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SMALLHOLDER FARMERS' PERCEPTION ON LIVELIHOOD AND ENVIRONMENTAL EFFECTS OF EUCALYPSUTS TREE- AN EMPIRECAL STUDY IN GURAGE ZONE, ETHIOPIA

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ABSTRACT*:*

Eucalyptus tree is expanding on farm lands of Ethiopia at an alarming rate and efforts of local authorities to control this expansion have become sources of conflict and wide spread grievances among smallholder farmers in Gurage Zone. Focus Group Discussion, key Informant Interviews as well as Household Survey were used as data collection methods. The result from the ordered logit estimation indicated households' perception to be influence by demographic and socio-economic factors such as age and educational level of household head and total land holding. Households, who have favorable perception towards eucalyptus tree, continue planting it despite the negative perception of experts and local officials and their efforts to control its expansion. The formulation and effective implementation of policy regarding eucalyptus trees and undertaking continuous awareness raising programs are essential measures needed to win the support of farmers in controlling the expansion of eucalyptus tree which is essential for a sustainable use of rural lands.

Keywords: Eucalyptus Expansion, Farm Forestry, Sustainable Land Use, Likert Scale, Ordered Logit, Perception Index

INTRODUCTION

Ethiopia is a country where more than 80% of its population depends on the agricultural sector for their livelihood. However, the performance of the agricultural sector is still very low due to many interrelated factors such as low adoption of modern technologies and inputs, small and fragmented land size and land tenure insecurity (Yigezu, 2021). As a result, the country's ability to feed its population is falling year after year. For instance, the share of food import as a percentage of all merchandise imports has continuously increased from 8.96% in 2014 to 18.40% in 2020 mainly due to continues population growth and decline in per capita food production (World Bank, 2022).

Despite efforts by the government to improve the food security of the country by increasing farm level productivity, smallholder farmers in several parts of the country are diverting their land and other resources to the production of cash crops and farm forestry. However, this has not received much attention by both policy makers and practitioners (Getachew, 2016). In relation to food security, an important issue that has to be addressed properly is the rapid expansion of eucalyptus tree at the expense of crop lands in many parts of rural Ethiopia (Mesfin & Wubalem, 2014; Tola, 2010). More and more researchers have come to argue that agroforestry and farm trees to improve households' food security in the face of declining productivity of smallholders' agriculture due to lower labor demand of trees, their capacity to generate more income and also declining access to land in many rural areas (Duffy et al., 2021;Waldron, et al., 2017). Though studies on the particular case of eucalyptus tree are scarce, a study by Peralta and Swinton (2009) indicated that farmers in Western Kenya are unlikely to replace food crops in the long-run due to the high cost of getting subsistence household requirement of food grain from the market. However, the case in Ethiopia seems different since empirical studies are showing eucalyptus tree to expand rapidly at the expense of crop lands in most part of the country (Jenbere, Limenih & Kassa, 2012; Getachew 2016; Alemie, 2009). For instance, a study conducted by Getachew (2016) in Bambasi *wereda* of Benishangul–Gumuz Regional State reported eucalyptus trees have concurred 45.15% of smallholders' fertile crop lands- within few years of its introduction into the area.

Eucalyptus is the most widely planted but also debated tree in Ethiopia (Tekelay, 2000). Its cultivation is believed to be influenced by many interrelated factors and the perception of farmers towards eucalyptus tree is one of the most important factors (Derbe, Yehuala, & Agitew, 2018). In many parts of rural Ethiopia, farmers continue to plant it on their limited land despite concerns about its negative implications on the environment and food security (Alemu, 1998; Getachew, 2016; Alemie, 2009). The various actors, i.e. farmers, experts and local officials do not agree with the benefits and cost of planting eucalyptus trees. As a result, conflicts arise among these actors mainly due to lack of understanding of farmers' motive and perception

about the tree. To find sustainable solutions to the eucalyptus conundrum observed in many parts of Ethiopian in general and in the study area in particular, it is crucial to understand smallholder farmers' perception about the livelihood and environmental effects of eucalyptus tree. Moreover, identifying the various factors that influence households' perception of the tree and the extent of their influence will be crucial since smallholder farmers are the major agents of eucalyptus expansion in many rural areas of Ethiopia (Zerga & Berta, 2016; Alemu, 1998). Hence, this study aims at addressing these issues and forwarding some recommendations that might be helpful for future planning and implementation programs in order to achieve a more sustainable use of rural farm lands of Ethiopia.

Oxford dictionary, edited by Stevenson (2010) defines perception as the way in which something is regarded, understood or interpreted and this implies it may or may not fully reflect the reality, but it influences one's opinion, attitudes and response to policies or programs (Pervin, 2017; Yohannes, 2019). The process of perception involves stimuli (inputs) which are transformed into perceptual outputs like feelings, opinion, attitudes, etc., which ultimately determines individual's behavior and actions and this ultimately determines our economic and social conditions (Ochoo, Valcour. & Sarkar, 2017). From the process of perception, we can see that one's attitude and action is the result of own perception about that agent or issue and therefore understanding peoples' perception can be a very important input in any development intervention.

One of the reasons for analyzing perception is because it varies from one individual to another due to various demographic and socio-economic factors. A study by Yohannes (2017) indicated that perception of households towards climate change is significantly affected by demographic factors such as sex and marital status of household head in addition to other economic variables. Studies also suggest that the perception of an individual is likely to change over time for various reasons. According to Hennessy (2012) earlier positive perception held by East San Francisco Bay residents on eucalyptus which was reinforced by resource management goals such as lumber, fire wood, oil, etc. and the promotion of wealthy landowners and influential members of society changed to negative perception due to historical events (massive fire hazard) and environmental education given to society as a result of which during the survey almost 98% of respondents described eucalyptus as invasive species.

This research is expected to have important contributions to knowledge and policy formulation. First, since we have not found such a study in the study area, the findings of this study are expected to help policy makers understand the local knowledge, opinions and views which can be used as inputs in formulating policies and designing future programs that aim at proper land use and management practices. Second, it adds to the existing but little literature on debate on agriculture-environment tradeoffs

with regard to incorporating the perceptions, opinion and views of farmers and other stakeholders in any rural development effort. In addition, nowadays there is an increasing awareness that only formal scientific knowledge will not be sufficient to solve the various problems the rural communities are facing. As a result, there is an increasing interest to incorporate knowledge of the local people and their perception in development programs (Arsiso, Tsidu, Stoffberg, Tadesse, 2017; Finucane, 2009). However, very little attention is given to views and opinions of smallholder farmers on eucalyptus tree plantation in Ethiopia in general and in the study area in particular.

MATERIALS AND METHODS

Study Area Setting

Gurage zone is found in the Northern part of Southern Nations, Nationalities, and Peoples' Regional State (SNNPRS) in Ethiopia. The zone covers wide ranges of altitude below 2000 meters and highlands of more than 3000 meters. As a result, the three main agro-ecology types are found in the Zone. These agro-ecology zones are lowland (*'Kolla'*) dominated by hotter climate and lowest amount of rainfall compared to the other two agro-ecological zones; while *'dega'* agro-ecological zone has cooler climatic condition and receives the highest annual rainfall compared to the other agro-ecological zones. Whereas, the mid altitude *('Weyinadega'*) zone exhibits a climatic condition between the two extremes. The annual mean temperature of the zone ranges from 13^0C to 30^0C while its mean annual rainfall ranges from 600 to 1600 mm. Welkite is the administrative center of Gurage Zone which is 150 km from Addis Ababa. According to population projection of CSA (2021), the total population of the zone was estimated to be 1,791,034 in 2021 of which more than 80 % were rural residents.

Though most farmers practice mixed farming system, '*ensete*' (enseteedulis, äsät or "false banana plant") is the principal crop in the Zone. It is characterized by its massive stem that grows underground and is involved in every aspect of Gurage life. In recent years there is a rapid land use pattern change in Gurage Zone due to the rapid expansion of eucalyptus tree which makes the zone one of the leading suppliers of eucalyptus logs to many parts of the country (Zerga & Berta, 2016). Figure 1, shows the map of the study area.

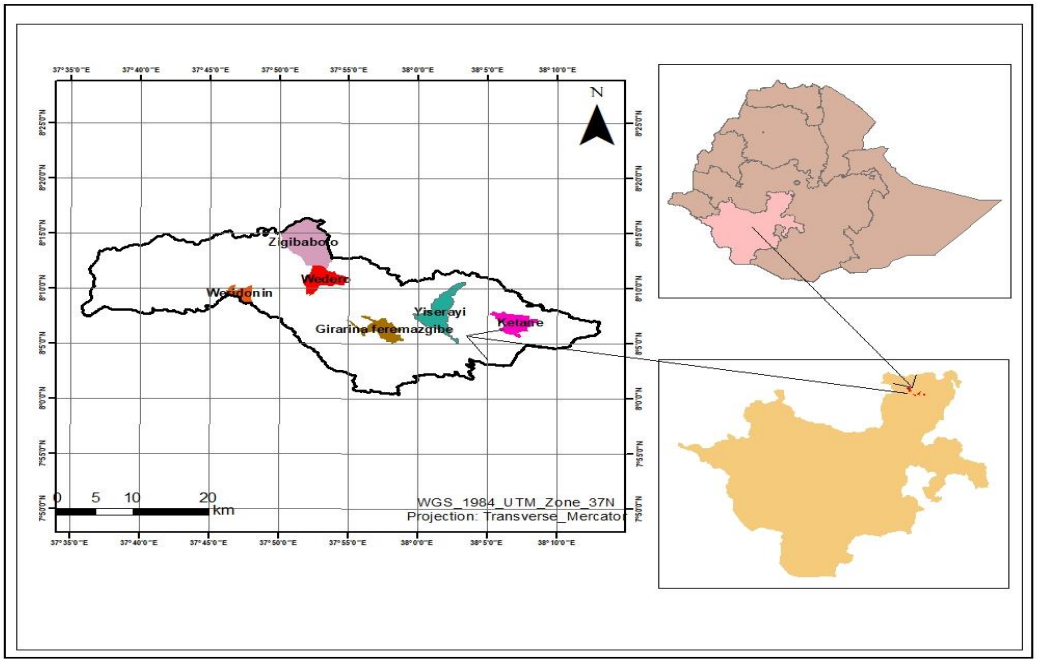

Figure 1 Map of Study Area (CSA 2021)

Sampling Techniques and Data Collection Method

There are fifteen *weredas* in Gurage Zone and each *wereda* is further divided into smaller administrative units called '*kebele'*. The study is done in two purposefully selected *weredas* where eucalyptus plantations are practiced widely. According to Zerga & Berta (2016), there are four *weredas* in Gurage Zone with higher practice of eucalyptus plantation- Enemor and Ener, Cheha, Ezha and Gumer. From these four the study was done in Ezha and Cheha *weredas*.

From each *wereda* three *kebeles* were purposively selected based on the extent of eucalyptus tree expansion and one *kebele* from each of the three agro-ecological Zones- lowland *('Kolla'*), mid altitude ('*Weyinadega'*) and highland ('*Dega'*). Experts from the respective Agriculture and Natural Resource Bureau were consulted in selecting *kebeles* from each *wereda*. The sample households were selected using systematic random sampling procedure in which the first household from each *Kebele* was picked randomly from a list of households obtained from their respective *kebeles* and then every 6th household was taken to get the required sample size from each *kebele*.

Using the formula given by Yemane (1967) for sample size determination, the total sample size for this study was calculated to be 480 households which then were divided to the six kebeles based on their respective household size. As a result 87 from Zigbaboto, 45 from Yesray, 103 from Ketane, 53 from Weredene, 88 from Wodro and 104 from Girar and yefermazigibe sample households were selected.

In addition, information was also collected using Focus Group Discussion (FGDs) and Key Informant Interviews methods. Participants in FGDs were selected in such a way that they represent the youth, elderly and women and a total of six FGDs (one in each Kebele) were undertaken. Key informant interviews at *wereda* and *kebele* level were also held with government officials, experts and DAs (Development Agents) who are more familiar with the socio-economic and environmental conditions of the study area.

Data Analysis

In this section a discussion on how the perception indicators are calculated will be presented first then a discussion on econometric model specification will follow.

Perception Indicators

We used different indicators (indicated by Table 1) to calculate a value of perception that reflects the level of agreement of each respondent to the different perception questions. Each perception question had 5 response options reflecting the level of agreement to each of the perception statement provided to the household head in our survey. The questions were presented as follow:

"Eucalyptus trees generate more income than your alternative agricultural produce"

(1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

Outcome Variables	Indicators
Household Livelihood	(1) Generate more income than alternative agricultural Produce.
	(2) Covering social contribution such as *ekub*[1] and *idir* [2].
	(3) Getting additional income.
	(4) Higher market demand (marketability).
	(5) Source of money during emergency cash needs.
	(6) Serving as a major input in construction.
	(7) Major source of fire wood.
Environmental Effects	(1) Negative effects on the growth of other plants (reduce food grain and forage availability).
	(2) Reduces availability of ground water.
	(3) Negative impact on future soil fertility (productivity).

Table 1: Outcome Variables and Perception Indicators Used (own questionnaire 2021)

[1] an informal financial institution like Rotating Savings and Credit Association (ROSCA) formed by individuals who usually know each other very well.

[2] an indigenous social insurance formed for the purpose of providing ecomomic and social support to members in the events of unfortunate incidences usually bereavement.

In our questionnaire, the questions on environmental issues were stated as negative statements like "Eucalyptus tree has negative effect on the growth of other plants (reduce food grain/ forage availability)". So agreement to such statements means holding the opinion that eucalyptus has negative effect on the environment while disagreement means holding the opposite opinion.

Econometric Model Specification

An ordered logit model which uses maximum likelihood estimation was employed to evaluate the probability of responding with one of the five categorical response options given to respondents. The use of OLS would treat, for instance, the difference between strongly disagree (1) and disagree (2) as the difference between neutral (3) and agree (4). However, these are only rankings representing the perception of individuals. In addition, when the response items are ordinal like the ones we have in this perception analysis, using OLS will not be appropriate as the estimates can be biased and misleading (Mckelvey & Zavonia, 1975). Using multinomial logit or probit model would also fail to capture the ordered nature of the dependent variables (Green, 2003). Therefore, we have employed ordered logit model to identify factors that influence the level of agreement to the perception statements.

Let Y^* be the feeling (Perception) of a given household about eucalyptus tree. Suppose this unobserved (latent) variable is assigned 0-100% point on a level of agreement on perception statement about eucalyptus but if the possible responses are condensed into five then respondents can express their feelings using the available five choices (ordinal variables) such as strongly disagree, disagree, neutral, agree and strongly agree. This means respondents must decide which one of the five available options best reflects their feelings (perception) about the livelihood and environmental effects of eucalyptus tree.

Let Y be the observed ordinal variable and hence:

$$Y = f(Y^*) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots .. (1)$$

Assuming we have M observed responses (Y_i=1, 2, 3,…,M) from the unobserved latent variable Y^* .

We can state that:

$$Y_i^* = X_i \beta + \varepsilon_i \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (2)$$

$$Y_i = j \qquad if \;\; Y_{j-1} < Y^* \leq Y_j \;\; \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . \ldots (3)$$

Then for any $Y_j s$ with $Y_0 = -\infty$, $Y_1 = 0$ and $Y_M = \infty$, the probability that alternative j is chosen is the possibility that the latent variable Y^* is between two boundaries Y_{j-1} and Y_j. In Eq 2, X_i refers to vector of independent variables that influence the dependent variable Y_i^* and ε_i is the disturbance term.

If we assume ε_i to follow a logistic distribution N(0,1), we have ordered logit model (Williams, 2021). For a five–scaled Likert scale response, there will be four cutpoints (C_i= 1… 4) separating responses from one another, then the ordered response model can be stated as:

$$Y_i^* = X_i \beta + \varepsilon_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$\begin{aligned} Y_i &= 1, \quad if\ Y_i^* \le C_1 \\ &= 2, \quad if\ C_1 < Y_i^* \le C_2 \\ &= 3, \quad if\ C_2 < Y_i^* \le C_3 \quad \ldots\ldots\ldots\ldots\ldots\ldots (5) \\ &= 4, \quad if\ C_3 < Y_i^* \le C_4 \\ &= 5, \quad if\ Y_i^* > C_4 \end{aligned}$$

Using eq. 5 and the assumed logistic distribution of the disturbance term, the ordered logit model can be used to estimate the probability that the unobserved variable Y^* falls within the various cutoff points.

Two estimations of ordered logit regressions are presented in this study. The first is for the perceived effect of eucalyptus tree on livelihood while the second one is for environmental effects. In our estimation, we have attempted to take both sides of the argument in relation to eucalyptus trees. The livelihood estimation takes those issues raised in favor of eucalyptus plantation (eucalyptus as a 'blessing'). Livelihood perception questions include issues such as income generation, firewood, construction material and marketability of eucalyptus. The estimation on the environmental effect on the other hand, addresses issues raised against eucalyptus tree (eucalyptus as a 'curse'). Those who claim eucalyptus tree to be harmful raises environmental issues such as shading and allelopathic effect of eucalyptus tree which negatively affect the growth of neighboring plants, and also reducing soil fertility and ground water (Bazzana, Gilioli, Simane, & Zaitchik, 2021; Zerga, 2015; Getachew, 2016).

Stata 14.2 software was used to analyze the data.

RESULTS AND DISCUSSIONS

Reliability of Indicators of Perception

In order to get a better result in a research like this which mainly uses Likert–type questions, undertaking reliability tests is very important. Since the outcome variables used in our perception analysis are latent variables, we use scale (group of questions) to make them measureable. As a result, we need to check to what extent the questions in the scale relate to each other and their degree of reliability. For Likert-type questions the most appropriate measure of reliability is Cronbach alpha (α) which is calculated by taking the variance, covariance and the total number of items included in a scale. Its values lie between 0 and 1 and if all of the items in the scale are entirely independent from one another Cronbach's alpha will be 0 and as it approaches 1, items in the scale have higher and higher covariance and suggests the items tends to measure the same underlying concept (Virginia, 2015).

Cronbach's alpha (α) is calculated for each outcome variable using the expression;

$$\alpha = \frac{K * \bar{C}}{\bar{V} + \bar{C}(K-1)} \qquad (6)$$

Where $K =$ Number of items in a scale

$\bar{C} = average\ covariance\ between\ items$ and $\bar{V} = average\ variance$

A Cronbach's alpha (α) greater than 0.95 may indicate redundancy of items in a scale and when the value is between 0.8 and 0.95, 0.7 and 0.8, and 0.6 and 0.7 shows very good, good and fair reliability, respectively. A value below 0.6 is unacceptable and needs reviewing (Zikmund, Babin, Carr & Griffin, 2010). Cronbach's alpha was calculated using Stata 14.2 software and the result is shown in Table 2.

Outcome variables	**№ of items**	**Scale Reliability Coefficient (Cronbach's Alpha)**	**Reliability Status**
Households' Livelihood	7	0.7521	Good
Environmental Effects	3	0.8234	Very Good

Table 2: Reliability Status using Cronbach's Alpha (own survey 2021)

The reliability test, in general confirms the questions used to capture each outcome variables are acceptable though at different degree since both Cronbach alpha values are above 0.7. Environmental effect has a higher value (0.82) which shows less

variance among the responses given to the three environmental items which suggests that respondents had more or less similar responses to the environmental perception questions compared to that of the livelihood perception questions.

Analysis on Households' Perception on Eucalyptus Tree

Households' Opinion on Issues related with Eucalyptus tree Expansion

Though the household may have different motives for engaging in eucalyptus tree farming, it is important to identify their prime pushing factors that lead to the decision to plant the tree. To this end, households were asked about their prime reason for planting eucalyptus trees. The results suggest that income generation is the prime motive for around 66% of the respondents. While nearly 18% of the sampled households reported that immediate cash need was their prime reason. Those who identified household own demand for wood as their prime reason constituted around 11.7% of the sampled households. Another interesting finding of this study is that unlike the claims made by other scholars, only 4% of the sampled households reported that their land holding was unsuitable for regular farm production. This suggests that most farmers are planting eucalyptus trees on lands which are suitable for crops. This is an issue to be explored further in order to find a balance between the forest and food nexus.

To examine the views of households towards the benefits of eucalyptus trees in their locality; we asked them the following question "Do you think eucalyptus tree plantation in your locality has benefited the community more?" The response shows that 61.7% of them responded 'yes' while the remaining 38.3% responded 'no'. From this we can say, though the majority was in favor of eucalyptus tree, there were also some households (more than a third) who had some concern about its expansion in their localities. From those who replied 'no' around 80% of the respondents reported eucalyptus tree's negative impact on local food production as their main reason followed by its negative impact on the growth of other neighboring plants and the environment as second and third reasons constituting 17.4% and 2.7%, respectively.

When asked about governments reaction towards the expansion of eucalyptus trees in their localities, more than 96% of the sampled households responded by saying 'the government discourage eucalyptus plantation', while only 0.83% replied with the option of 'government promote eucalyptus plantation' and the remaining 2.5% reported that they did not know about the reaction of the government. Participants, during the FGDs also stated agricultural experts and other government official discourage farmers from planting eucalyptus tree especially on farm lands suitable for crop production or *enset* plantation.

Table 3 below, presents the response of the respondents to the question on measures the government mainly uses in order to control and discourage eucalyptus plantation and expansion. The three measures mentioned by the sampled households were awareness creations, warnings and forceful uprooting of eucalyptus seedlings.

As summarized in Table 3, most households (55.4%) reported 'warning' to be the most commonly measure used by the government to control eucalyptus expansion. Around 43% of the respondents identified 'awareness creation' as another measure to control the expansion of eucalyptus tree. Forceful uprooting is not common and only 2% of the sampled households reported such cases in our study area. *Wereda* level officials mentioned cases of

Measures	**Frequency**	**Percentage**
Forceful Uprooting	9	2.0
Warnings	255	55.4
Awareness Creation	197	42.6
Total	460	100

Table 3: Measures Taken by the Government to Control Eucalyptus Expansio (own survey 2021)

eucalyptus uprooting measures taken by task forces formed for this purpose when found planted on communal lands left for grazing or other purposes. This usually creates grievances among farmers and it does not seem working since eucalyptus tree farming is continuously expanding in the study area.

According to the *wereda* level experts, the reason for such kind of land use is partly failure in implementing the existing Proclamation 110/2007 (SNNPRS, 2007), issued by the Regional Government which uder Articl 'Obligation of Rural Land Users' states "A holder of rural land shall be obliged to properly use and protect the land . When the land gets damaged the user of the land shall lose his use right." However, most farmers in the study area believe that it is their right to use their land in any way they like.

DAs and local officials consider eucalyptus tree as a conundrum that threatens future food security of the area due to its continuous expansion despite their efforts to reverse the condition. During one of the interviews held at the *wereda* level an expert responding to the question "Is there any support you provide to those who engage in eucalyptus farming?" replied "let alone giving support, if possible we would be happy to eliminate it from our Zone altogether." This opinion is far from being unique among local government officials and agricultural experts which may also suggest their frustration in controlling the expansion of eucalyptus trees under the existing circumstances. In addition, during the FGDs some participants clearly stated

that often DAs advice and warn them not to engage in planting eucalyptus trees. Hence in order to avoid confrontations, eucalyptus tree planting in the study area are usually undertaken when DAs and other government officials are not around. This suggests the need for awareness creation and policy formulation that enable a sustainable use of land that can strike a balance among the various objectives of stakeholders such as the need for food and forest products as well as addressing the environmental issues.

Our survey results further indicated that around 97% of the sampled households believed that eucalyptus tree plantation is expanding rapidly while the balance, that is only 3%, argue against. This indicates that the majority of the farmers themselves support the opinion of local administrators and experts that eucalyptus tree is expanding at an alarming rate in the study area. An attempt was also made to know what farmers feel about the expansion of eucalyptus tree in their locality, but the finding was inconclusive as those who replied they were happy to see this expansion were almost in equal percentage as those who were not happy (have some concern). However, according to a study conducted by Jenbere and et al. (2012) in Arsi Negele, 57.8% of the respondents were found to perceive eucalyptus expansion to cause a series problem to their community in the future who identified the adverse effects of eucalyptus expansion on local food production as their prime concern,

A question was given to the respondents in order to know their perception on the effects of eucalyptus tree expansion on future food security situation of the local community. The majority (around 53%) perceive that it is likely to improve the food security of the local community. This could be the result of expected higher income from selling eucalyptus products which might be used to buy essential agricultural inputs such as fertilizer and seed in addition to enabling them to buy some food items directly from the market (Tola, 2010; Alemie, 2009).

Calculating Perception Index

As mentioned earlier 7 and 3 perception questions (indicators) were presented to each household for livelihood and environmental perceptions, respectively. As a result, we get 7 responses from each household for perception on livelihood and 3 responses for environmental effects. However, for sake of generalization and summary, we need a single value that can give us the ‘average response’ of a particular household. Therefore, a mean value of perception (perception index) was calculated for each household using the following formula.

$$PS_i = \frac{\sum_{j=1}^{N} Q_j}{N} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

Where: PS_i= Perception Index (score) of the i^{th} Household (i=1 … 480)

Q_j= Response on the j^{th} perception question (j=1… N),

N= Number of indicators for each outcome variable

The mean perception score from Eq. 7 is a continuous number between 1 and 5. However, we need to assign a categorical ranking that ranges from strongly disagree (1) to strongly agree (5). For this purpose, we need to have five equal class intervals with the lowest and highest possible values being 1 and 5, respectively. Therefore, we used five equal ranges to label the perception indexes into the five categorical rankings. As a result, each household was categorized into one of the following level of agreement based on the Five –Scaled Likert criterion given by Al-Sayaad, Rebea and Samrah (2006).

№	Mean Range Option	Response Option
1	1.00-1.80	Strongly Disagree
2	1.80-2.60	Disagree
3	2.60-3.40	Neutral
4	3.40-4.20	Agree
5	4.20-5.00	Strongly Agree

Table 4: Five- Scaled Likert Criterion

Perceived Effects of Eucalyptus Tree on Households' Livelihood

A summary of results of households' perception on the livelihood and environmental effects of eucalyptus tree is given by Figure 2. The mean perception score obtained for the livelihood perception outcome was 3.78 with a 1.45 and 4.94 minimum and maximum scores, respectively.

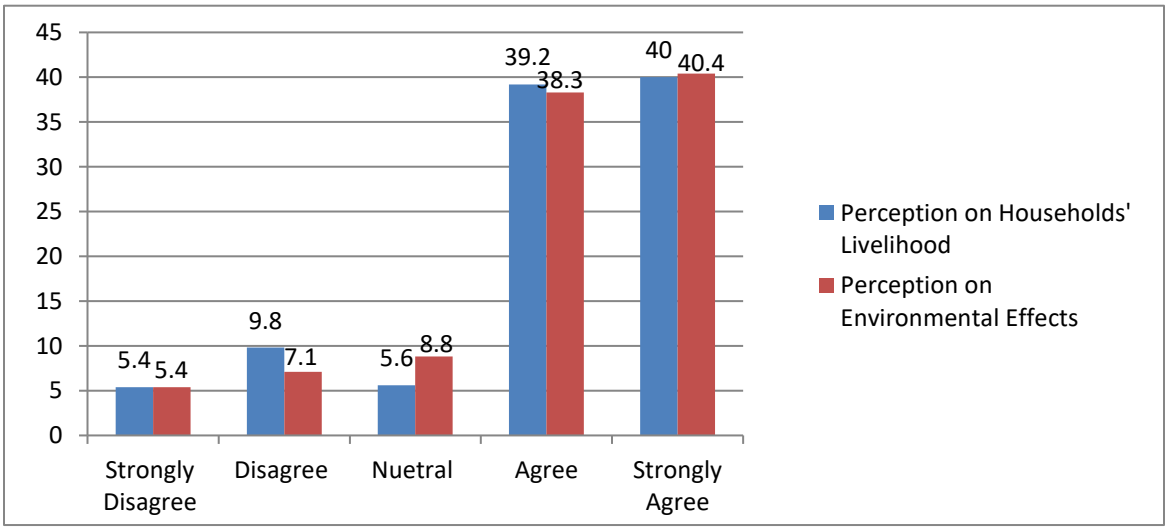

Figure 2: Response on the Perceived Effects of Eucalyptus tree (%) (own survey 2021)

The mean perception score of 3.78 for the livelihood perception indicates, on average the sampled households responded with the option of 'Agree'. This in general indicates that households have favorable opinion on the effect of eucalyptus on their livelihood which means they perceive eucalyptus tree to be important for their livelihood. From Figure 2, we can see that 39.2% and 40.00% of the respondents responding with 'agree' and 'strongly agree' to the livelihood role of eucalyptus tree. While 5.6% of the sampled households were neutral and only 9.8% and 5.4% responded with 'disagree' and 'strongly disagree', respectiverly.

Based on socio-economic studies on eucalyptus tree in Ethiopia, Dessie & Erkossa (2011) reported eucalyptus tree to have a significant contribution to household income compared to any other agricultural produce. This is in line with the findings of this study and this shows why household in the study area have positive opinion on eucalyptus and are eager to plant the tree. In addition, as part of livelihood strategies eucalyptus is also used as a security tree in many part of Ethiopia. This goes in line with the findings of Adimasu, Kessler, Yirga and Stroosnijder (2010) who argued that eucalyptus tree was considered by farmers in Ethiopia as a security crop in times of crop failure due to draught and pests.

Perceived Effects of Eucalyptus Tree on Environment

One of the major issues raised with the expansion of eucalyptus trees is its impact on environmental quality. Some question the expansion of eucalyptus tree from its 'negative impact' on the environment due to its allopathic and shading effect and also claims of decreasing soil fertility and ground water (Bazzana, et al., 2021; Alemie, 2009). To address these issues, as showen in Table 1, three questions were include in the survey to capture the perceived effects of eucalyptus tree on the environment.

Using equation 7, the minimum and maximum environmental perception index for the sampled households were found to be 1.33 and 5.00, respectively and the mean value was 4.18. The mean perception idnex indicates that households on average responded with the option of 'agree' to the statements that eucalyptus has a negative impact on the environment. From Figure 2, the most chosen option was 'strongly agree' with 40.4% of respondents and also the majority of the sampled households (78.7%) have responded positively to the statement that eucalyptus has a negative impact on the environment. While only 12.5% responded with ether 'disagree' or 'strongly disagree'. This indicates that sampled households overwhelmingly agree with the claim that eucalyptus trees have negative impact on the environment.

From the descriptive analysis of perception questions we can conclude that households in the study area plant eucalyptus tree knowing its negative environmental consequences in order to make advantage of generating more income, serving as means of fulfilling immediate cash and fire wood demands of the household among other uses. This finding is consistent with Alemie (2009) who claimed that farmers in Koga Watershed in Western Amhara Region of Ethiopia perceived eucalyptus plantation depreciates the potential of the environment but they keep on growing the trees because of the relative short time required to produce wood biomass for fuel, construction and cash.

Econometric Analysis of Households' Perception on Eucalyptus Tree

The results of ordered logit estimations on coefficients and marginal effects are presented in two sections. The first section discusses estimation result of the effects of eucalyptus tree on livelihood while the second one discusses the result of the environmental effects.

Results of Estimation for Perceived Effects of Eucalyptus Tree on Livelihood

A summary of result of estimations from Stata 14.2 for coefficients and marginal effects are given in Table 5 and Table 6, respectively. From the results of estimation, we observed the model as a whole to be statistically significant as compared to the null hypothesis that there are no predictors (the coefficients of all the estimates are zero) since the Likelihood ratio chi-square (97.76) has a p-value of 0.0000. This shows the independent variables included in the model as a whole have significant impact on the perception of households. The model also has a pseudo- R^2 of 0.0795.

Coefficients in general indicate the direction of the relationship between dependent and independent variable and their values indicate the log odds of increase or decrease being in a higher level of agreements to the perception statements depending on their signs. However, the interpretation of the numerical value of a coefficient is a bit complicated and its meaning is also somewhat confusing (Mckelvey & Zavonia, 1975; Williams, 2021). For this reason, we will give more attention for the interpretation of marginal values.

From the regression result presented in Table 5, we can see that the nature of land (being suitable for crop production or not) is not significant factor in explaining variation in the perception of households. This may somewhat reflect the observation of the researchers and also the opinions reflected during key informants interview that households use all types of lands including fertile crop land to grow eucalyptus tree and this is also consistent with the finding of other research such as Getachew (2016) and Tola (2010).

Variables	Description of Variables	Coef.	Std. Err.	p>|z|
gedr	Gender of Household Head (Male 1; Female 0)	0.3192181	0.2077404	0.124
mrstt	Marital Status (Married 1; Single 0)	-0.0479539	0.2074002	0.817
ageh	Age of Household Head (years)	-0.0215709	0.0116118	0.063
elhh	School year of Household Head	0.0900985**	0.027228	0.001
lnsz	Total Land of Household (ha)	0.8720645*	0.3733038	0.019
avcce	Availability of Cash Crops (Yes 1; No 0)	0.4674958*	0.1898679	0.014
acele	Access to Electricity (Yes 1; No 0)	-0.4219319*	0.1813718	0.020
sulne	Suitability of Land for crop prodcution (Yes 1; No 0)	-0.10094995	0.177831	0.538
flit	Family Members between 15 & 64 years	-0.2499401**	0.0833111	0.003
pnof	Participation in Non / Off-farm activities (1 Yes; 0 No)	0.6712425**	0.199736	0.001

** = significant at 0.01 level; * = significant at 0.05 level

Table 5: Coefficient Estimation for Perceived Effect of Eucalyptus tree on Livelihood (own survey, 2021)

The positive and significant coefficient of the variable years of schooling of household head (elhh) shows that an additional year of schooling increases the probability of having positive opinion on the perceived effects of eucalyptus tree on households' livelihood, if all other variables included in the model remain the same. The marginal value, as indicated by Table 6, indicates that education increases the chance of responding with 'Strongly Agree' by 2.1%. In general, households with better education are expected to be more open to adapt themselves to new opportunities and attempt to take advantage of market conditions compared to those with less education. This finding is consistent with Pervin (2017) who studied perception of smallholder farmers' towards eucalyptus plantation in Bangladesh.

The coefficient of the variable total land holding of the household (lnsz) is positive and significant. An increase of land size by one Hectare would increase the probability of responding with option 'Strongly Agree' by 20.4%, if all other factors remain the same. This suggests that households with larger land size have stronger favorable perception towards the role of eucalyptus for livelihood. Though the role and share of eucalyptus tree is higher in income generation for farmers with smaller land size compared to those with larger land size (Mekonnen, Kassa, Lemenh & Campbell, 2012), but still households with smaller land size tend to prioritize feeding family compared to income generation in the study area. This is because households with smaller land holding are found to be less willing to engage in eucalyptus farming for the purpose of income generation because these households give priority to food /*enset* production. This finding does not agree with Mekonnen et al. (2012) who claimed that those with relatively smaller land size tend to be more willing to plant eucalyptus trees.

Availability of cash crop mostly *chat* and/or coffee (avcce) is also significant and the marginal effect indicates that having cash crop increases the probability of being in the category of strongly agree by 10.6%, if all other factors remain the same. This positive opinion could be the result of having some exposure to market oriented production system that made those households with cash crop to be positive to eucalyptus tree compared to those who do not have such exposures. The FGDs also revealed that in areas where there are little or no cash crops respondents are not that much enthusiastic about eucalyptus tree compared to areas where there are cash crop production and sell.

Variable	**dy/dx**	**std. Err.**	**p>|z|**
gedr	0.72767	0.04611	0.115
mrstt	-0.0112316	0.04872	0.818
ageh	-0.0050372	0.00271	0.063
elhh	0.0210398**	0.00636	0.001
lnsz	0.2036441*	0.08714	0.019
avcce	0.1063458*	0.04186	0.011
acele	-0.0968909*	0.04088	0.018
sulne	-0.0255351	0.0414	0.537
flit	-0.0583659**	0.01945	0.003
pnof	0.1592179**	0.04763	0.001

Table 6: Marginal Effects of Ordered Logit Model on Livelihood for Outcome 5 (own survey, 2021)

Having access to electricity service (acele) decreases the probability of responding with 'Strongly Agree' by 9.7% as compared to those who do not have access, if all other variables remain as they are. This could be due to the fact that those who have access to electricity are less dependent on eucalyptus tree for lighting and to some extent for cooking.

Another important variable expected to affect the perception of households towards eucalyptus plantation was the availability of work force in the family (flit) represented by the number of household members between the age of 15 and 64. This was used as an indicator for availability of labour force in the household and it was found to have a negative and significant effect on households' perception as expected and is consistent with the findings of Jenbere and et al. (2012). The reason could be due to the fact that eucalyptus farming requires less family labour and attention compared to regular farm works. This was also reflected in the FGDs that absentee farmers and those who have two or more wives tend to engage more in eucalyptus farming due to shortage of labour for regular farm work (Adimassu, et al., 2010). The estimates show that one additional family member

who is in the working age group is likely to decrease the respondents chance of being in the category of strongly agree by 5.8%, if all other variables remain the same.

The ordered logit model also revealed that those who participate in off/non-farm activities (pnof) are more likely to hold positive opinion about eucalyptus farming. Being participant is associated with a 16% more chance of being in the 'Strongly Agree' category as compared to non-participants, if all other variables remain the same. This could be due to participants having less time to engage in regular agricultural work that demands more labour and attention compared to eucalyptus farming.

Results of Estimation for Perceived Effects of Eucalyptus Tree on the Environment

The result of estimation for coefficients and marginal effects on the perceived environmental effects of eucalyptus tree are summarized by Table 7 and Table 8, respectively. The estimation results showed the model chi-square to be 154.60 with 10 degree freedom and it is highly significant which indicates the independent variables included in the model have significant effect on households' perception of the effect of eucalyptus on the environment since the p-value is 0.0000.

Variable	Description of Variables	Coefficient	Std. Err.	p>|z|
gedr	Gender of Household head	-0.1185783	0.2161585	0.583
mrstt	Marital status	0.0448193	0.2070217	0.829
ageh	Age of Household head	-0.040261**	0.0119692	0.001
elhh	School year of household head	0.0833003**	0.0274646	0.002
lnsz	Total land holding of household (ha)	0.6831504	0.3928945	0.082
avcce	Availability of cash crops	1.766393**	0.2047513	0.000
acele	Access to electricity	0.424896*	0.1866353	0.023
suln	Suitability of land for agri. Works	0.3006944	0.181794	0.095
flit	Family members between 15 & 64 years	-0.1195058	0.0804415	0.137
pnof	Participation in non / off farm activities	-0.0842112	0.1967876	0.669

** = significant at 0.01 level; * = significant at 0.05 level

Table 7: Coefficient Estimation for Perceived Effect of Eucalyptus tree on Environment (own survey, 2021)

From Table 7, we see that variables such as age and school years of household head, availability of cash crops and access to electricity to be significant factors while the remaining variables are found to be statistically insignificant at 5%.

Variable	dy/dx	std. Err.	p>|z|
gedr	-0.0275286	0.05057	0.586
mrstt	0.0102885	0.04737	0.828
ageh	-0.0092714**	0.00277	0.001
elhh	0.0191828**	0.00632	0.002
lnsz	0.1573194	0.0905	0.082
avcce	0.3531613**	0.03401	0.000
acele	0.0989316*	0.04382	0.024
sulne	0.0693859	0.04164	0.096
flit	-0.02775204	0.01854	0.138
pnof	-0.0193201	0.04498	0.668

** = significant at 0.01 level; * = significant at 0.05 level

Table 8: Marginal Effects of Ordered Logit Model on the Environment for Outcome 5 (own survey, 2021)

Table 8 above, indicates that age of household head (ageh) is negatively associated with households' perception regarding the negative impact of eucalyptus on the environment. That is, when age of the household head increases by one year, the probability of responding with 'Strongly Agree' on the negative impact of eucalyptus on the environment decreases by 0.9%, if all other factors are held constant. This could be the result of younger people being more exposed to information from mass media and other sources of information on environmental issues. In addition, higher school year is positively correlated with higher perception of households regarding the negative environmental effects of eucalyptus. This could be the result of better awareness of the more educated about the alleged negative environmental effects of eucalyptus tree (Hennessy, 2012).

The result of estimation further showed that availability of cash crop and access to electricity to be positively and significantly correlated with the perceived effects of eucalyptus tree on the environment. The positive coefficient of the variable access to electricity indicates that those who have access to electricity hold stronger position on the negative impact of eucalyptus tree on the environment which could be the result of their exposure to mass-media and other sources of information about the negative effects of eucalyptus tree on the environment compared to those who do not have access to electricity.

CONCLUSION

This study indicated that 'income generation' is the prime motive for planting eucalypts tree in the study area. The study further showed that farmers are planting eucalyptus trees mostly on lands which are suitable for food production which implies that eucalyptus is expanding at the expense of food production as was the case in other parts of the country (Getachew, 2016;

Jenbere et al., 2012). The study also indicated that some households have concerns about the long-run effects of eucalyptus expansion on local food production capacity. This suggest that it is essential to undertake a continuous awareness creation programs in order to shape the perception and attitude of smallholder farmers towards eucalyptus expansion so that they can give their cooperation and support to any future plans that aim at controlling and managing the expansion of eucalyptus tree in order to make the best use of rural land in the most sustainable manner.

One of the main findings of this study is that eucalyptus tree is a source of confrontations between farmers who believe they can plant it anywhere on their land and local officials and experts who want to prevent them from planting the trees on farm lands. In relation to this, one important issue that needs to be addressed is the issue of law with regard to eucalyptus trees plantation and use. The existing general law on 'the proper use of agricultural land' is not strong enough to give local authorities to exercise their power in controlling eucalyptus expansion. This is because it does not clearly mention where eucalyptus trees can and cannot be planted in relation to the nature of the land and also with respect to the production of other essential agricultural products such as food crops and '*enset'* in addition to other important issues.

Sample households have responded positively to both perception questions. This means households have favorable opinion on the role of eucalyptus trees for their livelihoods. This clearly indicates that households in the study area continue to plant eucalyptus trees as it provides them with wide range of benefits such as generation of more income and fire wood in addition to serving them as a means of construction material. The study also finds that most households are fully aware of its claimed negative environmental consequences.

The perception of households toward eucalyptus tree was found to be affected by various demographic and socio-economic factors such as education, land size, availability of labour force and cash crops. Thus, efforts to control eucalyptus expansion in the study area should take these factors into account to get the desired results.

To sum up, while experts and local government officials have unfavorable perception on eucalyptus trees and are also attempting to stop its expansion by taking different measures. Smallholder farmers, on the other hand, have favorable perception due to its benefits as a result of which they show strong desire and commitment to plant it, though they are aware of its claimed negative environmental consequences. Therefore, based on the findings of this research the following measures are suggested in ordered to control the expansion of eucalyptus trees on farm lands in order to achieve a sustainable use of the rural lands of the study area.

- The formulation and implementation of an effective policy with regard to the planting and use of eucalyptus tree to:-
    - ✓ Enable farmers engage in eucalyptus farming without any unnecessary confrontations with local officials.
    - ✓ Enable authorities to effectively control the expansion of eucalyptus trees on fertile crop land and
    - ✓ Make waste lands and hillsides productive through planned eucalyptus and other permanent tree cultivation.
- A continuous awareness creation campaign by DAs and local experts in order to help farmers make an informed decision on their most critical resources- agricultural land.
- Since one of the most important drivers to eucalyptus expansion is income generation, it is important to improve the productivity and income of smallholder farmers through encouraging and supporting them to engage in commercial farming.
- Providing renewable and affordable energy to households in the country in general and to the study area in particular since the study area is a major supplier of eucalyptus biomass for fire wood as far as the city of Addis Ababa and beyond.

Finally, we suggest further research on the following two issues:

- ➢ Study on cost-benefit analysis of eucalyptus tree plantation is necessary. This has to be done by calculating the opportunity cost of using farm lands for eucalyptus trees instead of crop production.
- ➢ There are still no clear evidences on the environmental effects of eucalyptus trees. There should be a consensus among the various stakeholders regarding the perception that eucalyptus has negative effects on the environments which should be supported by rigorous study.

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REFERENCES

Adimassu, Z., Kessler, A., Yirga, C., & Stroosnijder, L. (2010, September). Mismatches between farmers and experts on Eucalyptus in Meskan Woreda, Ethiopia. In *Eucalyptus species management, history, status and trends in Ethiopia. Proceedings of the Congress. Ethiopian Institute of Agricultural Research, Addis Ababa* (pp. 146-159).

Alemie, T. C. (2009). *The effect of eucalyptus on crop productivity, and soil properties in the Koga Watershed, Western Amhara Region, Ethiopia* (Doctoral dissertation, Cornell University).

Alemu, B. (1998). Spatial study of soil nutrient status after natural forest conversion to plantation and secondary forests at Munessa Montane Forest, Ethiopia. *Ethiopian MSc in Forestry Programme Thesis Works (Sweden)*.

Al-Sayaad, J., Rabea A., & Samrah, A. (2006). *Statistic for Economics and Administration Studies*. Kingdom of Saudi Arabia, Jeddah: Dar Jafez.

Arsiso, B. K., Tsidu, G. M., Stoffberg G. H., & Tadesse T. (2017). Climate Change and Population Growth Impacts on Surface Water Supply and Demand of Addis Ababa, Ethiopia. *Climate Risk Management*, 18 (2017), 21-33. http://dx.doi.org/10.1016/j.crm.2017.08.004

Bazzana, D., Gilioli, G., Simane, B., & Zaitchik, B. (2021). Analyzing constraints in the water-energy-food nexus: The case of eucalyptus plantation in Ethiopia. *Ecological Economics*, *180*, 106875.

Central Statistical Agency (CSA). (2021). Population Projection of Ethiopia for Wereda. Retrieved from: https://www.statsethiopia.gov.et/population-projection

Derbe, T., Yehuala, S., & Agitew, G. (2018). Factors influencing smallholder farmers adoption of eucalyptus woodlot in Wogera District, North Gondar Zone, Amhara Regional State of Ethiopia. *International Journal of Scientifics Research and Management*, 6(07). https://doi.org/10.18535/ijsrm/v6i7.em07

Dessie, G., & Erkossa, T. (2011, May). Eucalyptus in East Africa, Socio-economic and Environmental Issues, Paper presented at Planted Forests and Trees Working Paper 46/E. Forest Management Team , Forest Management Division. FAO, Rome.

Duffy, C., Toth, G. G., Hagan, R. P., McKeown, P. C., Rahman, S. A., Widyaningsih, Y., ... & Spillane, C. (2021). Agroforestry contributions to smallholder farmer food security in Indonesia. *Agroforestry Systems*, *95*(6), 1109-1124. https://doi.org/10.1007/s10457-021-00632-8

Finucane, M. (2009). Why Science alone Won`t Solve the Climate Crisis: Managing the Climate Risks in the Pacific. *Asia Pacific*, 89: 1–8. Retrieved from: http://hdl.handle.net/10125/11545

Getachew, A. (2016). The Impact of Eucalyptus Plantation on Food Security in Bambasi *Wereda*, Benishangul-Gumuz Regional State. (MSc thesis). Addis Ababa University, Addis Ababa, Ethiopia.

Green, W.H. (2003). *Econometric Analysis*, 5th Ed. New Jersey: Pearson Education, Inc.

Hennessy, P.R. (2012). The History of Social Perceptions of Eucalyptus Globulus in the East San Francisco Bay Area. Berkely Environmental Science, University of California. Retrieved from: https://nature.berkeley.edu/classes/es196/projects/2012final/HennessyP2012.

Jenbere, D., Lemenih, M., & Kassa, H. (2012). Expansion of eucalypt farm forestry and its determinants in Arsi Negelle District, South Central Ethiopia. *Small-Scale Forestry*, *11*(3), 389-405.

Mckelvey, R. D., & Zavonia, W. A. (1975). Statistical Model for the Analysis of Ordinal Level Dependent Variables. *Journal of Mathematical Sociology*, 4 (1), 103-120.

Mekonnen, Z., Kassa, H., Lemenh, M., & Campbell, B. (2007). The role and management of eucalyptus in Lode Hetosa district, Central Ethiopia. *Forests, Trees and Livelihoods*, *17*(4), 309-323.

Mesfin, A., & Wubalem, T. (2014). *Eucalyptus in Ethiopia Risk or Opportunity*: Ethiopian Institute of Agricultural Research. Addis Ababa. Retrieved from: http://www. eiar. gov. et.

Ochoo B., Valcour J. & Sarkar A. (2017). Association Between Perceptions of Public Drinking Water Quality and Actual Drinking Water Quality: A community-based exploratory study in Newfoundland (Canada), *Environmental Research*, 159, 2017, 435-443. https://doi.org/10.1016/j.envres.2017.08.019.

Peralta, M.A., & Swinton, S.M. (2009, July). Dynamic Choices for Kenyan Samllholders, paper presented at the Agricultural & Applied Economics Association's 2009 AAEA & ACCI Joint Annual Meeting, Milwaukee, WI. .

Pervin, M. (2017). Farmers' Perception on Eucalyptus Tree Plantation as Cropland Agroforestry: A case Study of Bogura District. (MSc Thesis). Sher-E-Bangla Agricultural University, Dhaka, Bangladesh.

SNNPRS, (2007). Debub Negarit Gazeta. Rural Land Administration and Utilization Proclamation No. 110, 13th Year No. 10. Awasa, Ethiopia.

Stevenson, A. (Ed.). (2010). *Oxford dictionary of English*. Oxford University Press, USA.

Teketay, D. (2000). Facts and experiences on Eucalypts in Ethiopia and elsewhere: Ground for making life informed decisions. Walia, 2000(21), 25-46.

Tola, G. (2010, September). Expansion of eucalyptus plantation by smallholder farmers amid natural forest depletion: case study from Mulo district in Central Oromia. In *Eucalyptus species Management, History, Status and Trends in Ethiopia. Proceeding from the Congress held in Addis Ababa. September 15th-17th* (pp. 335-350).

Virginia, U. O. (2015). Using and interpreting cronbach's alpha. *Retrieved from University of Virginia Library: https://data. library. virginia. edu/using-and-interpreting-cronbachs-alpha*.

Waldron, A., Garrity, D., Malhi, Y., Girardin, C., Miller, D. C., & Seddon, N. (2017). Agroforestry can enhance food security while meeting other sustainable development goals. *Tropical Conservation Science*, *10*, 1940082917720667.

Williams, R. (2021). Ordered Logit Models– Basic and Intermediate Topics. University of Notre dame. Retrieved from: https://www3.nd.edu/~rwilliam/

World Bank (2022). The World Bank Group. Retrieced from: https://.worldbank.org.

Yamane, T. (1967). *Statistics: an introductory analysis*, 2nd edn, Harper and Row, New York.

Yigezu Wendimu, G. (2021). The challenges and prospects of Ethiopian agriculture. *Cogent Food & Agriculture*, *7*(1), 1923619.. Rertrieved from: DOI: 10.1080/23311932.2021.1923619

Yohannes, P.L. (2019). Perception, Vulnerability and Livelihood Adaptation of Smallholder Farmers to Climate Change: Evidence from Kembata Tembaro Zone, Southern Ethiopia. (PhD Dissertation). Addis Ababa University, Addis Ababa, Ethiopia.

Zerga, B. (2015). Ecological impacts of Eucalyptus plantation in eza wereda, Ethiopia. *Int. Inv. J. Agric. Soil Sci*, *3*(4), 47-51.

Zerga, B., & Berta, A. (2016). Preference, purpose, and pattern of Eucalyptus tree farming in Eza Wereda, Ethiopia. *International Journal of Research and Inovation in Earth Sciences*, *3*(2), 30-38.

Zikmund, W. G., Babin, B. J., Carr, J. C., & Griffin, M. (2010). Business Research Methods, South Western. *Cengage Learning*.

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