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The livelihood effects of landless people through communal hillside conservation in Tigray Region, Ethiopia

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In the *Tigray* region of northern Ethiopia, landless people contributed to the existing land degradation by exploiting the economic possibilities of natural resources from communal hillside areas. This has been practically observed in the area that the landless people have been depending on the available natural resources to supplement their means of living through sales of timber, fire-wood and charcoal. To address this problem, the *Tigray* Regional State has distributed denuded hillside areas to the landless people. It was believed that renovating bared mountain hillsides through conservation practices could serve as a means to create livelihood sources for the landless poor. This study has been inspired to investigate whether the introduction of communal hillside distribution to the landless people has resulted in livelihood and environmental improvements in the *Tigray* Regional State. Six districts were randomly selected namely; *Kola-Tembien*, *Hintalo-Wejerat, Kilte-Awlalo, Degua-Tembien, Alaje and Ofla* which all represented by 450 sampled respondents (418 males and 32 females). The respondents were interviewed using semi-structured questionnaires including ideas from group discussants and key informants. Results revealed that landless in all the districts applied conservation methods mainly of stone bund, trench and tree plantation. Their main livelihood sources using the hillside areas were; production of honey, fruits, livestock products, timber, vegetables, fuel-wood and animal fodder. Estimated results further indicated that supporting services given by forest experts and local authorities, credit access, membership in the village development committee, respondents' perception to land degradation and their educational levels were the major inducing factors that affect landless people to participate in hillside conservation.

Key words: Conservation, degradation, hillsides, landless, livelihood, sustainable, people.

INTRODUCTION

At global level, natural resource degradation on mountains slopes is widely believed to be one of the causes of environmental damage that expedites the adverse effects of climate change. The increased effect of this degradation coupled with climate change (Sanchez and Leakey, 1997; Havstad et al., 2007)

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has led to the decline in agricultural productivity in the Global South. The consequent loss in land productivity results in global economic and social crisis that is the dominant threat to the security and well-being of populations of most countries of the Global South (Fitsum et al., 1999; Hengsdijk et al., 2005; Atakilte et al., 2006). As much of the sources of land damage have prevailed on steep communal hillside areas and the available resources are fully accessible to the advantage of everyone, the issues of environmental management have become priority concerns in these countries (Gebremedhin et al., 2003). Cognizance of resource mismanagement due to the presence of externalities arising from communal resource overutilization, two collective action theories proposed by Hardin (1968) and Ostrom (1990) have developed over time. The mantra of each theory is based on the existing common resource challenges and thus it seems reasonable to view the analysis of this study in light of both theories.

From the time that Hardin (1968) published his article "The Tragedy of the Commons", many scholars understood that communal resources were often severely exposed to maximum overexploitation by free riders within any given community. For Hardin, it was assumed that individuals proceed to satisfy their self-interest by over utilizing the common resources with no regard for others, which would eventually damage the communal resource bases (Hardin, 1968; Welch, 1983). Their underpinning proposition was based on the absence of individual incentives to utilize communal resources in efficient ways. According to this theory, common pool resources can be managed through central stewardship either by a government or through privatization. The reason cited for this is that individual incentives evolving from numerous benefits are associated with property rights over long term, and thus privately owned resources are more sustainable than publicly owned resources.

An increasing number of scholars oppose Hardin's theory and base their reasons for their opinion that the source of the problems highlighted in 'tragedy of the commons' did not originate from the failure of common property ownership, but rather from institutional and policy failures to manage communal resources, nor the individual's mismanagement to enforce internal decisions for collective actions at communal level (Ostrom, 1990; Beaumont and Walker, 1996; Poteete and Ostrom, 2000; Forsyth, 2006). These scholars conceived that decentralized collective management of common property resources by users could be an appropriate system for overrating the 'tragedy of the commons' (Agrawal, 2001; Ostrom, 2008). As viewed by Trivers (1971), the tragedy of commons can be solved via people's dedication to manage communal resources altogether. As people exist within social bonds, they interact closely, including experience sharing among each, common cooperation against free-riders, and creation of local bylaws and binding regulations.

Furthermore, Axelrod and Hamilton (1981) contended that relationships among people usually strengthened due to their learning behaviour for cooperation in mutuality sense. In this sense, global environmental damages can be addressed via international collective actions (Ostrom, 2008).

The above debates over how communal resources can compatibly be governed by local community and which approach can plausibly be applicable for renovating the denuded resources have been studied widely. However, there is scant information on distributed mountainous hillside areas and how landless people utilize communal hillside resources and how the resources can be brought back into their natural green scenery. Such similar cases are apparently observed in the Tigray region of northern Ethiopia where land degradation is the major reason for low level of land productivity and devoid of vegetation (Hengsdijk et al., 2005; Wolde et al., 2007). Many landless people depended on the remnants of communal hillside forest patches by selling fire-wood and charcoal, timbering, traditional mining, cutting tree branches and herbaceous woods to feed their animals. This has further spirally escalated the ill-effects of land degradation (Hurni et al., 2005; Carolyn and Asenso, 2011). Due to their dependency on communal forest patches, lot of erosion is taking place and the areas are getting degraded year by year. In the upper catchment hillside mountain areas where many people cut-down live trees for firewood and charcoal sales, the position of forestland is being further exposed to severe land degradation (Badege, 2009). In other land areas in which mining and logging of trees have been taking place, large trees are almost lost, only bushes and stony degraded areas can be seen. At present, big trees can be observed only near to churches and mosques.

The increasing problem of landlessness in the areas has put pressure on the local administrators to rethink about the sustainable use of non-arable hillside mountains. The strategy designed was distributing the bared hillside areas to the landless people; after first establishing structures for soil and water conservation through community mobilization (Yifter et al., 2005; Carolyn and Asenso, 2011). Such hillside distribution to the landless poor started in 1999 in the Tigray region. As the result, landless people have conserved the areas by planting fruit trees, growing fodder for their cattle and engaging in honey production. The distribution of non-arable hillside areas to the landless people has two advantages; the areas which were previously found denuded are recently getting renovated, and, the landless people whose means of living previously depending on fuel-wood sales and traditional mining have started shifting to the production of fodder trees, fruits, vegetables, honey and commercial timber trees like eucalyptus.

However, those landless people who do not have access to other means of living are still dependent on the

hillside communal forests. Since they contributed to deforestation and land degradation, it is reasonable to address the problem by creating long-term linkages between livelihood sources and hillside conservation so as to enable the landless people to utilize the hillside areas in sustainable ways. In a community of having shortage of arable land like in the Tigray Region, linking hillside distribution to the landless people and conservation is crucial. Therefore, a clear understanding on the livelihood effects of landless people's participation on hillside conservation is helpful in bringing long-lasting hillside renovation. In doing this, the objectives of the study were:

(1) To examine perception of landless people on land degradation
(2) To verify the contributions of chosen hillside rehabilitation activities to the livelihood of landless people.
(3) To identify factors that affect the participation of landless people on hillside conservation

MATERIALS AND METHODS

Sampling design

Field survey was done in the Tigray Regional State of northern Ethiopia during 1 April to 30 May, 2013. In the study area, many landless people were reaping benefits by practising hillside rehabilitation. Following Atakilte et al. (2006), the six research sites selected for this study were categorized on the basis of their agro-climatic classifications. Areas below 1500 m above sea level are considered as lowland (*Quola*), areas situated at 1500 to 2300 m above sea level are medium altitude (*Weina-Degua*); and the areas over 2300 m above sea level are highland (*Degua*). Based on these classifications, *Quola-Tembien* is located at an altitude of 800 to 1500 m above sea level in a lowland district. While *Degua-Tembien* (midland) is situated at an altitude of 1200 to 2100 m above sea level, *Kilte-Awlalo* and *Hintalo-Wejerat* (midland) are found at an altitude of 1500 to 2540 m above sea level. The high land areas of *Alaje and Korem* are also positioned with a proxy altitude range of 2300 to 3140 m above sea level.

Across all climatic zones, the Tigray Regional government is the first region that has undertaken distribution of bared communal hillside areas to landless people to enable them access to various livelihood sources in a sustainable way. In Tigray region, there are 35 *woredas* (districts) that have distributed non-arable hillside areas to the landless people. During sampling, criteria were used so as to distinctively identify the districts that have fully practised the hillside rehabilitation from those did not. They were:

(1) Districts that distributed hillside areas to landless people
(2) The presence of landless people whose livelihood sources depend on the conserved and improved hillside areas
(3) Landless people who have got training regarding hillside rehabilitation.

Six districts that have fulfilled the criteria were selected and the survey was conducted across three stratified agro ecological zones (lowland, midland and highland). From each agro ecological zone, individual sample representatives were selected using simple random sampling technique. Following Chand et al. (2012), the required sample size was estimated at 99% confidence level and below 1% error commitment as shown below:

$$n = \frac{NZ^2P(1-P)}{N.e + Z^2P(1-P)}$$

Where: n = is the sample size, N = is the population size, Z= Confidence level at 99%, Z=2.57, P= Estimated population proportion (0.5), e = is the error level (0.003).

Based on the sampling estimation made out of the total 1808 population size, the required sample size was 450. Doing a proportionate stratification from the total 1679 males and 129 females, the representative sampled households were 418 males and 32 females drawn from each of the three agro ecological zone (117 from lowland, 166 from midland and 167 from highland) as shown in Table 1.

Data sources and collection

This study was based on data obtained from both secondary and primary sources. Due to the wide ranging implications of the involvement of landless people into hillside conservation to generate their income, primary data were broadly collected by mixing both qualitative and quantitative methods. The following methodological approaches were employed to address the objectives. In order to bring together logical information addressing the research objectives, eight key informants were taken. The selection of the key informants was based on their experiences, better technical knowledge on hillside conservation, representatives of both men and women landless people and village leaders drawn from each district. In the presence of the chosen discussants, the whole thing was open for discussion and the informants were participating to criticize, correct, or point out, and answer in any way based on the context of their villages. The eight key informants participated in the in-depth interviews were: animal expert, two experienced farmers (a male and a female), forest expert, representative elder, leader of Farmers' Association, Women's Association and leader of development committee.

Dependent and independent variables

Dependent variable

The dependent variables are two consecutive hillside conservation actions. The first one is participation of landless people on hillside conservation and the next one is the amount of conservation done by the landless people, measured in meters of stone/soil bund.

Independent variables

Some of the independent variables are: income sources from the hillside areas, (household demographics such as gender, age, education, marital status of household head), active family size, value of livelihood assets gained from the hillside rehabilitation, cattle size, land size in the hillside, non-cattle tropical livestock unit, access to water sources, cost of conservation, cost on water use, new hillside conservation strategies, conservation methods, source of information, experience in hillside conservation, contact with extension agents, member of farmers association, satisfaction with improved tree varieties, access to off-farm activities, location of the hillside area, hillside income, non-hillside income, etc).

Table 1. Sample frame of the respondents.

Agroecological zone	Sex	Population	Sample
	Females	29	8
Lowland	Males	403	109
	Total	432	117
	Females	60	15
Midland	Males	844	151
	Total	904	166
	Females	40	9
Highland	Males	431	158
	Total	464	167
	Females	128	32
Total	Males	1680	167
	Total	1808	450

Data analyses

Both qualitative and quantitative data analyses methods were applied. Qualitative data analysis was carried out to capture information that was collected from key informant interviews, household surveys, and direct observations. As the project uses a mix of methods to understand the richness and complexity of the hillside conservation and their effects on the benefits of landless people, data triangulation was used to analyse, validate and verify the results. During triangulation, the results from different methods of qualitative and quantitative information were compared to strengthen the outcome of the project. To analyse the linkages between livelihood sources obtained from the hillside areas and the role of the landless people on hillside conservation, descriptive statistics such as measures of central tendency and dispersion were employed. The strength and direction of relationships between different selected dependent and independent variables were examined using statistical tests like chi-square to look at the associations between discrete variables and t-tests to compare the mean differences between continuous variables.

Econometrics techniques

To identify various factors that influence the involvement of landless people on hillside conservation the two-stage Heckman model was applied. Conservation activities can be influenced by various explanatory factors. Some of these factors can be household-behaviours, income levels and sources, resource availabilities, land management and institutional variables. In this view, it is possible to analyse the different factors that instigate landless people to participate in environmental rehabilitation. Households in the study areas undertake two decisions (such as decision of participation in hillside conservation and construct some amount of stone-bunds, trench, tree plantations, and others in the hill-side areas) as the activity provides them a certain threshold level of utility in terms of yield gained from the improved hillsides after rehabilitation, (fodder, honey or fruit produce or commercial trees).

The choice that the landless people have to make is based on the unobserved utility obtained from participation in those activities. These kinds of choice models assume that an individual household's choice is the result of his/her preference (Wooldridge, 2002). In such a scenario, some of the factors that influence the behaviour of landless people in conservation participation activities may also influence their performances on the level of conservation or produce using the hillside. Analytical estimation of the outcome equation (hillside conservation in meters) alone would be, therefore, biased in the presence of sample selection. Sample selection may occur as a result of self-selection by research units (observation units – landless people in this case). The resulting bias (sample selection bias) emanates from the correlation between the error term and independent variables (Heckman, 1979; Verbeek, 2004). All these problems basically may arise from endogenous relationships among variables, measurement error of variables and missing cases of variables. Hence, the selection equation in the first stage of the Heckman two-stage model is accountable to capture factors affecting participation decision made by the landless people. This equation is used to construct a selectivity term known as the 'Inverse Mills ratio' which is added to the second stage 'outcome' equation' so as to explain factors affecting hillside conservation measured in meters. The inverse Mill's ratio is a variable for controlling bias due to sample selection (Heckman, 1979). The second stage involves including the Mills ratio to the amount of hillside conservation to be measured in meters and estimating the equation using Ordinary Least Square (OLS). Moreover, with the inclusion of extra term (inverse Mill's ratio) into the second stage, the coefficient in the second stage 'selectivity corrected' equation becomes to be unbiased (Wooldrige, 2002; Verbeek, 2004). Specification of the Heckman two-step procedure, which is written in terms of the probability of landless people to participate in hillside conservation, is given as follows:

$$\left.\begin{aligned} z_i^* &= \theta_i x_i + \varepsilon_i \\ z_i &= 1 \quad \text{if } z_i^* > 0 \\ z_i &= 0 \quad \text{if } z_i^* \le 0 \end{aligned}\right\} \; \textit{Selection Equation} \tag{1}$$

$$\left.\begin{aligned} y_i^* &= \lambda_i v_i + u_i \\ y_i^* &= y_i \quad \text{if } z_i = 1 \\ y_i &\text{ is not observed if } z_i = 0 \end{aligned}\right\} \; \textit{Outcome Equation}$$

$$\text{Where } (i = 1, 2, 3 \ldots n) \text{ for both equations} \tag{2}$$

Table 2. Socio-economic characteristics of the landless people.

Socio-economic characteristics of landless people	Mean	Minimum	Maximum
Age in years	40.9	20	68
Experience in years	7.4	3	12
Cattle Holding (cows and oxen)	2.5	1	7
Family size	2.8	1	6
Net gain in Birr annually	783.3	20	2330

In this case, the amount of hillside conservation measured in meters represented by Equation (2) becomes the outcome equation- the variable on which we are interested to see the effect of various factors and the income gained from the hillsides. Equation (1) represents the decision for the participation activities of the landless people become the selection (precondition) equation. The overall selection model indicates that the extent of hillside conservation (y_i^*) is observed when a given landless household (*i*) participates in conservation activities, that is, z_i= 1. In the given model, in Equations (1) and (2), sample selection occurs when the correlation between the error terms of the two models, corr(ε_i , u_i) = ρ, is different from zero, assuming that the error terms ε_i and u_i are jointly normally distributed, independently of x_i and v_i , with zero expectations. Both x_i and v_i are the vectors of independent variables that affect the participation of landless households on hillside conservation. In the presence of the selection bias, typical models such as probit models are inefficient and OLS estimation is biased (Verbeek, 2004). Thus, the implication is that the selection problem should be corrected and we need a superior estimator for this. Based upon the specification of the dependent variable of the outcome equation, the two-step Heckman selection model is appropriate.

RESULTS AND DICUSSION

Socio-economic characteristics of respondents

According to the criteria profoundedly categorized by Jacobsen (1999), the *age* between 15-64 years was active labour force population, whereas people whose age less are than 15 years and the older people whose ages exceeding 64 years were grouped as economically passive and dependent. Following this, the results shown in Table 2 indicate that the mean age of the sample respondents was found to be about 41 years; implying the involvement of the landless people mainly from the active labor force group. Out of the total 450 interviewed respondents, male landless people were 418 and females were 32. Based on additional ideas obtained from the key informants and group discussants, the females in these areas were dominantly burdened with indoor family management tasks and cultural stereotypes which hindered their participation in hillside conservation to support their own livelihood.

This finding has similarity with the studies made by Chala et al. (2012) and FAO (2012) in the sense that females in Ethiopia have cultural hindrances that obstructed their involvement in various developmental activities outside their home. It was found that women were engaged in family management of daily house tasks such as cooking, washing and taking care of their children. In most cases, the men acted as the head of the household; in making money and satisfying the family demand. The survey result further revealed that the landless people in the study areas had an average experience of 7.4 years in hillside conservation with a minimum of 3 and maximum 12 years. Each respondent consisted of an average family size 2.8, and owned a mean number of cattle about 2.5 with a minimum 1 and maximum 7. The average annual net gain reaped by the respondents out of their participation in the hillside rehabilitation was estimated in Ethiopian Birr 783 with a minimum of 20 and maximum 2330.

Perception of landless people and their particiaption on hillside conservation

The landless people were asked to elucidate their perception towards the damages they imposed on the environment due to their dependence for fire-wood and charcoal sales by exploiting the remnant forest areas. The key informants and group discussants reported that degradation on hillside areas was perceived as a problem hindering livelihood improvement and agricultural productivity in the study areas. The data gathered from the field survey further confirmed that the landless people sensitized the exisitng damages they were imposing on the environment such as charcoal and fire-wood extraction. About 95% of the interviewed landless people witnessed that the severity of land degradation in the area was getting worsened year to year. These respondents largely examined the incidence of land degradation predominantly occurred in denuded mountain hillside areas. Of the landless people who reported the problems of land degradation in the hillside areas, more than 86% admitted that their dependence on the mountain hillsides accelerated the damages. The remaining 5% of the respondents did not notice the prevalence of land degradation in the hillside areas (Table 3).

Table 4 depicts the summary of hillside conservation done by the landless people all over the six *woredas* (districts). The landless households participated in conservation activities of soil bund, stone bund, tree plantation and a mix of trench and bunds to rehabilitate

Table 3. Perception of landless people on land degradation.

Perceive land damages	Worsened	No Change	Improved
Frequency	427	15	8
Percentage	95	3.3	1.7

Table 4. Summary of hillside conservation done by the landless people.

Conservation methods	Observation	Mean	Std. Dev.	Min.	Max.
Soil/Stone bund in meters	421	111.5	51.3	32	196
Trench (in meter square)	450	22	9.5	0	53
Tree plantation (Number)	402	36	19.2	6	81
Mix of trench and stone bund	356	72	44.3	86	108

Table 5. Ways to achieve livelihoods of landless people using hillside conservation by woredas (Districts).

Income Sources	Woredas (Districts)							
	Alaje	Hintalo-wejerat	Degua-Tembien	Kilte-Awlalo	Quola-Tembien	Ofla	Frequency	Percent
Sale of timber/Fodder	3	14	4	11	7	7	46	10.2
Sales of vegetables	5	15	7	7	5	3	42	9.3
Sale of honey	12	22	14	37	10	22	117	26
Livestock	8	26	10	28	10	20	102	22.7
Sale of fuel-wood	7	16	5	16	7	11	62	13.8
Others	8	24	5	18	11	15	81	18
Percent	9.6	26	10	26.5	10.5	17.3	100	100

the hillside areas. On average, about 111.5 m of soil/stone bund was implemented by the landless people. The average number of trees planted by the landless people was about 36. Some efforts made by the landless households to implement conservation practices using trench was accounted for 22 m^2 during the year 2012/2013. Applying different types of conservation methods, the landless people in the area were to rehabilitate the denuded hillside areas from which they generated their income sustainably. The amount of soil and water conservation done in the hillside areas indicates that the landless people who have obtained land grants did not perform sufficient hillside conservation as compared to the hillside areas given to them. Group discussants mentioned that the large portion of the hillside areas distributed to the landless people has not yet been conserved. Another study done by Gebremedhin et al. (2003) similarly found that in the Tigray Regional State, various conservation measures have been carried out by community mobilization mainly of stone terraces and bunds, micro-dams, trenches, tree planting, area enclosures, regulations for grazing lands, control of burning and applications of natural fertilizers like manure and compost.

Contributions of chosen hillside conservation to the livelihoods of the landless poor

Table 5 illustrates the major ways through which the landless people pursued to improve their livelihoods by applying various hillside conservation methods. There is a potential for improving the livelihoods of the landless people by restoring the degraded hillside areas through their participation in various conservation methods. As the result of their participation, various income sources were created by the use of hillside areas. Out of the total income, the portion obtained from the sales of honey accounted for 26%. This was followed by 22.7% of the income share generated from the livestock products. Using the hillside areas, about 10.2% of the total income was reaped from sales of timber like commercial eucalyptus trees, and 9.3% was from sales of vegetables. While the landless people still continue to generate 13.8% of the total income sources from the sales of fire-wood and charcoal, the remaining 18% was from other income sources such as daily labour wage, pity business, poultry and sales of fodder. It is indicated in the figures that different livelihood sources have served the landless people as sources of additional income to supplement

Table 6. Total Annual Gain in Birr from the Hillsides by Agro-ecology.

Agro-ecology	Summary of Income from the Hillside Rehabilitation in Ethiopian Birr				
	Frequency	Mean	Standard Deviation	Minimum	Maximum
Lowland	117	778.2	436.1	32	2107
Midland	166	772.8	478.5	26	2327
Highland	167	797.2	433.6	20	2318

Table 7. Participation of landless people on hillside conservation using heckman regression.

Explanatory variables	Soil/Stone-bund		Explanatory variables	Soil/Stone-bund	
	Coefficient	P-Value		Coefficient	P-Value
Tree satisfy	1.056088	0.646	Religious leader	-4.461652	0.700
Benefit hillside	-2.763954	0.311	Social committee	.2037514	0.956
Experience	3.842082	0.323	Village justice	-17.01396	0.291
Absence of demarcation	-8.161377	0.122	Perceived degradation	24.37742	0.000***
Dummy advice	6.878082	0.021**	Farm size	4.426882	0.215
dummy extension	4.436521	0.007***	education	-7.33115	0.001***
age	-.5748796	0.057	credit	8.600637	0.000***
seedlings	.2487836	0.054	_cons	133.3123	0.000
Development committee	5.945144	0.047**			

Note that *** and ** are significant at 1 and 5% respectively.

their means of living. Sales of honey and livestock played a considerable role in supplementing the landless people with additional incomes.

The proportion of fuel-wood comprising both charcoal and fire-wood (13.8%) serving as an income source for the landless people has important implication that about 62 landless people were found to be dependent on the natural resource forests. This may show how their dependency on the natural forests has imposed them to pursue on their short-term perspective, whereby they stick to deal with the immediate livelihood needs without considering the long-term effects of their actions on the natural resource base. This requires compatible intervention that can reshape the direction of the landless people towards honey production, commercial tree plantation, livestock rearing and vegetables which are eco-friendly livelihood alternative sources. In light of these findings, similar conclusions made by Habibah (2010) indicating that farmers can only be active participant in conserving natural resources if they find that it gives them any kind of perceived benefits. Hence, all the benefits from the hillside areas should be clearly categorized as environment friendly and non-friendly so that the landless people could be directed towards the sustainable pathways. The landless people whose income sources generated from the hillside areas in each woreda (district) is presented in Table 5. The income share of the landless people by districts as ways of their livelihood sources were: Quola Tembien (37.1%), Hintalo-wejerat (26%), Ofla (17.3%), Degua-Tembien (10%) and Alaje (9.6).

The recorded annual income obtained by the landless people from the highland, midland and lowland agro-ecologies were on average 797.2, 772.8 and 778.2 birr, respectively (Table 6). The one way anova test revealed that there was no statistical and significance income differences among the three climatic zones. However, the big variations between the minimum and maximum income earnings in each agro-ecology indicates the need to intervene to narrow the disparities among the landless people.

Factors that affect participation of landless people on hillside conservation

Table 7 demonstrates the regression outputs of the two-stage Heckman Model to distinctively identify the major factors that induce the landless people to involve in hillside conservation. The coefficient of the inverse Mils ratio (lambda) using the Heckman first stage regression was statistically significant at 1% probability level (Prob > chi2 = 0.0000), indicating the presence of sample selection bias. After the correction of selection biases by including the inverse Mills ratio into the second stage of the Heckman model (OLS regression), the results were obtained as shown on Table 7.

Conservation was used as dependent variable which dominantly practiced by the farmers in the study area

such as soil and stone-bund measured in meters. Regressing the dependent variable soil/stone bund on the explanatory variables, the variables like extension services given by the agriculture experts (dummy extension), membership of the development committee in the village (*Development committee*), perceived land degradation (*Perceived degradation*), access to credit services (Credit) and educational level (*education*) are statistically significant at 1% probability level. The variable, dummy advice refers to support given to the landless people mainly from the local authorities which is statistically significant at 5% as shown in Table 7. It indicates that the more the landless people received advices from the forest experts and local leaders; they would be inspired to apply more meters of soil and stone bund in the mountainous hillsides. For instance, the landless people that received advice regarding hillside conservation implemented about 6.9 more meters than those did not receive the services, where the other intervening variables held constant.

The implication may be that the advisory service provided to the landless people is helpful in facilitating hillside conservation. This conforms to the view of Kashwan (2013) in the sense that development agents offer technical advices in conservation and bringing workable collaboration between the entire community and the forest users. Similarly, practical lessons and experiences disseminated by the forest experts and local leaders in the study areas hasten the action of the landless people through which the hillside areas have become livelihood sources for the landless people. This further encourages them to share responsibilities in hillside conservation along with the community which eventually leads to reduce social costs. Accordingly, the landless people and the community at large will have intimate knowledge in renovating the hillside areas sustainably and are able to monitor and protect the area from any threats.

The participation of the landless people at various development activities within the village is another important factor affecting the level of hillside conservation by the landless people. Hence, the landless people having exposure to participate as a village development committee (*Development committee*) tended to apply 5.9 more meters of soil and stone bund than the ordinary people. Their participation as a member of development committee in the village may broaden their awareness about the severity of land degradation.

Hence, the landless people that perceived the existing land degradation (*Perceived degradation*) implemented more stone bunds of about 24.4 m than those did not perceive. With respect to educational level, the landless people having high level of years of schooling may tend to conserve their environment. But, the Two-Stage Heckman model regression output shows that additional one year schooling on average decreases the participation of the landless people by about 7 m of stone and soil bunds in the hillsides (Table 7). The negative result indicates the decrease level for the landless people to participate in stone bund conservation. This was also supported by the key informants and group discussants in the sense that most of the landless people having higher level of education are assigned in various administration activities in the villages. In addition, some migrate to other places to search better income sources temporarily.

CONCLUSIONS AND SUGGESTIONS

Landless people have contributed to the existing land degradation by exploiting the economic possibilities of natural resources from the communal hillside areas. This has been practically observed in the hillside mountain areas from which landless people supplemented their livelihoods through sales of *fire-wood* and charcoal, timbering and fodder production, livestock rearing, growing fruit trees, and growing vegetable items. The study has been inspired to investigate whether the introduction of communal hillside distribution to the landless people has resulted in livelihood and environmental improvements in the Tigray Regional State. It was based to verify the idea that environmental rehabilitation in Tigray can be achieved via conservation of mountainous hillside areas with concurrent emphasis of supporting the livelihoods of the landless poor. The study revealed that landless people have tackled land degradation by applying various hillside conservation methods such as soil/stone bunds, trenches, tree plantation and zero grazing. However, lots of landless people have still relied on sales of fire-wood and charcoal to supplement their means of living. Besides, the people' participation on hillside conservation was found to be insufficient due to several restraint factors. The Heckman two-step regression output indicated that collaborative advisory services from forest experts and local authorities (dummy advice), membership in the village development committee (Development committee), landless people' perception on land degradation (Perceive degradation), extension services, credit accesses and educational levels are the major determinant factors that induce the landless people' participation on hillside conservation to improve their livelihoods. Therefore, the following actions can possibly be sound to use hillside areas sustainably:

(i) Provision of continuous support from local leaders and development agents by instigating the landless people to involve on hillside land grants and undertaking extensive conservation to improve their livelihood bases.
(ii) Build the capacity of the landless people through training, workshops, demonstrations, information dissemination, and experience sharing to increase their ability to utilize the hillside areas sustainably.

(iii) Enable the landless people to be fully detached from the sales of fire-wood and charcoal by providing substitutive income sources via communal hillside distributions.
(iv) Identify trees compatible to each agro-ecology and cultivate the hillside areas with trees that can bear fruits, and serve for animal feed.
(v) Plant bee forage, thereby increase honey yield with positive attitude for forest care and protection, which leads to sustainable job creation for landless people.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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