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## ***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.***

**B. Gessesse et al.**

berhanavu@gmail.com

Received and published: 9 January 2016

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 land-

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scape 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 (afforestation 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 man-

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agement 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 prob-

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lem 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, siltation, 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 availabil-

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ity; 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 and 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 calamities 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.

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tion 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<sup>2</sup> 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.

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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  $1 - R^2$  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

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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

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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 decreased 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-

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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.

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#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.

Please also note the supplement to this comment:

<http://www.solid-earth-discuss.net/7/C1822/2016/sed-7-C1822-2016-supplement.pdf>

Interactive comment on Solid Earth Discuss., 7, 3245, 2015.

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