg and Ludi, 1999; Gebremedhin and Swinton, 2003; Ewnetu and Bliss, 2010). However, as shown in Table 4, the likelihood of household size (FAMSIZE), productive labour force availability (LABFORCE); the disparity of schooling age (EDUC), perception of the deforestation process (PERCDEFO) and the current land tenure system (LATENURE) have positively and significantly influence on tree growing investment decision.

Family size (FAMSIZE): Results in Table 4 shown that household size was one of the demographic variables affecting tree planting decision. Because large rural family size is on the whole linked with a higher labour human resource, which would enable a household to realize a range of forms of agricultural activities as well as land resource conservation and management practices. The results presented in Table 3 show that nearly 37.2% of the respondents had at least five household members. The remaining had more than five members.

This study clearly confirmed that household size was positively and significantly (at 5% level of significance) correlated with the realisation of farm level tree growing decision in the forms of afforestation, reforestation and agro-forestry systems. The model output reveals that the likelihood of tree planting increases with family size. The marginal effects of the odds ratio show increasing the size of the household by one unit increases the probability of participation in tree growing by nearly 0.6 times (95% CI = 0.49, 2.64), other predictor variables being constant in the model. Although the calculated odds ratio is quoted as 0.6, it can be 95% confident that the actual value of the odds ratio in the population lies somewhere between 0.49 and 2.64.

This result is keeping with the findings of previous studies that reported family size had a positive and significant influence in adopting land management technology (Amsalu and De Graaff, 2007; Alamirew, 2011) whereas negative and significant relationship between family size and land resource management technology adoption was reported by Shiferaw and Holden (1998) and Tadesse and Belay (2004). The same authors commented that households with larger family size together with high dependency ratio are likely to face food shortage in periods of famine and starvation so that these groups of households may be enforced to sidetrack a fraction of the labour force to off-farm activities to maximise and cop-up recurrent food shortage. As a result, they would be less motivated in a land management investment whose benefits can be obtained in the long run.

Productive labour force availability (LABFORCE): It is believed that the households with large productive labour force having a good opportunity for the adoption as well as application of different types of land resource management and agricultural technologies. In this study, the effect of productive labour force availability for tree growing was assessed and the model correlation result is positive and significant indicating that households with adequate productive labour are more willing to be involved in tree growing as a degraded land management strategy. The marginal effects of the odds ratio in the disclosed logistic regression model show that for every extra number of productive labour force of a household head gets the odds of his/her participation in tree growing which would be increased by a factor of 0.58 (95% CI= 0.34, 0.89), while all other factors remaining equal in the model.

Similar studies carried out in other areas confirmed that there is a positive and significant relationship between labour availability and land management technology adoption (Pender and Kerr, 1998: Gebremedhin and Swinton, 2003), though these authors used soil conservation technology adoption as a dependent variable. However, Tenge *et al.* (2004) claimed that no significant difference in household labour size between adopters and non-adopters of soil and water conservation measures. This is because soil and water conservation measures implementation depend on: i) decisions about labour allocation; ii) adopters may get additional labour to implement soil and water conservation measures from the labour-sharing groups; and iii) adopters also receive and use remittances from their relatives outside the catchment to hire additional labour.

Literacy status (EDUCU): The study showed that literate farmers were more involved in tree growing than their counterparts. As can be seen from Table 4, the educational status of the household head significantly increased the probability of planting trees to rehabilitate environmental degradation. The regression coefficient of the three schooling age categories is also positive in line with the tree planting decision for the purpose of degraded land recovery, indicating the existence of a positive relationship between literacy status and land-users' tree growing investment choice. It is indicated that respondents who had schooled levels of 'only read and write', 'grade 1 to 8' and 'grade 9 and above' are 15.45, 15.41 and 2.41 times more likely to participate in tree growing investment than their illiterate counterparts.

The findings of the present study also agree with previous studies conducted in different regions which had a positive and significant effect of education status as a predictor variable to adopt land management technologies (Pender and Kerr, 1998; Tenge *et al.*, 2004), however, adoption of various forms of soil and water conservation and management technologies was considered as outcome variables. On the other hand, Alamirew (2011) highlights a contradictory argument by stating that if land-users' have a better educational status, she or he may find better opportunities outside the farm sector so that this reduces labour availability for agricultural and farm management activities.

Perception of deforestation as an environmental problem (PERCDEFO): Local land-users' perception of deforestation as an environmental predicament together with its negative environmental and socioeconomic impact had influences to plant trees regularly. This study confirmed that land-users' perception and awareness regarding the problem of deforestation had a major and affirmative implication on the likelihoods of participating in tree growing. The likelihood of tree growing was 2.19 times (95% CI = 0.86, 5.6) higher among land-users who perceived the magnitude of deforestation compared with those who did not perceive the same way (Table 4). The result correlates well with previous studies conducted elsewhere by Pender and Kerr (1998), Shiferaw and Holden (1998) and Tenge *et al.* (2004); however, these authors considered the farmers' perception of environmental degradation as predictor variable and adoption of physical soil conservation measures as a dependent variable.

Public ownership of land: Although empirical studies showed mixed result, it is widely believed that land tenure insecurity leads to inefficient resource use, allocation and management. In this study, an attempt was made to capture the impact of the current land tenure system on the adoption of tree growing investment decision in the Modjo watershed. In general, tree growing as a land management measure was a long term investment with long payback periods so that land-users in the study site might seek land tenure security to plant trees and keep them in their own farmlands. Findings in Table 4 asserted that the current public ownership of land significantly discourages farmers' participation in tree growing activities in the study area. Studies from elsewhere had also showed that land tenure insecurity was a barrier for the adoption of land management technologies, and tenure security encouraged soil conservation investments (Shiferaw and Holden, 1998; Gebremedhin and Swinton, 2003; Tenge *et al.*, 2004; Bewket, 2007; Alamirew, 2011). Mekonnen and Damte (2011) and Mekonnen *et al.* (2012) also found that land certification, as a partial indicator of land tenure security, has increased the likelihood that households to grow trees in Ethiopia, however, not a significant determinant of the number of trees grown.

A number of variables considered in the model including age, sex, land holding size, farming experience, participation in training, livestock ownership status, access to the road and agroecology were found to have non-significant relationship with adoption of tree growing land management strategy. For example, a positive relationship between land holding size on one hand and the dependent variable of tree growing decision on the other hand is expected for the study site, though not statistically significant. Contrary to this, the relationship between predictor variables (such as age and gender of the household heads, farming experiences, participation in short term training, livestock ownership status, access to road and agroecology) with the dependent variable (tree growing decision) was negative and not significant. Most importantly, variables such as age, gender and participation in short term training had an unexpected sign in the model and they were non-significant. Thus, further investigation should be needed to examine these cases and to come across conclusive arguments.

4. Concluding remarks

This paper examines major determinants of smallholder farmers' tree planting decision as a land management strategy in the Modjo watershed, Ethiopia. The result of the study revealed that the challenges for sustaining the current land resource management options including tree planting decisions as a land management strategy are enormous in the study watershed. As a result, meaningful results are not achieved to address degraded land rehabilitation. In this connection, local land users' low level tree planting investment achievement is highly compromised by various determinants. Among others, the likelihood of household size, productive labour force availability; the disparity of schooling age, perception of the process of deforestation and the current land tenure system have significantly affected the practice of tree growing investment decision to combat land degradation and its consequent impacts on soil fertility exhaustion and ecosystem disruption as well as to scale up ecological sustainability. The findings of this study also contribute a lot to provide relevant policy inputs for stockholders and decision makers to ameliorate determinants of tree planting investment decisions. Thus, the study recommended that integrated watershed-based land resource management strategies are essential to: (i) take corrective measures to stabilise the determinants of land management practices as well as prioritise, rehabilitate and protect ecologically vulnerable and degraded sites; (ii) raise awareness about the negative impacts of land resources degradation process and the effect of inefficient utilization of natural resources, and (iii) secure stable land-use rights and land ownership legal enforcement. In addition to this, further studies are still needed to establish institutional, economic, livelihood and ecological sustainability principles which guide the practice of continual land management implementation in the study watershed in particular and in other similar geographical setting at large.

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Table 1. Distribution of sample respondents in the Modjo watershed.

Position	Elevation(m)	Climate zone	District	RKA	Sample size	%
Upstream	2300-3060	Temperate	Gimbichu	Adadi-Gole	32	26.45
Midstream	1740-2300	Tropical	Addaa	Godino	47	38.84
Downstream	1740-2300	Tropical	Addaa	Ouda	42	34.71
				Grand Total	121	100

Table 2. Definition of variables used in the study.

Variables	Description of variables
Dependent: TREPLANT	If the farmers' grew trees to combat land degradation takes, "1" for tree growers and "0" otherwise.
Predictors:	
GENDER:	Sex of the household head, takes "1" for male and "0" otherwise.
AGE :	Age of household head measured in years.
FAMSIZE:	Household members in number.
LOBFORCE:	Number of active household members engaged in farm labour in number.
EDUC:	The literacy status of household heads, takes "3" grade 9 and above, "2" between grade 8 and 1, "1" only read and write and "0" otherwise.
EXPERIAN:	Household head farming experience in the study watershed, takes "1" greater than 30 years and "0" otherwise.
PERCDEFO:	Household heads' perception of deforestation process, takes "1" they perceive well the process of deforestation and "0" otherwise.
LASIZE:	Total area of landholding size (cultivated, grazing, homestead and plantation sites) in hectare.
LIVESTOC:	Total livestock (cattle, equines, sheep and goat) owned by a household heads measured in Tropical Livestock Unit (TLU).
TRAININ:	Farmers' participation in trainings and advices organized by natural resource conservation experts and extension workers regarding natural resource management at least once in a year, takes "1" yes and "0" otherwise.
LATENURE:	Farmers' perception of land tenure security takes "1" if the current land tenure system is considered discouraging to plant trees and "0" otherwise.
ACESROAD:	Perception of farmers' on access to the road to get seedlings and to sell harvested woods, takes "1" they feel road access has positive impacts and "0" otherwise.
AGROECOL:	Local agro-ecology classification, takes the value of "1" if the site of the sample household head is *Weyna-Dega* and "0" otherwise.

Table 3. Households' demographic, socioeconomic and livelihood characteristics.

Demographic and socioeconomic characteristics	Peasant Associations (PAs)							
	Adadi-Gole		Gudino		Ouda		Total	
	#32	%	# 47	%	# 42	%	# 121	%
Gender: Male	23	22.3	43	41.8	37	35.9	103	85.1
Female	9	50.0	4	22.2	5	27.8	18	14.9
Age: 21-30	3	9.4	2	4.3	6	14.3	11	9.1
31-40	16	50.0	12	25.5	14	33.3	42	34.7
41-64	13	40.6	26	55.3	22	52.4	61	50.4
≥ 65	--	--	7	14.9	--	--	7	5.8
Household size (N): 1 – 5	24	75.0	4	8.5	17	40.5	45	37.2
6 and above	8	25.0	43	91.5	25	59.5	76	62.8
Productive labour force :1 – 3	21	65.6	12	25.5	22	52.4	55	45.5
4 – 6	11	34.4	18	38.3	12	28.6	41	33.9
7 – 10	-	-	17	36.2	8	19.1	25	20.7
Education : Illiterate	11	34.4	17	36.2	-	-	28	23.1
Read and write	17	53.1	17	36.2	13	31.0	47	38.8
Primary school(1-8)	3	9.4	10	21.3	21	50.0	34	28.1
High school and above (≥ 9)	1	3.1	3	6.4	8	19.1	12	9.9
Farming experience:21-30 yrs	3	9.4	2	4.3	6	14.3	11	9.1
>30 yrs	29	90.6	45	95.8	36	85.7	110	90.9
Landholding size:0.50-1.75	11	34.4	29	62.0	26	61.9	66	54.5
1.76-2.75	8	25.0	14	30.0	15	35.7	37	30.6
2.75-4.75	13	40.6	4	9.0	1	2.4	18	14.9
Livelihoods: Only crop cultivation	0	0	15	31.91	18	42.9	33	27.3
Mixed framing	31	96.9	30	63.8	24	57.1	85	70.3
Off-farm activities	1	3.1	2	4.3	0	0	3	2.5
Involving in tree planting for only the purpose of reversing land degradation: Yes	16	50	45	95.7	14	33.3	75	62
No	16	50	2	4.3	28	65.7	46	38

Table 4. Logistic regression results for predicting whether trees are planted using thirteen predictors as independent variables.

	β (S.E.)	Exp(β)	95% C.I. for EXP (β) Lower	Upper
Intercept	-1.338 (1.842)	0.998		
GENDER(1 = male)	-0.002 (.725)	0.993	0.241	4.131
AGE	-0.007 (.031)	1.612	0.935	1.755
FAMSIZE	0.478 (.251)**	0.579	0.486	2.636
LOBFORCE	0.546 (.273)**	15.452	0.339	19.990
EDUC (1= only read and write)	2.738 (1.078)***	15.415	1.867	17.869
EDUC (2 = from grade 1 to 8)	2.735 (.953)***	2.144	2.081	9.807
EDUC(3= grade 9 and above)	0.763 (.902)***	0.430	0.366	12.553
FAREXPERIAN (1= > 30 years)	-0.844 (.697)	1.069	0.110	1.686
LAHOSIZE	0.066 (.323)	2.191	0.567	2.214
PERCDEFO(1 = yes)	0.785 (.487)*	3.066	0.858	5.600
LATENURE(1= has an effect)	1.120 (.498)**	0.944	1.101	8.540
TRAININ(1= Yes)	-0.057 (.514)	0.914	0.345	2.588
LIVESTOC	-0.090 (.073)	0.503	0.392	1.055
AGROECOLO(1= Wonyna-Dega)	-0.688 (.776)	0.862	0.110	2.300
ACCESROAD(1= yes)	-0.149 (.777)	0.262	0.188	3.955
Observation	121			
Model Chi-square	37.29 (15)***			
-2 Log likelihood	123.43			
Cox and Snell R^2	0.273			

NB: β is regression coefficients, S.E. Is standard errors, *, ** and *** are levels of significance (probability value) at 10, 5, and 1%, respectively and EXP (β) is the odds ratio.

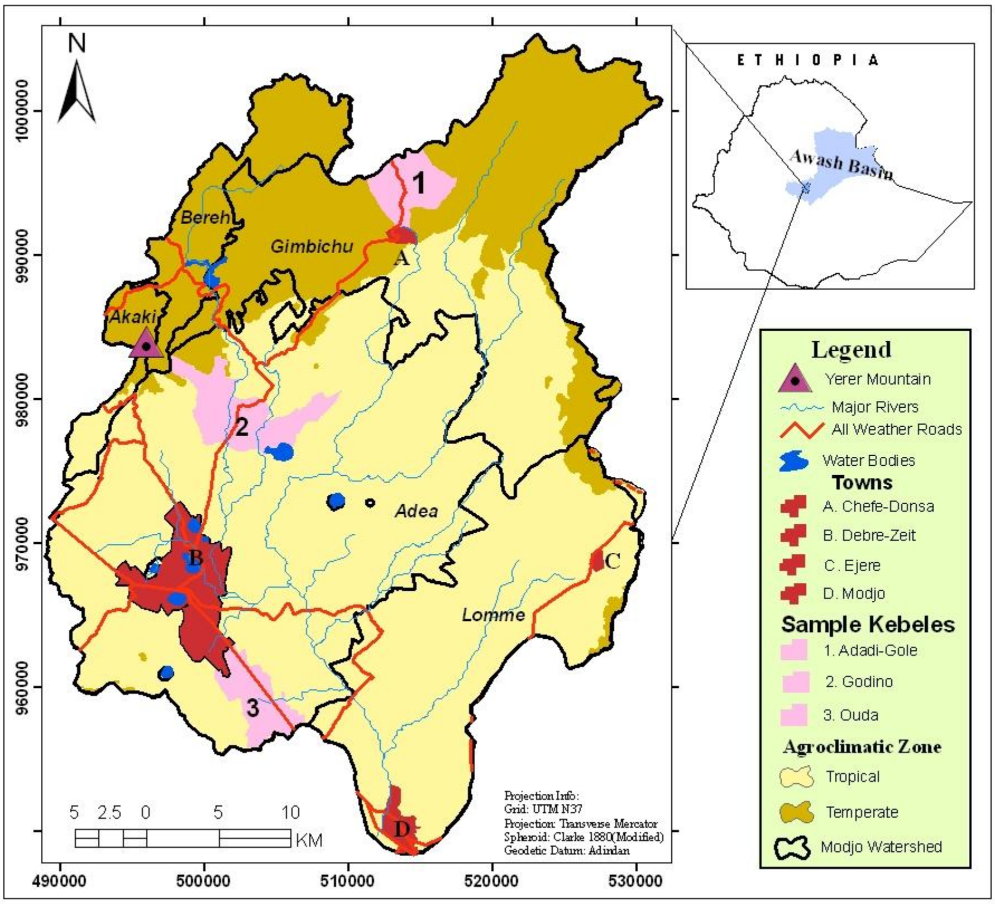

Figure 1. Location map of the Modjo watershed and sample Rural *Kebele* Administrations (RKAs) .