Factors determining farmers’ decision and level of participation in terracing as a response to land degradation in Dejen Woreda, North-West Ethiopia

Mengistie Mersha¹*, Bamlaku Alamirew² and Linger Ayele¹

Abstract: This study was carried out with the objective of examining the major factors that determine rural households’ decision to participate and level of participation in terracing activities as a response to the prevailing land degradation in Dejen woreda, north-west Ethiopia. Using simple random sampling technique, 360 households were selected. Qualitative and quantitative data were emanated from both primary and secondary sources using questionnaire, interview, focus group discussion and observation. While qualitative data were analyzed using narrative and interpretative methods, quantitative data were analyzed using descriptive statistics (such as mean, percentage, frequency & standard deviation) and inferential statistics (namely, Chi-square test and Double Hurdle regression). Results of the first hurdle regression indicated that family size engaged in farming, landholding size, slope of land and training on land management practices have positive and significant contributions to farmers’ decision to participate in terracing practice. On the other hand, sex has negative and significant influence on farmers’ decision to participate in terracing. On the other hand, results of the second hurdle showed that

ABOUT THE AUTHOR

Mengistie Mersha (correspondent author) is a scholar with a good experience of teaching and research work. I have taught at elementary, secondary and tertiary levels of education in Ethiopia for the last 20 years. Currently, I am a Ph.D. candidate specializing on natural resource and environmental management at University of Gondar, Ethiopia. This research report is, therefore, one component of my dissertation project that is already finalized and expected to be defended in September 2022. So far, I have published more than four original research and systematic review articles on reputable international journals. My research areas focus on natural resource conservation, environmental management, climate-smart agriculture, development issues, population-environment dynamics, climate change, land use planning, environmental modeling and the like.

PUBLIC INTEREST STATEMENT

Land degradation is a serious problem in most parts of Ethiopia. It is particularly a critical problem in the northern highlands of Ethiopia where agricultural activity has been practiced for many centuries. On the other hand, the major way out of land degradation is conducting land management practices. In the study area, however, the rate of land degradation is still out-weighing land management practices. So, conducting a research work focusing on the major factors that determine farmers’ participation decision and level of participation in terracing practices will have its own significances. Woreda (district) and kebele (sub-district) level agricultural experts and natural resource specialists are expected to benefit from the result of this study. Moreover, the wider rural community can utilize the major findings of this study that enable them to improve their participation decision and level of participation in terracing practices. Towards this end, sensitization workshops will be organized to disseminate the findings.
Landholding size, slope of land, access to credit and training on land management practice have positively and significantly influenced households' level of participation in terracing. Conversely, sex is found to have a negative and significant influence on farmers' level of participation in terracing practices. As a solution to this problem, the concerned body at the woreda and kebele levels should devise mechanisms that enhance their socio-economic capacity and enable them to increase their decision and level of participation in terracing activities.

Subjects: Development Studies; Sustainable Development; Development Policy; Environment & the Developing World; Environmental Economics; Physical Geography

Keywords: Land degradation; land management; terracing; participation decision; level of participation; Dejen Woreda

1. Introduction
Ethiopia is endowed with enormous natural resource potentials. Since the country's economy hinges highly on agriculture, land is the most important resource. However, the country is still challenged with land degradation, the most critical environmental problem, which is manifested in the form of soil fertility loss, gully formation, soil erosion, and water scarcity (Yihenew & Amede, 2014). Land degradation includes all processes that reduce the capability of land resources, functions and services in ecosystems (Hurni et al., 2010). The problem is more critical in the north central highlands of Ethiopia where there is dense population and high concentration of livestock (Meseret, 2016). Of all forms of land degradation, soil erosion by running water is the most critical and widespread, which is responsible for low agricultural productivity and food insecurity in Ethiopia (Abebe & Sewnet, 2014; Mihretu, 2014) in general and in Amhara region in particular (K. Hurni et al., 2015). Land degradation in the form of soil erosion is not a new phenomenon in Ethiopia; it goes back to the beginning of agricultural practices (Meseret, 2016).

Land degradation is a critical problem in Amhara region even more than other parts of Ethiopia. The combination of natural factors, long history of settlement, increasing population pressure, and age-old agricultural practice made the region more vulnerable for the risk of land degradation (Tsegaye & Dessalegn, 2017). The rapidly growing population in the region has caused for the cultivation of hillsides, steeper slopes and ecologically fragile areas (Figure 1). Crop residues and cattle dung which were previously used by the community as important sources of organic fertilizer to the soil are now used either for household energy sources or for commercial markets (K. Hurni et al., 2015). The growing number of the rural population has severely destroyed available forests in search of farm land, construction material and fuel wood. In line with this, a study by Hurni et al. (2010) revealed that about 20 thousand hectares of forest are annually cleared in Amhara region for construction, logging and firewood purposes. In addition, free grazing and browsing too much livestock on forest and pasture lands (which are common practices in the region) are reported to exacerbate land degradation further jeopardizing the already precarious livelihood conditions of farmers.

A study by Jiru and Wari (2019) indicated that the region loses about 119 million ton of fertile soil every year due to water erosion that accounts for 70% of the soil loss in the country as a whole. As a result, about 10% of Amhara region experiences very high erosion rate (>200 t/ha per year); 29% is found to have high erosion rate (51.2 t/ha per year); 31% of the region receives moderate erosion rate (16.50 t/ha per year); and the remaining 30% experiences low erosion rate (<16 t/ha per year; K. Hurni et al., 2015).

Even though sporadic efforts had been in place, a more consolidated and institution-driven land management practice has been implemented in Amhara region as well as throughout Ethiopia since the 1970's after the occurrence of the deadly famine episode in the northern part of Ethiopia (Belachew & Aytenfisu, 2010; Haregeweyn et al., 2015; Mushir & Kedru, 2012). Since then, the region
is implementing various land management practices in degraded areas through mass mobilization of the community and separately on household basis (Assefa, 2010). It comprises structural conservation measures (physical earth works like construction of terracing, cut off drain and bunds) followed by biological measures (plantation of grasses and forage plants to stabilize physical measures). In spite of all efforts made so far, land management in the region is reported not achieving its intended objectives (GIZ, 2015) for land degradation is still outweighing the management efforts.

Even though the literature on the issue seems rich at the national level, such studies are scarce in East Gojjam zone and absent in the study woreda. This study is, therefore, aimed at examining of the major factors affecting farmers’ decision to participate and level of their participation in terracing activities in Dejen woreda, East Gojjam zone of Amhara regional state, north-west Ethiopia.

2. Materials and methods

2.1. Study area description

Dejen Woreda is one of the 17 Woredas in East Gojjam administrative zone, Amhara Regional State. It is located in the North-Western part of Ethiopia, about 230 km away from Addis Ababa. Astronomically, Dejen Woreda lies between 10° 01' 00" N—10° 21' 00" N latitude and 38° 03' 00" E —38° 19' 30" E longitude. It is bordered by Awabel Woreda in the West; Debay-Tilatgin and Enermay Woredas in the North; Shebel-Berenta Woreda in the East and Oromia regional state in the South (Figure 1). Dejen Woreda covers a total surface area of about 570.9 km² which makes it relatively a smaller Woreda in East Gojjam administrative zone. The woreda is almost encircled by the deep gorge of Abay (Blue Nile) river and its tributaries such as Bechet and Suha. Administratively, Dejen Woreda is currently divided in to 19 rural and 2 urban kebeles (Figure 2).

Topographically, Dejen Woreda is characterized by varying relief with altitudes ranging from about 1000 m at the Abay gorge to 2650 m in the northern limit. As a result, there is a pronounced difference among the dega, woina-dega and kola climatic zones. Most of the lands in the dega and woina-dega zones are flat plateaus. But areas lying in the kola climatic zone are characterized by extreme relief variations. Just like many other parts of Ethiopia, the climate of Dejen Woreda is greatly affected by altitude though other factors such as latitude and cloud cover do have their own
influence. As a result of great variations in terrain structures, three vertically stratified temperature zones are found in the Woreda (kola, woina-dega and dega). While woina-dega climate covers 48% of the total area, kola and dega climates constitute 39% & 13% of the woreda land mass. The average temperature and total annual rainfall of the district range between 20 and 24°C and 800 and 1200 mm, respectively (Dejen Woreda Agriculture Office (2018)).

2.2. Sample size and sampling techniques
This study follows multi-stage sampling procedures. First, one woreda, namely, Dejen is purposively selected among 17 woredas in East Gojam zone administration. Then, Kebele administrations in the woreda were grouped into two agro-ecological zones—kola (tropical) and woina-dega (sub-tropical). Second, a total of four kebeles, namely, Minj, Gelgelie, Sebshengo and Hagereselam (the first 2 kebeles with kola and the next 2 kebeles with woina-dega climate) were selected as representatives of the lowland and highland parts of the woreda. Third, respondent households were selected from each sample kebele using probability sampling techniques.

Sample size determination formula developed by Cochran (1977) was used to estimate the sample size from the population and presented as follows.

(i) For the infinite population, the formula use is;

\[ n_0 = \frac{z^2pq}{e^2} \]  

Where, \( n_0 \) is sample size, \( z \) is the selected value of desired confidence level, \( p \) is the estimated proportion of an attribute that is present in the population, \( q = 1 - p \) and \( e \), the desired level of precision.

(ii) From the finite population, the sample size is estimated as follows;

\[ n = \frac{n_0}{1 + \left( \frac{n_0 - 1}{N} \right)} \]
Here, \( n_0 \) is Cochran's sample size recommendation, \( N \) is the population size, and \( n \) is the new, adjusted sample size.

By using the above formula, the total number of respondents in this study was found to be 360 household heads. Proportional to their total household size, 86, 100, 90 and 84 households were selected as sample units from Sebshengo, Agere-selam, Gelgelie and Minj kebeles, respectively.

2.3. Data collection and analysis
Both primary and secondary data sources were used for this study. While secondary sources of data were extracted from policy documents, performance reports, and research papers through document reviews, primary data were generated using questionnaire, interview, focus group discussion, and observation.

- **Survey Questionnaire**—to obtain relevant data from 360 household heads, structured survey questionnaire was prepared. In the survey questionnaire, carefully formulated items are included which can capture information from the sample households on socio-economic issues, land tenure security issues, and land management practices.

- **Key Informant Interview**: key informant interview was employed using semi-structured guiding questions. Key informants who have rich knowledge and expertise on the issue under investigation as well as institutions involved directly or indirectly in the land management process were considered as interviewees. Interview with key informants included 40 individuals: 4 development agents (1 from each sample kebele), 2 woreda Environmental Protection, Land Administration and Use Authority (EPLAUA) experts, 2 woreda agriculture and rural development experts, 8 Kebele Land Administration Committee (KLAC) members (2 from each sample kebele) and 24 household heads (6 from each sample kebele).

- **Focus Group Discussion (FGD)**: Totally, 12 FGDs (3 in each sample kebele) were conducted with KLAC members and household heads in the sample kebeles. Each FGD had 5–8 participant members. Separate group discussions were also held with each sex (male and female) and age (youth and adult) categories.

- **Observation**: In this study, observation was widely used to gather data about land management practices and triangulate data generated through the aforementioned tools and techniques.

Data gathered from different sources using different tools were analyzed using qualitative and quantitative methods. To analyze qualitative data, the research employed narrative analysis and interpretive analysis methods. On the other hand, both descriptive and inferential statistics were utilized to analyze quantitative data. In addition to descriptive statistics as mean, percentage, frequency and standard deviation, the study also employed inferential statistics including chi-square test and double hurdle regression.

2.4. Model specification
This study employed double hurdle regression to evaluate households' participation decision and their level of participation in terracing practices. In the first hurdle of the regression, farmers' participation decision in terracing is measured as a dummy dependent variable (1 = participant, 0 = otherwise). In the second hurdle of the regression, farmers' level of participation in terracing was measured as a continuous dependent variable (number of days). The explanatory variables included are mixtures of continuous, ordinal and categorical items (detailed description of the explanatory variables is presented in Table 1). In sum, the double hurdle regression model is used to investigate the major factors that affect joint decisions of farmers as far as their participation in terracing practices is concerned.

Double-hurdle is the model introduced as a more flexible and alternative to Tobit model (Cragg, 1971). It assumes a two-step decision process: the first step involves the decision whether to participate in terracing and secondly the level of participation. The model estimation involves a Probit regression and truncated normal regression to identify factors affecting the decision to participate and level of participation in terracing in the first and second stages, respectively.
### Table 1. Variables, variable description and unit of measurement

| Variables                              | Variable Description                                                                 | Unit                        | Expected Signs |
|----------------------------------------|---------------------------------------------------------------------------------------|-----------------------------|----------------|
| PARTICIPATION LEVEL OF PARTICIPATION^1 | Decision on participation in terracing Level of participation in terracing            | Continuous (No of person days: where 1 day consists of 8 working hours on average) |                |
| Explanatory variables                  |                                                                                      |                             |                |
| SEX                                    | Sex of the household head                                                             | 1 = Male, 0 = Otherwise     | -              |
| AGE                                    | Age of the household head                                                             | Continuous                  | -              |
| EDUC                                   | Household head’s level of education                                                  | 1 = Illiterate, 2 = Read & Write, 3 = Grade Level | +              |
| FAM_SIZE_FARM                          | Family size engaged in farming                                                       | Continuous                  | +              |
| AGRO_ECO                               | Agro-ecology in which a household is found                                            | 1 = Kola, 0 = Woina-Dega    | -              |
| LANDSIZE                               | Land holding size of the household                                                   | Continuous                  | -              |
| TRAINING_LMP                           | Training on land management practices                                                | 1 = Yes, 0 = Otherwise      | +              |
| ACCESS_CREDIT                          | Households Access to credit services                                                 | 1 = Yes, 0 = Otherwise      | +              |
| SLOPE                                  | Slope of the land                                                                    | 1 = flat, 2 = moderate, 3 = steep | +              |

#### 2.5. Specification of double-hurdle model

The standard Probit model that assesses the household’s participation decision was described in Eq. (3) as:

\[
D_i = \alpha Z_i k + \epsilon_i \\
D_i = 1, \text{ if } D_i > 0, \text{ and } 0, \text{ if } D_i \leq 0 \tag{3}
\]

where \(D_i\) is a dummy variable that takes “1” if the household participates in terracing and “0” otherwise, \(Z_i\) is a vector of independent variables hypothesized to influence participation decision, \(\alpha\) is the regressor, \(\epsilon_i\) is error term.

In the second-stage, we used truncated regression that excludes part of sampled observation based on the value of the dependent variable. The regression considers the observations that take “1” for participation decision. Therefore, the second hurdle represents the actual level of participation in terracing activity expressed by the number of person days in which a farmer works for 8 hours per day, on average. The truncated regression model with the lower left truncation equal to “0” was also used to determine factors affecting the level of participation.

The truncated regression model for level of participation in terracing was described in Eq. (4) as:

\[
y_i = \beta x_i + \mu \lambda_i + \epsilon_i \\
y_i' = \beta' x_i + \epsilon_i' \\
y_i = \begin{cases} y_i' & \text{if } y_i' > 0 \text{ and } D_i = 1; 0 \text{ Otherwise} \end{cases} \tag{4}
\]

where \(y_i'\) and \(y_i\) are latent and the observed level of participation, respectively, \(x_i\) is a vector of variables influencing level of participation and \(\beta\) is a vector of parameters to be estimated. The error terms are assumed to be independently and normally distributed as: \(\epsilon_i \sim N(0, 1)\) and \(\epsilon_i' \sim N(0, \sigma^2)\).
The log-likelihood function for the double-hurdle model that nests Probit model and a truncated regression model is given following Engel and Moffatt (2014) as:

\[
\text{LogL} = \sum \ln \left[ 1 - \Phi(Z_i \alpha) \frac{x_i \beta}{\sigma} \right] + \sum \ln \left[ \Phi(Z_i \alpha) \frac{1}{\sigma} \frac{Y_i - x_i \beta}{\sigma} \right]
\]

(5)

Where,
- \(\Phi\) = represent standard normal probability
- \(\phi\) = density functions
- \(Z_i\) = independent variables for the probit model
- \(x_i\) = independent variables for truncated regression model
- \(\alpha, \sigma\) and \(\beta\) are parameters estimated from each model.

2.6. Working hypothesis and variable specification

Decisions to engage and level of engagement in long-term investments like terracing are made after considering various factors. In this regard, it is hypothesized that farmers’ decision to participate and their level of participation in terracing practices in the study area are affected by various socio-economic and physical factors. From literature review and experience, the following working hypotheses were made for the relationship between the dependent variables and each explanatory variable pertaining to sample households. Details of variables that are included in the model are indicated in Table 1.

3. Results and discussion

3.1. Descriptive results

As Table 2 clearly indicates, nearly equal numbers of samples were selected from kola and woina-dega agro-ecological zones that indicate the presence of comparable number of households in the two zones. But, one can see a great deal of disparity in the number of male and female
participants in the study. This is, however, not surprising for the total number of female-headed households in the study area is by far smaller in number than that of male-headed households. With regard to education, 31.9% of the participants are illiterate who are totally unable to read and write at least in their local language (Amharic). While 35.3% of the participants were able to read and write, the rest had attended some grade levels (32.8%).

Asked about their exposure to trainings on land management practices, an overwhelming majority of the participants (75%) indicated that they had never got any training of such kind. This result is against the chains of reports and media releases that propagate for the success of farmers’ trainings about land management practices including that of the study area. This implies that to be successful in terracing, the most important method is working on the minds of farmers inculcating in them about the benefits of training on issues related to land management practices thereby bring meaningful change on their knowledge, attitude and practices towards terracing.

The study also examined sample households’ access to credit service. Unexpectedly, 92.2% of the participants witnessed that they had access to credit services mostly from non-formal financial institutions (Table 2). Key informants and group discussants also confirmed that even though Amhara Credit and Saving Institution (ACSI) is the most dominant financial institution in the study area, its stringent group collateral system deters most from getting access to credit. Even if some get, the high interest rate is beyond what farmers could afford to repay.

Engagement in non-farm income generating activities is another variable considered in this study. As Table 2 depicts, 68.6% of the sample households participated in any one type of non-farm income generating activity in their kebele or out of their residence site. From this, it is possible to deduce that most farmers use their time to earn incomes from non-farm activities rather than investing their time and energy on terracing to maximize crop productivity suggesting an important trade-off between these two activities. Only about one-third (31.4%) of the total sample households were, however, found fully engaged in farming activities including construction of terraces.

In the process of land management practices like terracing, age plays a significant role due to the laborious nature of the work. Results of the descriptive analysis show that there is a range of 56 years between the older and younger household head. The average age was 47.18 years with a standard deviation of 12.22 years (Table 3). In terms of family size, the average figure stands at 5.19, which is greater than the regional and national averages (4.5 and 5.07 respectively; CSA, 2007). Available datum clearly showed that the study area is one of the most densely (193 Persons/Km²) populated woredas in Amhara region (Dejen Woreda Agriculture Office, 2018). This means that higher agricultural density has its own implications on land degradation and land management practices such as terracing.

Land holding size is the most basic and crucial issue for the livelihood of rural communities, as they depend on it directly for food and feed. Because the agricultural population density is very high (179 persons/km²), the average size of land holding for the sample households is found to be only 1.55 hectares with a standard deviation of 0.66 hectares, which is in fact a little bit larger than the national average (1.02 ha; Paul & Wa Githinji, 2018). There is also a great disparity in land holding size among the sample households. While the largest holding size is 3.5 hectares, the smallest holding is found to be 0.5 hectares. This implies that there is unfair possession of farming land among the farming communities that might be linked with the land tenure system of the government. With the average holding size of about 1.55 hectares, the mean number of plots owned by the sample households reaches 3.16, which is about 0.49 hectares for each plot if divided equally. This clearly indicates the presence of land fragmentation in the study area that is one factor for the most accelerated land degradation in the study area (Table 3).
Table 3. Descriptive statistics of continuous variables

| Descriptive Statistics | N   | Minimum | Maximum | Mean   | Std. Dev. |
|------------------------|-----|---------|---------|--------|-----------|
| Age of the household head | 360 | 20      | 76      | 47.18  | 12.219    |
| Household head's family size | 360 | 2       | 9       | 5.19   | 1.336     |
| Farmer's land holding size (ha) | 360 | .50     | 3.50    | 1.5515 | 0.657     |
| Number of plots hold by the farmer | 360 | 1       | 8       | 3.16   | 1.226     |
| Valid N (listwise) | 360 |         |         |        |           |

Source: Field survey, 2021

3.2. Farmers perception towards land degradation and conservation practices

The study area (Dejen woreda) is characterized by severe land degradation. More than one-third of the woreda’s landmass is lying in the Abbay Gorge and characterized by rugged topography that is suitable for soil erosion by running water. Moreover, both human and animal population are growing so rapidly and becoming beyond the carrying capacity of the woreda’s landmass. Literatures indicate that understanding farmers’ perceptions and knowledge about land degradation is fundamental to making wise decisions about sustainable land management (Mushir & Kedru, 2012; Woldemariam et al., 2013). As the study result clearly shows, sample households in the study area seem to have very high understanding about the existence of land degradation in their respective localities.

[N.B. Severity of land degradation (High = gully erosion; Medium = rill erosion and Low = sheet erosion) based on visual measurement]

Farmers’ life is directly attached with their land. They cultivate it, produce from it and the produce sustains not only the life of the farmers but also the life of all of us. So, they are very much concerned about their land more than anyone else. Results reveal that farmers are aware of the existence of land degradation in their respective kebeles. However, when asked about the severity of the problem, more than half (55.3%) of the participants responded that the level of land degradation can be rated as “medium”. While 37.8% of the respondents believe that there is high level of land degradation in their locality, only about 7% said that the severity of the land degradation problem is rather low (Table 4). This has an implication on their level of engagement in land management practices and decisions they make in allocating resources towards this end.

In terms of agro-ecological zones, perception of farmers vary on the severity of land degradation. For instance, while 35.6% of respondents from kola agro-ecology perceived the presence of high level of land degradation, the corresponding figure in the woina-dega agro-ecology is only 2.2%. Similarly, the majority of the respondents (44.4%) from woina-dega rated the existing land degradation level in their locality as “medium” while only 10.8% participants from kola region have the same perception. The difference in respondents’ perception on the severity of land degradation across agro-ecologies is also statistically significant with $X^2 (2) = 184.1$, p <0.001 (Table 4).

Key informants and group discussants have also revealed that farmers in the study area have been engaged in various land management practices as a response to the prevailing land degradation problem. Although different types of structural, biological and agronomic land management practices have been implemented by the rural community, the most common ones include terraces such as stone bund, stone-faced soil bund and soil bund. While stone bund and stone-faced soil bund are common types of terraces in the kola climatic zone, soil bund is widely
used in the woina-dega areas. In the kola agro-ecological zone, stone bund and stone-faced soil bund are found to be the dominant land management practices for two main reasons. First, the topography is so rugged and steeply which oblige farmers to construct such slope reducing structures as terraces in order to check the physical removal of the soil by the running water. Second, there is excess stone of different size that is an important input to construct stone bunds and stone-faced soil bunds. On the other hand, soil bund is the dominant land management structure in the woina-dega agro-ecological zone where the topography is flat or nearly flat, stone is a scarce resource and the soil has developed very thick profile. Compared to kola areas, the extent of land degradation in woina-dega areas is small which can be treated with such small structures as soil bund.

According to group discussants and key informants, terracing is the most commonly used land management practice in the study area. In the first place, it reduces slope gradient and runoff. Consequently, it reduces soil erosion and contributes to soil conservation. In line with this finding, various studies (Mekonnen & Getahun, 2020; Liu et al., 2018) found out that terracing has contributed to the reduction of runoff and soil loss. As a result of reduced erosion and enhanced conservation due to terracing, the soil becomes productive. In sum, they indicated that farmers usually strive for maximizing crop productivity by applying appropriate land management practices. However, participants could not cover their opinion about the negative sides of terraces. If, for example, terraces are poorly constructed, they have the potential to bring disastrous effects on the land itself and properties of the community upon failure. Besides, farmers claim that construction of terraces consumes a considerable amount of land so that it aggravates the scarcity of the farming land. In spite of these shortcomings, it is reported that farmers in the study area prefer to construct terrace as its advantages outweigh the possible shortcomings.

To evaluate the participation level of sample households, chi-square tests were run for terracing by sex and agro-ecology. As the data in Table 5 clearly show, there seems to be great difference between respondents from kola and woina-dega agro-ecologies in terms of participation level on terracing. While the majority (82.8%) of the participants from kola zone were engaged in terracing, the figure is very small (20.7%) for those from woina-dega agro-ecological zone. As group discussants pointed out, this disparity has a direct linkage with the severity level of land degradation in the two agro-ecological zones. Besides, it is only 52.8% of the participants who are engaged in terracing activities from the total 360 sample households. The disparity of engagement in terracing activities between kola and woina-dega residents was also found statistically significant with $X^2$ (1) = 139.133, P =0.000.

The study has also examined the participation level of male-headed and female-headed sample households in terracing practices. A little bit more than half of the total respondents (53.2% for males, 52.1% for females) from each sex group responded that they have engaged in terracing activities. From this result, it is possible to conclude that there is no difference
between male-headed and female headed sample households towards engagement in terracing. The chi-square results also suggested that the level of participation in terracing by male-headed and female-headed sample households is almost similar with $X^2 (1) = 0.012$, $P =0.914$. This result implies that both male and female households are trying to reverse the devastative effect of land degradation through implementation of various land management practices like terracing.

### 3.3. Result of econometric analysis

The decision to participate in terracing activity is mainly guided by the slope of the land and availability of stone. From the descriptive statistics, it is found that 52.8% of the total participants participated in terracing activities. Most of them are from Kola agro-climatic areas where the topography is steeply where stone is an abundant resource (Table 6). To the contrary, the level of participation in terracing varies from household to household depending on various socio-economic and environmental factors. While the least amount of participation in terracing activity is 1 person day per year, the highest participation level is 62 person days per year, which clearly depicts the presence of great disparity in participation level among farmers in the study area. With an average amount of participation of about 38 days per year and a standard deviation of 22.158, the result implies that a household invests $\frac{1}{10}$ of its time in a year on terracing activities.

As evident in Table 7, double hurdle model was used to estimate the determinants of decision to participate and amount of participation in terracing activities. The analysis reveals that there are some differences in terms of variable type as well as the magnitude and direction of determinants significantly affecting the decision to participate and the level of participation in terracing practice.

#### 3.3.1. Determinants of the decision to participate in terracing practice (First hurdle)

**Sex**: is found to have a negative correlation with farmers’ decision to participate in terracing. The result is statistically significant at 5% level ($P =0.047$) which implies that being female reduces the probability of participation in terracing activities. The marginal effect revealed that being female reduces the probability of participation in terracing by 16.3% provided that all other variables are held constant. The finding is consistent with the results of some studies (Aberha, 2008; Eleni, 2008; Tiwari et al., 2008). The finding is not surprising owing to female is physically weaker than male in such strong works as terrace construction. Moreover, it is reported during interviews that there is a culturally accepted practice in the study area that says that “constructing terraces is the role of males”. For they have limited exposure to it due to the aforementioned belief, female farmers lacked the know-how to build terraces even if they tried to do so.
### Table 6. Summary statistics for dependent variables (participation decision and level of participation in terracing activity)

| Have you ever participated in terracing activities? | Frequency | Percent | Cum. percent |
|------------------------------------------------------|-----------|---------|--------------|
| Yes                                                  | 190       | 52.8    | 52.8         |
| No                                                   | 170       | 47.2    | 100          |
| Total                                                | 360       |         |              |

| Variable                                                                 | Obs. | Mean   | Std. Dev. | Min. | Max. |
|--------------------------------------------------------------------------|------|--------|-----------|------|------|
| Level of participation in terracing activities (days/year)               | 190  | 37.967 | 22.158    | 1    | 62   |

Source: Field survey, 2021

3.3.1.1. Family size engaged in farming. As the regression results in Table 7 indicated, family size engaged in farming influenced the possibility of deciding to participate in terracing activities positively and significantly at 1% level (p = 0.003). The Probit model result confirmed that households with larger family size engaged in farming are more likely to decide to participate in terracing practices compared to their counterparts. The regression result indicated that the probability of deciding to participate in terracing increases by 12.5% as the number of family size engaged in farming increases by one person. This is due to the fact that terracing is labor demanding, as findings of other studies also reveal corroborating evidence (Addisu et al., 2015; Kerse, 2018; Mekuriaw et al., 2018; Belachew et al., 2020; Yifru et al., 2022).

3.3.1.2. Land size. Households’ farming land size determines their decision to participate in terracing practices. By its nature, constructing terrace on farmland consumes a considerable amount of land. Thus, households with larger landholding size have the higher possibility to decide to participate in terracing activities. The result of this study also showed that land size has a positive and significant association with farmers’ decision to participate in terracing at 5% level of significance (p =0.05). For every 1-ha increase in landholding size, the probability of households’ decision to participate in terracing increases by 13.95% (Table 7). This result is also in line with the findings of Sileshi et al. (2019) and Wolka and Negash (2014).

3.3.1.3. Slope of land. Slope influences farmers’ conservation decision positively for the reason that erosion is more serious on steeper plots than on flat plots. As the data in Table 7 depict, slope of land is positively and significantly influencing farmers’ decision to participate in terracing activities (p =0.000). Explicitly, the probability of farmers’ decision to participate in terracing practices increases by 70% for steeper slopes than flat slopes. This suggests that farmers are more likely to build terraces on steep slopes that are susceptible to more rapid surface runoff. The result is also in line with the finding of previous studies (Amsalu & De Graaff, 2007; Kerse, 2018; Desalew & Akilulu, 2017; Kassie et al., 2009; Wossen et al., 2015) who reported that slope of the land has positively and significantly affected farmers’ decision to participate in land management practices.

3.3.1.4. Training on land management practices. Training is expected to increase the knowledge, attitude and skill of the trainee. As a result, farmers who have got training on land management practices are expected to have higher likelihood to participate in terracing. The finding of this study is also consistent with the expectation. As shown in Table 7, training on land management practices has positively and significantly affected households’ decision to participate in terracing.
Table 7. Factors determining farmers’ decision to participate and level of participation in terracing (Double Hurdle Model)

| Tier 1                      | Coeff. | Std. Err. | Z    | P>|z|   | Marginal Effect (dy/dx) |
|----------------------------|--------|-----------|------|-------|------------------------|
| Sex of the household head  | −0.4197| 0.2429    | −1.73| 0.047 | −0.1630                |
| Age of the household head  | −0.0067| 0.0130    | −0.52| 0.822 | −0.0011                |
| Family size engaged in farming | 0.4578| 0.1182    | 3.87 | 0.003 | 0.1251                 |
| Education level of the household head | 0.4971| 0.2663    | 1.87 | 0.213 | 0.0720                 |
| Land size of the household | 0.4185| 0.1933    | 2.17 | 0.050 | 0.1395                 |
| Slope of the land          | 2.8310| 0.4595    | 6.16 | 0.000 | 0.7002                 |
| Agro-ecology               | 0.2269| 0.2175    | 1.04 | 0.544 | 0.0508                 |
| Access to credit service   | 0.2044| 0.3482    | 0.59 | 0.586 | 0.0718                 |
| Training on land management practice | 1.1617| 0.3609    | 4.62 | 0.000 | 0.4289                 |
| Constant                   | −0.0153| 1.0022    | 0.10 | 0.987 |                        |

| Tier 2                      | Coeff. | Std. Err. | Z    | P>|z|   |
|----------------------------|--------|-----------|------|-------|
| Sex of the household head  | −0.5454| 0.2053    | −2.66| 0.008 |
| Age of the household head  | −0.0126| 0.0109    | −1.15| 0.248 |
| Family size engaged in farming | 0.1538| 0.1189    | 1.29 | 0.196 |
| Education level of the household head | −0.0028| 0.2339    | −0.01| 0.991 |
| Land size of the household | 1.2596| 0.1556    | 8.10 | 0.000 |
| Agro-ecology               | −0.1551| 0.1646    | −0.94| 0.346 |
| Access to credit service   | 0.5430| 0.2248    | 2.42 | 0.016 |
| Slope of the land          | 3.8417| 0.3960    | 9.70 | 0.000 |
| Training on land management practice | 0.7604| 0.2428    | 3.13 | 0.002 |
| _cons                      | 2.5296| 0.8201    | 3.08 | 0.002 |
| Sigma                      |        |           |      |       |
| _cons                      | 0.9245| 0.0542    | 17.05| 0.000 |

Source: Field survey, 2021
at 1% level of significance \( (p = 0.000) \). The probability of households to participate in terracing increases by 42.9% for those who took training on land management practices. This result is also in line with the findings of other studies (Guteta & Abegaz, 2015; Ketema & Bauer, 2012; Addisu et al., 2015; Kerse, 2018; Dufera et al., 2020; Adetoro, 2021).

(N.B. Tier 1 is participation in terracing and Tier 2 is level of participation).

3.3.2. Determinants of the level of participation in terracing practices (Second Hurdle)

The second stage of the Double Hurdle model measured the level of participation in terracing activities among participant households. The level of participation in terracing practice is significantly affected by five explanatory variables. As shown in Table 7, the result of the second hurdle indicates that variables such as sex, land size, slope of land, access to credit and training on land management practices are the significant factors that affect farmers’ level of participation in terracing activities.

3.3.3. Sex

In the first hurdle, sex was found to have a negative and significant role in determining households’ decision to participate in terracing activity \( (p < 0.05) \) indicating that male-headed households have higher participation in terracing activities than female-headed households. In the second hurdle, too, sex is found to have a negative and significant contribution in determining households’ level of participation in terracing activities \( (p < 0.01; \text{Table 7}) \). This implies that being female reduces the level of participation in terracing activities by 54.5%, which is consistent with the finding of Asfaw and Neka (2017). As per information gained from interviews, this is due to gender stereotypes in the study area that propagate the idea that constructing terraces is the role of males. Females are also highly absorbed in household works like cooking food, caring for children and all other household chores. As a result, female farmers lack the time to build terraces in their farmlands even if they wish to do so.

3.3.4. Landholding size

It is true that terrace construction consumes a considerable size of land with in a plot. Hence, farmers’ decision to engage in terrace construction depends on the size of their plots. As the second hurdle result in Table 7 indicated, plot size has positively and significantly affected households’ level of participation in terracing at 1% level. The result clearly showed that 1-ha increase in landholding size increases the level of households’ participation in terracing activity by 125.9%. This result is also in line with the findings of Sileshi et al. (2019), Girma (2017), Dachito and Angelo (2021), and Wolka and Negash (2014).

3.3.5. Slope of land

by its nature, terraces are constructed on farmlands mainly to minimize soil erosion and enhance soil fertility. On the other hand, the magnitude of soil erosion and necessity of terrace construction in a farmland depends on the nature of its slope. As the findings of this study pointed out, slope of the land is positively correlated with farmer’s level of participation in terracing activities that is significant at 1% level \( (p = 0.000) \). The result showed that as the steepness of the land increases by 1%, farmer’s participation in terracing practice also increases by 384%. This implies that households farming on steeper lands are more frequently to engage in terrace construction than less steep lands. Slope of land is, therefore, the most influential variable in shaping farmers’ level of participation in terracing activities. As farmers with farmlands of steeper slope perceive the presence of severe soil erosion, they frequently and actively participate in terracing practices. The findings of this study are also consistent with the results of other studies (Belete, ; Desalew & Aklilu, 2017) who reported that slope of land has a statistically significant and positive correlation with farmer level of participation in terracing activities.

3.3.6. Access to credit service

most households in the study district are poor. So, access to credit service is seen as a way out of the poverty trap and through it to carry out their agricultural practices. Moreover, farmers use the money to build physical land management practices like terrace. As can be seen from the second hurdle in Table 7, there is a positive and significant relationship between credit access and
households' level of participation in terracing activities. For those households who have easier access to credit service, their level of participation in terracing activity increase by 54.3%, which is significant at 5% level. This result is also similar with the findings of Abebe and Sewnet (2014) and Tesfaye et al. (2014). As explained by key informants, access to credit service enabled women and the aged, who are less able to engage in terracing for it seeks high energy, to hire labour force and buy tools/implements in order to get their farmland terraced.

3.3.7. Training on land management practices
In most literatures, there is a positive and significant relationship between training and level of involvement in land management practices (Guteta & Abegaz, 2015; Ketema & Bauer, 2012; Addisu et al., 2015; Kerse, 2018; Dufera et al., 2020). This implies that getting training on land management practices increases farmers' level of participation in terracing practices as the knowledge gained through training enables farmers to be equipped with the technical know-how required for constructing terraces. The result of this study is also consistent with the findings of the aforementioned studies. For additional training a farmer takes, the level of his/her participation on terracing activity increases by 76%, which is significant at 1% level (Table 7). Whenever farmers take trainings on land management practices, they acquire adequate and relevant information and technical skill on how they construct terraces that consequently increase their level of participation.

4. Conclusions
Land degradation is a crucial environmental problem directly affecting the livelihood of the rural community in Ethiopia. Amhara region in which this study has been carried out is one of the most severely affected by land degradation in the form of soil erosion. Being cognizant of the threatening effect of land degradation, both the government and the rural community have been engaged in various land management practices since the 1970s. The management practices were, however, mainly focused on physical structures like terracing. Even if the physical structures implemented for the last few decades are criticized for not fully achieving the intended targets, it is an observable fact that these structures have protected the land from severe degradation. Specifically, this study has assessed the participation decision and participation level of rural households in terracing activities and found encouraging results in both cases. However, various socio-economic and physical factors are found to have negative effects on households' decision to participate and level of participation in terracing. One serious problem identified in this study is the role of female headed households in the terracing activity. Their decision to participate and level of participation are found to be very low due to various social and economic reasons. As a solution to this problem, the study recommends that both woreda and kebele level agricultural experts and other stakeholders should find mechanisms to support female headed households to enhance their socio-economic capacity that enables them to increase their decision and level of participation in terracing activities.

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Author details
Mengistie Mersha1
E-mail: mengiste123@yahoo.com
Bamlaku Alamirew2
Linger Ayele1
1 Department of Geography and Environmental Studies, University of Gondar, Gondar, Ethiopia.
2 Department of Project Planning and Management, Yom Postgraduate College, Addis Ababa, Ethiopia.

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Notes
1. Woreda is lower administrative unit next to zone.
2. Kolla, Woina Dega and Dega agro-ecological zones lies between 500–1500, 1500–2300 and 2300–3200 mean above sea level, respectively.
3. Area terraced could have been a better variable. However, due to fragmentation of plots and lack of records, farmers do not know the exact area terraced. Instead, what they recall is the number of 8-hour person days that they allotted for terracing activities in different plots that they farm.

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