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Challenges and Opportunities of Degraded Land Rehabilitation in Northeastern Ethiopia: An Implication for Livelihood and Ecosystem Services Improvement

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Abstracts
Struggling land degradation is an international precedence with its strictness in developing countries. Despite, all rehabilitation efforts, land degradation is continuing with an aggregate rates in Ethiopia. Therefore, this study aimed at assessing challenges and opportunities of degraded land rehabilitation in Northeastern Ethiopia: an implication for livelihood and ecosystem services improvement. A multistage sampling method was used. Interviews, focus group discussion, key informant interview and informal discussions were made. Besides, field walks, field observation, and preliminary survey were conducted to identify the types of plants used for rehabilitation of degraded land and the success of rehabilitation practices in the area. The descriptive statistics such as mean, range, frequencies, and percentages were used. Majority of respondents (97.5%) perceive that there is land degradation problem in the study area. Moreover, 77.9% of respondents perceive that land degradation might be rehabilitated though it takes time. About 65.5%, 19.5%, 6.5%, and 4.5 of the respondents replied soil erosion, deforestation, overgrazing, and reduction of land productivity as the main forms of land degradation in their locality, respectively. Majority of respondents (68.5%) stated that rehabilitation practices previously carried out in the study area were not successful. Lack of follow-up by the implementing agencies, lack of watering, tending and protection of rehabilitated site from free grazing were among challenges that makes rehabilitation practice unsuccessful in the study area. Besides, low sense of ownership of rehabilitated site by the communities, poor seedling survival, land tenure & institutional problems, socio-economic problems and availability of limited livelihood options and higher degradation level of the site to be rehabilitated were reported as challenges that affect success of rehabilitation measures. However, the presence of willingness of communities to participate, presence of multi-purpose plants, government attention, involvement of various stockholders, and presence of diversified types of agro-ecologies for plant survival and huge degraded areas to be rehabilitated are among opportunities for rehabilitation of degraded land. It is concluded that rehabilitation efforts could not be successful unless those challenges are addressed. Therefore, frequent follow-up and applying tending operations, control of free grazing, planting edible trees for livelihood benefits and creating sense of ownership are strongly suggested to increase success of rehabilitation practices.
Keywords: ecosystem rehabilitation, ecosystem services, follow-up, free grazing, livelihoods
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1. Backgrounds

Land degradation which is a result of a long-term loss of ecosystems services (Baumgartner and Cherlet 2015) is environmental and developmental challenge of this era globally (Pendleton et al. 2012; Gashaw and Bantider 2014). However, land degradation is very sever in developing countries (Ezeaku and Davidson 2008; Lemenih and Kassa 2014; Jha et al. 2020). Recently, approximately 5 billion hectares (43% of the Earth's vegetated surface) have been degraded via soil erosion, deforestation, agricultural expansion, and human activities (Pendleton et al. 2012; Gashaw and Bantider 2014). Accordingly, land degradation is distressing 3.2 billion people globally and it takes many forms (Wolka 2014; Yirdaw et al. 2017) and affects forests, soils, water, biodiversity, livelihoods, and social services derived from the ecosystem (Nachtergaele et al. 2010; Baumgartner and Cherlet 2015). For example, from 1980 to 2000 more than half of the new agricultural land across the tropics was obtained by clearing intact forests (Chirwa et al. 2015). Therefore, the functioning of forest ecosystems and the capacity of forests to deliver ecosystem services were threatened by the loss of forests and biodiversity (Aerts and Honnay 2011).

Fighting land degradation is an international priority (Jha et al. 2020). It is one of the major socio-economic and environmental problems, affecting livelihoods of billions of people globally (FAO 1986; Rakodi 2014). Land degradation may occur at any time in any geographical region of the planet (Graham et al. 2014). Nevertheless, particular types of land degradation issues and their severity vary significantly in different parts of the world (Ezeaku and Davidson 2008). 500 to 600 million hectares (30-40%) of the forest area in the tropics is degraded (Acharya and Kafle 2009; de Paula et al. 2015; Jha et al. 2020).

Degradation is evident in a declining soil productivity, loss of biodiversity and increasing rate of soil erosion

(Watson et al. 2002; Blay et al. 2004; Mganga et al. 2010; Reubens et al. 2011; de Paula et al. 2015). The signs of land degradation included poor soil cover, dominance of undesirable plant species, low soil quality and erosion of top soil (Bajocco and Bajocco 2018). Accordingly, the indicators of land degradation can be grouped into three broad categories; biophysical indicators (degradation of soil, water and vegetation cover), socio- economic indicators (poverty and food insecurity) and institutional indicators (failures in the public/government, private/market, civil/community sectors and civil strife) (Mganga et al. 2010). The problem of land degradation can partly be reversed through re-vegetation or rehabilitation (Mganga et al. 2010). Ultimately, land deterioration and rehabilitation are human-made processes that depict how human civilizations utilize and appreciate the soil that sustains them (Haigh 2000).

Ecosystem functioning is (activities, processes or properties of ecosystems such as decomposition of organic matter, soil nutrient cycling and water retention), and consequently the ability of ecosystems to provide ecosystem services (Ezeaku and Davidson 2008). Ecosystem services have been defined as the benefits that people obtain from ecosystems (Ezeaku and Davidson 2008; Abera et al. 2020) such as 1) provisioning services (food, water, timber, and fiber) 2) regulating services that affect climate (carbon sequestration, pollination, biological pest control, floods, disease, wastes, and water quality) 3) cultural services that provide recreational, aesthetic, and spiritual benefits and 4) supporting services (soil formation, photosynthesis, and nutrient cycling) (Millennium Ecosystem Assessment (MA) 2005; Lemenih et al. 2007). From sub-Saharan Africa countries, 'Ethiopia is particularly threatened by land degradation processes due to high dependence of agriculture, population growth, frequent famine and poverty' (Lemenih and Kassa 2014). Ethiopia has a long history of severe deforestation and land degradation, particularly in the central and northern highlands, where towns and subsistence farming have altered the terrain for millennia (Lemenih and Kassa 2014; Darbyshire et al. 2015). Over the past three millennia, the northern Ethiopia has undergone cyclical deforestation (Darbyshire et al. 2015). Land degradation is a severe problem that leads to low agricultural productivity, which aggravates food security problems and one of the major environmental threats that have well been acknowledged as a serious problem in Ethiopia (Kahsay 2011) and it affects local climatic resources (Watson et al. 2002). Land rehabilitation practices in Ethiopia dated back to the 1985 famine in northern Ethiopia (Hoben 1995; de Paula et al. 2015).

Land degradation is a natural process or a human activity that causes the land to be unable to provide intended services for an extended time (FAO 1986; Oldeman 1992) or a reduction in the land's capability for production that may be temporary or permanent (Oldeman 1992). Land degradation, especially in the highland of Ethiopia, has been identified as the most serious Environmental problem (Feoli et al. 2002a; Kahsay 2011; Gashaw and Bantider 2014). 27 million hectares representing approximately 50% of the highlands in Ethiopia are degraded. Land degradation is more credible in Amhara Region as 90% of the population lives in the highlands and 90% of the regularly cropped land is found (Kahsay 2011; Gedefaw and Soromessa 2015; Meseret 2016; Yirdaw et al. 2017; Mekuria et al. 2018). Land degradation has contributed to the reduction of yield and at times to a complete loss of land productivity and human suffering (Koo et al. 2010; Fenetahun and Yong-dong 2019). Estimation indicates that agricultural soil degradation will cost Ethiopia about U.S $7246.4 million over the next 25 year of which this annual averages loss at U.S $290 million; nearly 80% the losses are attributed to the reduced crop production and the rest to reduced livestock production (FAO 1986). Land degradation increases farmers' vulnerability to drought by reducing soil depth and moisture-holding capacity (Ezeaku and Davidson 2008).

Following land degradation, ecological rehabilitation has recently started to adopt insights from the biodiversity-ecosystem functioning point of view (Lemenih et al. 2007). Rehabilitation consist of management interventions that aimed at recovering ecosystems that have been degraded, damaged or destroyed by human activities (Bojo and Cassells 1995). Therefore, ecological restoration is a crucial procedure that could raise biodiversity levels in ecosystems that have undergone human influence (Castro-Izaguirre et al. 2016), mitigate the impact of climate change and livelihoods (Lemenih et al. 2007; Perfecto and Vandermeer 2008; Lewis et al. 2013; Fenetahun and Yong-dong 2019). Following land degradation, the sustainable development goal 15 of the United Nations (UN) aims to "protect, restore and promote sustainable use of ecosystems and forests, combat desertification, end and reverse land degradation and biodiversity loss" (United Nations Human Settlements Programme 2006).

The rehabilitation interventions have resulted in dramatic biophysical changes within few years (Bojo and Cassells 1995; Jamison et al. 2010; Belete 2015). Rehabilitation contains little or no implication of recreating the original ecosystem (Feoli et al. 2002a). It is enhancing the productive capabilities of land in cropped, grazed, upland and downslope areas, flat and bottom lands; reforestation of deforested areas and maintain the integrity of watersheds for water supply for different uses and restore the capability of valuable land resources to serve farm and other productive activities (Birhane et al. 2017). It is an action to stop and reverse degradation land or mitigate the adverse effects of misuse (Jha et al. 2020). Rehabilitation is seen as the most viable way of mitigating the effects of land degradation (Belete 2015; Mesene 2017). Rehabilitation refers to any attempt at repairing or restoring a damaged ecosystem, without necessarily attempting a complete restoration to any specific prior conditions or status (Haigh 2000). The word 'rehabilitation' is used to indicate any act of improvement from a degraded state (Fenetahun and Yong-dong 2019). Degraded land rehabilitation works in a landscape level varies with site conditions, species types prevailing in an area, socioeconomic, policy, and political issues (Lamb and Gilmour 2003).Therefore, success in fighting land degradation requires an improved understanding of its opportunities and challenges that hinders it. Furthermore, clear understanding about the extent and impacts of land degradation and the rehabilitation practices undertaken so far will assist for future sustainable land management programs to enhance productivity of land in south Wollo (Gedefaw and Soromessa 2015).

Despite all rehabilitation efforts in Ethiopia, land degradation is continuing with an aggregate rate and have not been successful as such (Meseret 2016). 53 million hectares of land in Ethiopia is highly degraded and 13 million hectares of land will be deserted if urgent rehabilitation measures will not carried out (Lemenih et al. 2007). Similarly, large portion of land in south Wollo to date remains degraded as the intervention is limited to a smaller part (Gedefaw and Soromessa 2015). Thus, high lands of Wollo are facing problem of land degradation (Bojo and Cassells 1995; Little et al. 2006; Gedefaw and Soromessa 2015; Asfaw and Neka 2017; Teshome 2019). However, scientific study has not been carried out on issues related to challenges of land rehabilitation practices in Wollo (Tekle 1999; Lemenih et al. 2007; Birhane et al. 2017). Therefore, it requires scientific information on challenges and opportunities of degraded land rehabilitation in south Wollo zone (Tekle 1999). It is also sensible to study and address the challenges of land degradation in different areas as it require different dealings. Besides, there are limited information on factors that determined success of rehabilitation works. In an attempt to contribute bridging the gabs, this types of studies are a must. Accordingly, challenges need to be investigated and more targeted guidance would be very helpful to see which particular land rehabilitation approaches are likely to be successful (Tekle 1999; Fenetahun and Yong-dong 2019). Therefore, this study is aimed to 1) asses the perception of communities towards degraded land rehabilitation, 2) identify challenges and opportunities of degraded land rehabilitation practices, 3) identify plant species used for land rehabilitation, 4), asses the success of previous rehabilitation practices

3. Materials and Methods

3.1. Description of the study area

South Wollo zone is located at 10°10' N latitudes to 38° 28'E longitudes and has a total landmass of 17730.823 km (Alefew 2016) (Figure 1). North Wollo zone borders South Wollo zone on the north, East Gojjam zone on the west, South Gondar zone on the northwest, and North Shewa zone on the south, Afar Region on the northeast, and Oromia Zone and the Argobba special woreda on the east (Tekle 1999; Alefew 2016). The zone endowed with mosaic agro-ecological zones such as Kolla, 25.33%; Woina Dega, 40.03%; Dega, 33.15% and wourch, 1.49% (Gedefaw and Soromessa 2015). The mean annual rainfall in South Wollo ranges between 400 and 1600 mm and mean annual temperature between 10 and 25°C and drops with the increase in latitude (Gedefaw and Soromessa 2015).

Annual rainfall varies considerably from 900 to 1000 m and much of this rainfall falls in Belg (February to May) and Meher (June-September) (Tekle 1999). The area can be characterized as highly drought prone area (Tekle 1999). Based on the classification of Land Use Team Department, about 13% of the cultivated land and 44% of the total area of the zone is beyond 30° slope (Tekle 1999). The major soil types covering large parts of the region are phaezoms, cambisols, lithosols, and vertisols (Gedefaw and Soromessa 2015; Asfaw and Neka 2017; Agidew and Singh 2018). The major soil types of western part of the zone is vertisol followed by luvic and nitosol. The southern and eastern parts of the zone have cambisol, vertisol and dark brown silt clay soils, water logging as a result of poor surface drainage, shallow soil depth and Infertility (Tekle 1999).

South Wollo Zone has a total population of 2,518,862, of whom 1,248,698 are men and 1,270,164 women (Central statistics Authority 2007). South Wollo has a population density of 147.58. 301,638 or 11.98% are urban inhabitants while 89.4% of population lives rural areas (Central statistics Authority 2007). South Wollo zone had been reported to have a total of 598,447 households (Central statistics Authority 2007). 10.6% of the population engaged in non-farm related jobs, compared to the national average of 25% and a regional average of 21% (Tekle 1999). The increasing demand for agricultural land is being largely met by the expansion of agricultural land into marginal and steep slope areas (Tekle 1999; Belete 2015). Vegetation in the study area consists of Afroalpine and sub-Afroalpine vegetation, Juniperus forests, Podocarpus forests, Arundinaria (bamboo) forests, Juniperus and Acacia woodlands, steppe, and halophytic vegetation (Tesemma 2002). However, at present large parts of South Wollo are under intensive or moderate cultivation and grazing) and only in very few places can one see small patches of original or secondary forests (Belete 2015; Gedefaw and Soromessa 2015).

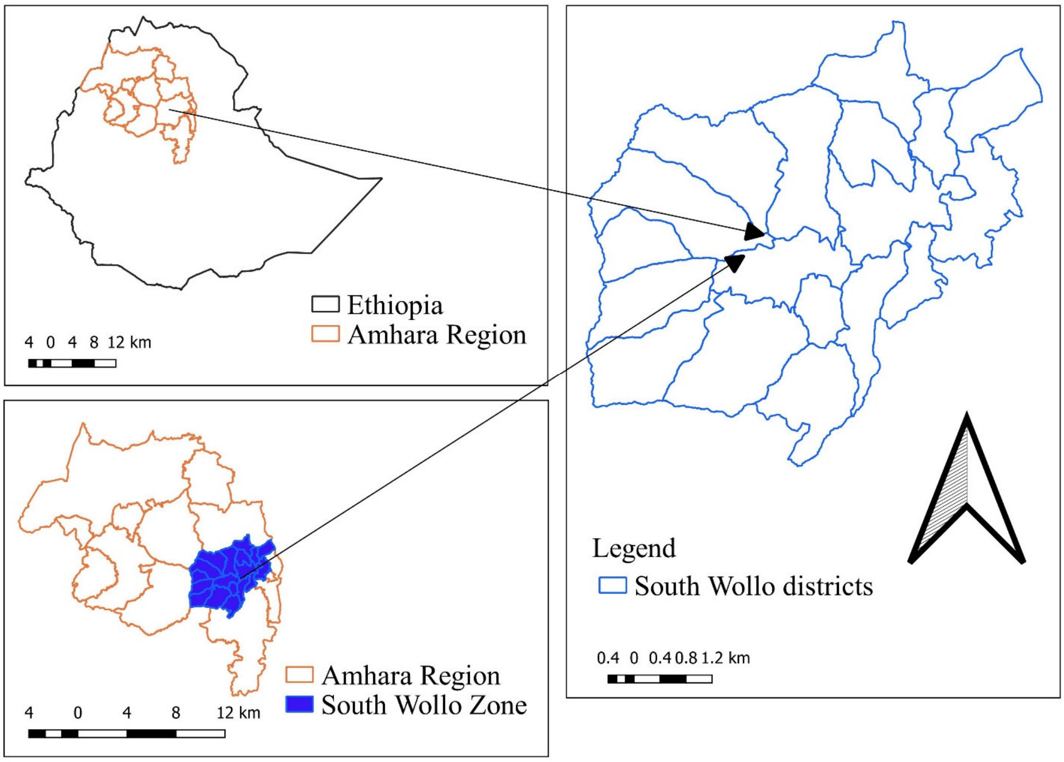

Figure 1. Map of the study area

3.2. Methods of data collection

A multistage sampling method was used. In the 1st stage from the prevailing 22 Woredas of south wollo zone four Woredas (Dessie Zuriya, Legambo, Mekdela and Tenta) were selected purposely. In the 2nd stage kebeles within each Woreda were selected purposely taking in to account the level of participation in land rehabilitation and their distance from the rehabilitation site. Accordingly, two kebeles from each Woreda (a total of eight kebeles) were taken. In the 3rd stage household selection was made randomly. Thus, a total of 408 households (51 from each kebele) were randomly selected. The number of households was determined using a simplified formula following (Taro 1967) at 90% confidence level.

$n = N/ 1+N (e)^2$ ____equation 1

Where, 'n' denotes the sample size, 'N' is the population size (number of households in total), and 'e' denotes the degree of precision.

Besides, two Focus Group Discussion (FGD) (8-15 people in each group) at each Kebele, 10 key informant interview (KI) and informal discussion with subject matter specialists of the district and development agents were administered to supplement and fill the gaps inquired during the individual household survey (Alefew 2016). FGD was also conducted with selected officials and stockholders and other community members to obtain possible challenges and opportunities of degraded land rehabilitation. The participants were selected purposely based on their roles in relation to land rehabilitation practices and their knowledge and experience on the subject of the study for the qualitative survey. The selection of KI at each kebele was done by adapting snowball method. The KI is defined as individuals who are knowledgeable about rehabilitation works (HHs) and are elderly persons who lived in the area for more than 35 years. To select individuals who could identify KI, tour was made with kebele council members and development agents. During the village tour, five individuals was randomly asked to give the names of KI. Besides, questionnaires were used to interview officers, agricultural experts, and development agents to better investigate challenges and opportunities of degraded land rehabilitation and future potentials (Taddese 2001; Baumgartner and Cherlet 2015).

Before the entire data collection process the interview schedules qualitative data was pre-tested, re-designed and standardized by incorporating the feedback of the pre-test administrated on 15-20 non-sample respondents (Acharya and Kafle 2009). To facilitate the primary data collection process, five enumerators was engaged based on their education level in addition to their experience in land rehabilitation activities. Then training was offered for enumerators on how to approach the respondents, selection of appropriate place, time and how to control the interview situation and record the information accurately; and collected the data with the close supervision of the researchers. The qualitative data was obtained using checklists prepared for this purpose. Questions were dichotomous, multi-choice, and open ended to allow ease capture of the diverse issues that was being investigated, with necessary detail (Baumgartner and Cherlet 2015). Moreover, secondary data was collected from relevant sources of different governmental and non-governmental, district and Zonal agriculture development offices, and local administration offices. Through this survey, information about the agro-ecological, socio-economical, institutional, and physical factors for rehabilitation were gathered. For better communication with the respondents, questionnaires was translated into the local language (Amharic) and presented to them.

3.2.1. Filed observation and preliminarily survey

Field walks, participatory interviews, filed observation, and preliminary survey were conducted to identify the types of plants used for rehabilitation of degraded land in the area. The success of rehabilitation practice was assessed by the help of district natural resource management expert and other field assistants from the community (Jamison et al. 2010; Koo et al. 2010; Jha et al. 2020). Besides, FGD was held with community members during the field work about the success of rehabilitation works.

3.3. Method of data analysis

The descriptive statistics such as mean, range, frequencies, percentages, standard deviation, and frequency of appearance were used with respect to the opportunities and challenges for rehabilitation. Besides, all biophysical and socio-economic data from the study sites were organized (Cooper et al. 2008). Qualitative data obtained from interview and discussion were analyzed and described through concepts and opinions, by sorting out, grouping and organizing to supplement the quantitative data of the survey result. The quantitative data was first summarized, tallied, and coded and processed, and analyzed with Microsoft Excel 2019. Thus the result was placed with tables, graphs, % and text.

Results and discussion

Socio-economic status of households

From a total of 408 households' participated in the formal survey, 96% of respondents were in the age range of 20 - 64 years and the mean age of all respondents was 42.59 years old. Respondents above 64 years (elder) constituted 4%. Therefore, most of the households belong to the productive age group that might be helpful to access family labor. In regard to sex composition of respondents, 84.18% of the respondents were males and 15.82% were females. In fact, in rural parts of Ethiopia, around 18% of householders are headed by women (Central statistics Authority 2011). Therefore, the proportion of female headed households in the study area is less than the country's average. This indicated that many social obstructions might affect the involvement of female headed households in land rehabilitation activities. This was in line with (Tesfaye 2008; Asfaw and Neka 2017; Joshi Rajkarnikar and Ramnarain 2020) stating that female headed households' participation in land rehabilitation activities had been low. 89.8% of the respondents were married. The remaining 6.5%, 1.2% and 2.5% of respondents were single, divorced and widowed, respectively.

The respondents' families ranged in size from one to twelve. The average family size of the study area was six. However, the country's average rural household size is about 4.9 persons (Central statistics Authority 2011). An accessibility of labor is among a leading factor that determined participation of households in land rehabilitation activities implemented by community mobilization (Asfaw and Neka 2017; Joshi Rajkarnikar and Ramnarain 2020). On the other hand, the larger family size could affect the environment negatively since people go to meet their food, wood and cash requirements from the environment (Zubair and Garforth 2006; Harris 2012; Coelho et al. 2020; Hussein et al. 2021). Studies showed that recently human population globally pose greatest threat to the environment (Bredemeier 2002; Ashenafi and Leader-Williams 2005; Ezeaku and Davidson 2008; Laboy-Nieves et al. 2009). So that sustainable development should be directed to reduce impact of population growth on the environment through technological and social innovation (Bradshaw 2014).

Education status of households

38.6% of the respondents can read and write. While, 31.4% of households were illiterate. Whereas 25.5% had completed primary school. 2.5% of households have completed high School and above. Moreover, the remaining 2% of households have attended religious education. 58% of women and 44 % of men are illiterate in Ethiopia (Central statistics Authority 2011). When knowledge on the environment increases, awareness of land rehabilitation measures also increase (Harris 2012). Thus an educated farmer might have a perception of land rehabilitation measures.

Landholding and options of getting extra land

Table 1: Average land holding size in the study area, Northeastern Ethiopia

land size in ha	(%)
0- 0.5 ha	29.5
0.5-1.0 ha	31.5
1-1.50 ha	21
1.50-2.00 ha	15
> 2.00 ha	3
Total	100

Sources: household survey 2022

As shown in the Table 1, 29.5% of households own 0.0-0.5 hectares of land. Whereas only 3% of the households own a land more than two hectares. The highest average land holding was owned by households of elder age group (> 50 years), whereas, the younger household groups have lesser land holding size. The result of the present study indicated that there is scarcity of land in the study area. This in turn determined householders' production capacity. Young member of households, newly wedded households and other landless young have no means of gaining land except from their parents. Those household members share land with their parents and relatives during marriage and obtain land use access through land transaction systems (sharecropping and renting).

The average rural households in Ethiopia have 0.7 hectare of land (compared to the national average of 1.01 hectare of land and an average of 0.75 for the Amhara Region(Kassa 2017). 80% of farmers in the highlands of Ethiopia cultivate less than one hectare of farming land (Eweg et al. 1998). Moreover, the average land holding in the Amhara region is 0.75-1 ha (Kassa 2017). Therefore, land fragmentation and shortages are emerging as the main problem in the highlands of Ethiopia as a result of farmers voluntarily in sharing their land with their children when they form their own families (Tesfaye 2008; Pittock 2009; Nachtergaele et al. 2010; Gashaw and Bantider 2014; Bajocco and Bajocco 2018). This pressing problem is pushing the search for marginal lands for cultivation and increases the rate of land degradation. Nearly, 22 % of households lease land for farming activities (mixed farming). Moreover, land scarcity in the study area has resulted householders to apply pressure on the nearby forest and grazing land to acquire additional land which has resulted with land degradation and damage to the natural environment (Baumgartner and Cherlet 2015; Report 2016; Kassa 2017; Miheretu and Yimer 2017).

Livelihood options of householders

Mixed farming (crop production and animal rearing) were the major sources of livelihood in the area. 92% of households involved in crop production. Thus crop production is the main source of income for households in the study area. Whereas Livestock production is the second major source of income (89% of households involved in Livestock production). On the other hand, Trees, agroforestry, forests and forest products accounted for 21.8% of the households' income.

Landholding trends of the sampled households

Majority of the households (92.5%) indicated that the sizes of the agricultural lands were decreased. 5.5% of the respondents reported that there is no change in the size of the farm land over time. Accordingly, the decrease in landholdings was attributed to increase in human population (68.9%). An increased human population resulted sharing of land to children and youths. Besides, land degradation and increase in marginal land due to loss of quality (25.1%), land redistribution (2.5%) and land taken away by government (3.5%) have been resulted in reduction of land size in the study area. In addition to response obtained from household survey, the participants of FGD have confirmed that the higher population growth in the study area resulted in land fragmentation and decrease in size overtime. Accordingly, due to absence of diversified livelihood, alternative job opportunities and lack of other means of acquiring land, sharing parents land to their youth had become common in the area particularly, for newly formed households.

Land tenure security

65.5% of respondents reported that the current land tenure system is good for them. They revealed that the current land tenure system is good because they can easily access to land through sharing and renting. Besides, they believe that land certification enhance tenure security. However, 34.5% of householders' believe that land tenure security affects long-term investment on their land. Land tenure security has been reported as an important factor affecting householders' decisions to practice land rehabilitation measures. Therefore, land users must have secure property ownership rights of the lands to carry out rehabilitation measures for benefits from land. In fact, in a condition where the householders are not certain, they will not carry out rehabilitation measures on their lands (Ashenafi and Leader-Williams 2005; Ezeaku and Davidson 2008; Kahsay 2011; Lemenih and Kassa 2014).Thus householders will be more concerned about the proper use and management of the land when there is proper land tenure (Ashenafi and Leader-Williams 2005; Tefera and Sterk 2010). Land has been under the state control since 1975 in

Ethiopia. Thus land tenure insecurity might influences householders' decisions in land management practices (Simane and Zaitchik 2014).

Householders' perception and forms of land degradation in the study area

Land degradation is recognized by the householders in the study area. Majority of respondents (97.5%) perceive that there is land degradation difficulty in the study area. Besides, most of them (97%) perceive that rehabilitation of degraded land should be carried out/ needed. Moreover, 77.9% of respondents perceive that land degradation might be rehabilitated though it takes time. Similarly, most of respondents have responded that they get awareness on degraded land rehabilitation. However, though land rehabilitation measures were introduced a long time ago, the farmer's attitudes towards using them in a sustainable way is not at the expected level (Tatek and Barkarson 2015). Moreover, land rehabilitation measures in the highlands of Ethiopia are determined by family size, sources of income, wealth status and extension services (Amsalu et al. 2007; Ezeaku and Davidson 2008; Mganga et al. 2010; Asfaw and Neka 2017).

As indicated in Table 2, major forms of land degradation in the study area were soil erosion, deforestation, overgrazing, and gully formation. About 65.5%, 19.5%, 6.5%, and 4.5 of the respondents replied soil erosion, deforestation, overgrazing, and reduction of land productivity as the main forms of land degradation in their locality, respectively. 4% of the respondents recognized gully formation as the major forms of land degradation. Studies indicated that there is a considerable loss of topsoil in the highlands of Ethiopia due to erosion (Tatek and Barkarson 2015). Moreover, Ethiopia loses more than 1.5 billion tons of topsoil from the highlands of Ethiopia due to soil erosion (Simane and Zaitchik 2014; Tatek and Barkarson 2015). Besides, land degradation is increasing in the highlands of Ethiopia due to human activities (Feoli et al. 2002b). Therefore, soil erosion determines food insecurity and poverty in the rural community (Eweg et al. 1998; Wolka 2014). Moreover, 'land degradation inventory from the Bureau of Agriculture in the Amhara region shows that out of 2,165,604 ha of the degraded land, 182,080 ha are affected by gully erosion' (Eweg et al. 1998; Tekle 1999; Meseret 2016). Therefore, the role of interventions by effective rehabilitation of gullies reached far beyond land reclamation if the attitude change brought about by local communities and policy makers is considered (Meseret 2016). Besides, land degradation poses pressure on the surrounding remnant forests as local communities pursue to search new fertile agricultural land (Eweg et al. 1998). This might be resulted with further land degradation (Sreedevi et al.; Bojo and Cassells 1995; Mganga et al. 2010; Chirwa et al. 2015; Abera et al. 2020; Jha et al. 2020).

Table 2. Forms of land degradation in the study area

Forms of land degradation	% respondents
Do you perceive that there is Land degradation in your area?	
Yes	97.5
no	2.5
If yes do you think that rehabilitation of degraded Land should be carried out?	
Yes	97
no	3
Have you ever get awareness on Degraded land rehabilitation?	
Yes	90.5
no	9.5
What were the major forms of land degradation in your area?	
Soil erosion	65.5
Deforestation	19.5
Overgrazing of range land	6.5
Gully formation	4.5
reduction in land productivity	4
Others (specify)	
Is it possible to minimize degradation problem?	
Yes	77.9
no	22.1

Households' response to land degradation problems

land rehabilitation practices	% respondents
Is there land rehabilitation practices in your area?	
Yes	65.9
no	34.1
If your answer is 'yes', what land rehabilitation practices have been carried out in your area?	
area closure	40.5
Biological soil and water conservation	31.5
agro-forestry	10.5
planting in degraded land	17.5
Where rehabilitation practices are carried out?	
at private land (farm boundary/farm land)	20
Communal land	75
Land owned by government	5
Which land rehabilitation method is /are/ practiced in your area?	
Natural regeneration	34
Planting	65
Direct seedling	1
Which rehabilitation measures do you think are more effective in rehabilitation of degraded lands?	
area closure/ natural regeneration	31.5
Biological soil and water conservation	37.5
agro-forestry	5.5
planting/ seedling in degraded land	25.5
How do you rate land rehabilitation practices over time in your area?	
Increasing	61.5
Decreasing	36.5
No change	2

Participation trend of households to land rehabilitation practices

There is recognition by community members that deforestation, over grazing, over cultivation, land fragmentation, and population pressure are contributors of land degradation. 85% of respondents reported that they participate in land rehabilitation practice in the area. Besides, the involvement of communities in land rehabilitation practices is increasing. This was confirmed by 90.5 % of respondents. However, (9.5 %) of the respondents reported that participation of households in rehabilitation practices had been decreased. For instance, communities are mobilized to provide 30 to 40 days of free labor each year as a contribution to the rehabilitation of degraded land (Tatek and Barkarson 2015). However, 15% of respondents reported that they did not participate in rehabilitation practices. Low socioeconomic and socio cultural benefits from rehabilitation activities, difficulties of getting access to credit or financial support, high opportunity costs, and long gestation period of rehabilitation works, and a limited market for many of the products arising from rehabilitation practices impeded householders' from participating in rehabilitation practices. A significant number of respondents (30%) participated in rehabilitation work by external pressure from rehabilitation work leaders. However, a majority of respondents (50%) participated in rehabilitation activities by their own initiation and interest as land rehabilitation work is means of survival. However, though degraded land rehabilitation measures were introduced before a long time ago, the attitudes of local communities towards practicing it in a sustainable way is not at the expected level in the study area. Therefore, it is reported that degraded land rehabilitation practices are supposed to ensure the community-based problem identification, planning, implementation and governance (Tefera and Sterk 2010). Moreover, understanding the socioeconomic and cultural situation of the communities and the need of sufficiently involving them in degraded rehabilitation practices are helpful for successful rehabilitation (Tefera and Sterk 2010; Simane and Zaitchik 2014). For example, studies confirmed that communities rarely participate in development programs with the expectation of new benefits; rather they participate because of the hegemonic party-farmers historical relation and because of the top-down pressure that government agencies put on local politicians (Eweg et al. 1998; Feoli et al. 2002b; Simane and Zaitchik 2014; Kassa 2017). This leads farmers to accept mobilization programs even when knowing that they are not suitable for them (Abera et al. 2020). Therefore, rehabilitation intervention should be participatory, detail planning, documentation, and research are required for its success (Ashenafi and Leader-Williams 2005; Zubair and Garforth 2006; Lemenih and Kassa 2014; Simane and Zaitchik 2014). For instance, each year watershed rehabilitation is practiced in 1500 to 2000 community watersheds across Amhara region, though trainings and supply of hand tools are provided for communities, little is done to address their socioeconomic issues (Blay et al. 2004; Wolka 2014; Tatek and Barkarson 2015).

Success of rehabilitation practices in the area

Majority of respondents (68.5%) stated that degraded land rehabilitation practices previously carried out in the study area were not effective or successful. While, 31.5% of respondents reported that land rehabilitation practices carried out in the study area were successful. The dominant reasons for unsuccessful degraded land rehabilitation practices were lack of frequent supervision (free grazing and human intervention), tending and management activities. Besides, land tenure, land user access, customary property rights, institutional issues, low quality in planting material and site and species selection problem were also the other reasons too.

Assessing the success of a rehabilitation work is needed to advance rehabilitation management (Koo et al. 2010). The success or failure of a rehabilitation practice can be determined by examining the similarity of the plantings to naturally regenerating forests and the resilience of the rehabilitated sites (Abera et al. 2020). The success of the rehabilitation project needs to be assessed to determine how much of the disturbed lands are rehabilitated, whether human intervention can be stopped or not (Hobbs and Norton 1996). Moreover, to assess the success of a rehabilitation activity, first, it is needed to set objectives and goals clearly for a particular time period (Hobbs and Norton 1996). The objectives can be addressed in terms of the ecosystem structure, composition and function which ecosystem restoration seeks to return to treated areas (Hussein et al. 2021). Hence, acceptance and success of tree planting and land rehabilitation activities depend upon the amount of attention given to local environment, social conditions, cultural values, and people's needs and knowledge (Zubair and Garforth 2006). Furthermore, involving local people in the design, implementation, and evaluation of such activities will further contribute to success of rehabilitation practices too (Toosey 1988).

Though in the previous 40 years, degraded land rehabilitation have received attention, most of the rehabilitated land has been destroyed because of free grazing, lack of frequent supervision, and maintenance. Therefore, each year local communities are forced to perform land rehabilitation measures on similar areas (Meseret 2016). Therefore, mobilization of communities is highly needed for success of rehabilitation works the same as mobilization in mass planting. Moreover, incorporating or addressing socioeconomic, environmental, institutional, and biological aspects are highly needed for success of land rehabilitation (Zubair and Garforth 2006). In fact, moisture deficiency, frost, fluctuation of weather events, plant species selection and quality of planting materials are reported to affect success of rehabilitation measures in the study area (Koo et al. 2010; Abera et al. 2020). Moreover, in areas where seedlings were planted, survival rate was low (Wolka 2014).

Policy formulation for degraded land rehabilitation, the implementation of existing policies, development of guidelines and an integrated approach are helpful to successfully rehabilitate degraded land (Gichuki et al.; Nkonya et al. 2008). On the other hand, success stories from the intervention of different projects and programs which have been successful in ensuring sustainability of rehabilitated land have been reported (Tatek and Barkarson 2015). For instance, according to the impact assessment for the 'Abba Gerima' project watershed, free grazing has decreased by 57% and fodder supply has improved by 46% as a result of the project's intervention in a number of socioeconomic factors (Tatek and Barkarson 2015). Accordingly, the cut and carry feeding system or zero grazing is helpful to increase the success of restoration site and livestock productivity (Eweg et al. 1998; Asfaw and Neka 2017). In contrary, some of communities believed that the rehabilitation of degraded land via mobilization process affected their livelihood. For example, some communities agreed that area closure brings a shortage of grazing lands. Some respondents (8%) agreed that rehabilitation affected their livelihood indirectly through taking their time from social networking, labor rent and collection of wood for fuel. This requires creation of alternative livelihoods such as home garden development, off-farm activities, and improved agricultural technologies for them. Besides, this entails the need for an integrated approach for consideration of the current needs of communities to cope with the problem of shortage of grazing, fuel wood and other forms of livelihood alternatives that the communities deal with (Simons and Leakey 2004).

The ever-increasing population in the highlands of Ethiopia needs alternatives other than farming, especially the youths (Mesene 2017). The intensification of off-farm activities and other non-farm livelihood options will reduce the pressure on intensification of agriculture that is practiced at the expense of forest clearing (Ezeaku and Davidson 2008; Htun et al. 2011; Rakodi 2014; Fenetahun and Yong-dong 2019). In addition, appropriate livestock management practices will reduce the pressure of free grazing, consequently minimizing the destruction of rehabilitated land (Ashenafi and Leader-Williams 2005; Yayneshet et al. 2009). The public mobilization based degraded land rehabilitation is mostly addressed in a top-down manner and gives little room for the communities to decide (Simane and Zaitchik 2014; Castro-Izaguirre et al. 2016; Kassa 2017). The government officers ranked the role of the communities differently than did the communities themselves. From the interviews of communities and experts, it is clear that the process of land rehabilitation work lacks adequate involvement of the communities in all processes. For example, 75.5 % of communities reported that they were participated during implementation of rehabilitation work, only 2.5 % during the monitoring and evaluation stage. However, 16.9 % of respondents did not participate in any of the project stages. Moreover, none of communities participated in selection of rehabilitation sites and species.

FGD discussion and key informants stated that poverty, poor land management (poor farming practice, settlement in steep sloping, farming hill sides, over cultivation), unpredictable rain fall, and change of weather patterns affect success of rehabilitation practices in the area. Few FGD participants reported that land degradation is a punishment from **God**/ **Allah**/. Socioeconomic issues such as population pressure, land use change, overgrazing, poverty, and a high demand for energy have been generated stress on environment and influenced the rehabilitation (Tatek and Barkarson 2015). The effects of changes of state (impacts) require efforts by communities, local governments, researchers, and policy makers to move towards sustainable natural resources management in the highlands of Ethiopia (Hobbs and Norton 1996; Simane and Zaitchik 2014).

In fact determining the success or failure of a restoration work within a specific time frame is extremely difficult due to the absence of any standard criteria for refereeing the success of the project (Jamison et al. 2010; Koo et al. 2010). To assess the success of rehabilitation activities, evaluation program must be included (Koebel and Bousquin 2014). Therefore, a detailed evaluation of ecosystem structure and function establishing cause and effect relationships is needed (Hussein et al. 2021). Besides, rehabilitation measures and ecosystem response, biological responses of rehabilitation, documentation of ecosystem changes, and their social effects, and essential processes to the success of rehabilitation are needed (Ezeaku and Davidson 2008; Damptey et al. 2020). Moreover, detection, documentation, and understanding of physical, chemical and biological changes resulting from a rehabilitation work is helpful (Acharya and Kafle 2009). Therefore, the rehabilitation project should integrate taxonomic, habitat, functional, structural, and conceptual approaches to achieve its general objectives (Koebel and Bousquin 2014).

Moreover, KI stated that the rehabilitated areas had improved in terms of natural forest recover, grass cover, animal feed, and reduced flood. Moreover, the results of the present studies are in line with other studies which reported that population pressure, mismanagement of agricultural practices, deforestation, and over grazing affects success of degraded land rehabilitation (Mulugeta and Stahr 2010). For example, rehabilitated areas in the high lands of Tigray region, Northern Ethiopia, have been effective in restoring plant species composition, diversity, biomass cover, and structure of both herbaceous and woody vegetation factors that normally lead to improved ecosystem (Yayneshet et al. 2009). Participants reported that the rehabilitated land had improved after the intervention and this improved water flow and reduced flood while increasing availability of fodder for livestock and making the land escape greener. However, open grazing and poorly defined ownership of the rehabilitated land, poor biomass from parts of the watershed where biological measures were not conducted properly were weaknesses that need to be addressed. On the other hand KI and officials agreed that there is no proper plan and follow up guide line for monitoring and maintenance of rehabilitated areas. Because of this, the surrounding villages didn't perform any significant maintenance work. KI emphasized that the absence of proper plan and binding hand over arrangement with defined responsibilities of the local government offices and the community might result with failure of rehabilitation practices. A study pointed out that ownership issue, limited benefit and unequal benefit sharing, weak laws, and inefficient monitoring are major challenges for failure of rehabilitation activities in Ethiopia (Tekalign 2010). Portion of rehabilitated communal lands given for the landless youth will be better managed, communally owned will not be protected properly (Belete 2015). However, few KI had doubt about the sustainability of project achievements. Moreover, lack of ownership, drought, free grazing, and weak by- law enforcement and population increase were major factors that make common pool resource management difficult in the central high lands of Ethiopia (Ashenafi and Leader-Williams 2005). According to participants the rehabilitated land could be sustained if appropriate measures are taken before, during and after rehabilitation. Some also added that a strong concern that the rehabilitated areas will not be sustainable unless benefits are increased and ownership aspects are addressed clearly. In reality, the methods chosen to restore a particular degraded area depend on a number of factors, including stakeholder priorities and management goals, the costs and benefits of various rehabilitation techniques, and the economic, social, and environmental values of the land resources in their present and desired future states (Lamb and Tomlinson 1994).

Challenges to rehabilitate degraded land in the study area

As indicated in Table 3, lack of follow-up by the implementing agency, lack of watering, tending and protection of rehabilitated site from free grazing as the first challenges that makes degraded rehabilitation practice/effort/ unsuccessful in the study area. In this regards, degraded land rehabilitation practice /efforts/ should not restricted to a certain season (at a time of mass mobilized planting). Besides, both communities and officials agreed that low sense of ownership of rehabilitated site by the communities, seasonality of rehabilitation activities, poor seedling survival due to biophysical stresses, land tenure & institutional problems, socio-economic problems and availability of limited livelihood options and higher degradation level of the site to be rehabilitated are among the challenges that affect success of rehabilitation measures. The result of this study is in line with other study stating that ownership of rehabilitated land still remains unclear (Tatek and Barkarson 2015). Besides, there is no legal transfer of land management and user rights to the community (Ashenafi and Leader-Williams 2005). In this regards, the communities who are responsible for managing rehabilitation areas is also not stated (Abate 2020). Besides, if free greasing and livestock management is properly addressed, it will be difficult to ensure success of rehabilitation (Table 3). However, government officers prioritized free grazing while communities argued that the priority problem was associated with lack of follow-up, supervision and ownership.

Rehabilitation efforts will not successful because of species and site selection problems, vague and untestable rehabilitation objectives, no gathering of follow-up data, no supervising, denied access to evaluate the project, no scientifically justifiable reports and absence of indigenous species (Aronson et al. 1993; Palmer et al. 1997). However, it should be extremely cautious in judging success or failure of rehabilitation at all stages or process and it requires enough time to do so. For instance, a rehabilitation work that is reported successful after 3 years of observation could be failed at the end of a 13-year, because of an unexpected effects (Koo et al. 2010). Moreover, (García-Ruiz et al. 2015) specified a dated of at more than 20 years of measurements is vital to get consistent evaluations of soil erosion degree drops which yield extreme events into account. Therefore, holistic and long-term views could be necessary to understand processes in rehabilitation and recovery. According to the results from discussion with officials and focus group discussions and key informant interview, land tenure problems, problems related to ownership of rehabilitation sites, free grazing and lack of frequent follow-up and supervision are the major challenges of degraded land rehabilitations. Moreover, FGD and KI interviews confirmed that officials and stockholders are responsible to reverse land degradation with the involvement of the societies through awareness creations. Most of the key informants and focus group discussions asserted that adequate attention should be been given by the government towards rehabilitating land degradation in the study area. Accordingly, unless strong efforts from all stockholders (community, professionals, and government) is done to restrain the land degradation, the consequence would be irreversible. For example, development agents, KI and FGD informants stated that the degraded sites to be rehabilitated by governmental efforts /via mass planting/ is often selected by higher administration officials excluding the communities and professionals. Therefore, active participation of the community and ownership of rehabilitation site is a major factor that affect rehabilitation of degraded land sustainably. Besides, participation in all aspects of degraded land rehabilitation needs to be strengthened.

Table 3. Challenges to rehabilitate degraded land successfully in the study area

Challenges/Constraints to rehabilitate degraded land successfully in your area?	% respondents
Land shortage, high population pressure, unsustainable consumption, and management practices.	1.5)
Poor seedling survival due to biophysical stresses (Pests, diseases, drought, frost, high temp, soil erosion, land infertility, water access and other environmental factors)	10
Lack of extension services and awareness	0.5
Lack of supervision and follow-up by the implementing agency, lack of watering, tending and protection from free grazing	54.5
Land tenure & institutional problems	10.5
low availability /access/ & restrictions to transport planting materials	0.5
Species selection problems/ inaccessibility of required species (indigenous)	3
Rehabilitation site selection problems	0.25
mass/group planting	0.5
Exclusion of involvement of professionals in rehabilitation decision	0.5
Socio-economic problems and availability of limited livelihood options	5
lack of incentives and awards	4.5
Higher degradation level of the site to be rehabilitated	6
Insufficient funds to support the rehabilitation activities	4
Seasonality of rehabilitation and tree planting activities	10.5
Low sense of ownership of rehabilitated site by the communities	25.5

Table 4. Measures suggested for the rehabilitation of degraded land in effective Manner in the study area

Measures suggested for the rehabilitation of degraded land in effective Manner	% respondents
Addressing Socioeconomic (consideration of alternative livelihoods to reduce pressure on natural resources, ensuring communities participation) constraints that are affecting the effectiveness of land rehabilitation program	13.75
Protection of rehabilitated land from free grazing, farming practices and human interference	65.25
Rehabilitation of degraded lands through biological soil and water conservation measures	11.5
Solving Ownership problems in rehabilitated land	37.5
Increasing the benefits from rehabilitated site through planting edible, plants used for fodder, and multipurpose trees	2.5
Creating sense of ownership by the community	7.5
Area enclosure	25.5

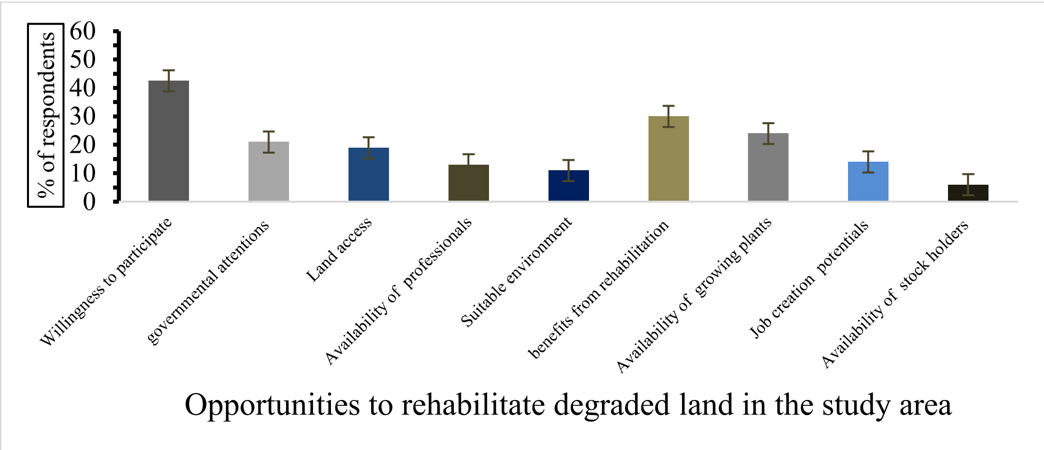

Figure 2. Opportunities to rehabilitate degraded land in the study area

Willingness of communities to participate and multidimensional benefits from rehabilitated land are reported as opportunities of rehabilitation by most respondents (42.5% and 30% respectively) (Figure 2). In the view of FGD and KI, presence of biological and physical soil and water conservation activities or practices, presence of multi-purpose trees, shrubs, legumes and grasses that are able to protect the land from erosion and treatment of the land are opportunities to rehabilitated degraded land in the study area. Moreover, beyond government attention for land rehabilitation, involvement of various stockholders in rehabilitation practice through soil and water conservation, rehabilitation, afforestation, REDD+, clean development mechanisms, and sustainable land management (SLM) programs are other opportunities too. According to experts, KI and FGD, the presence of diversified types of agro-ecologies, presence of large areas to be rehabilitated, afforestation/ reforestation programs, the presence of potential plantation species, agroforestry practices, payments for environmental services such as carbon financing from $REDD^{+}$ and participatory forest management, and sustainable land management programs are among the opportunities for rehabilitation of degraded land. Moreover, the presence of high wood demand, high market opportunities, and the presence of market chain were reported by professionals as of opportunities for the rehabilitation of degraded land. Similar results were reported by (Feoli et al. 2002a; Alexander et al. 2011; 2019) in line with the present study.

Plant species used for degraded land rehabilitation practices in the study area

Among respondents who planted trees 47.7% planted eucalyptus species. Respondents indicated that they plant because of economic (meeting own and market demands for feed and wood) and environmental benefits. Therefore, beyond their roles to rehabilitate degraded land, planting and management of trees or shrubs in rehabilitated land helps to get economic, social, cultural and ecological benefits. According to the observations made in the study area and the interview, various multipurpose trees and shrubs have been planted in the rehabilitated site. For instance edible plants such as *Mammea Americana, Syzygium samarangense, and Mangifera indica* were planted at rehabilitated sites. Besides, multipurpose plants such as *Sesbania sesban* and *lucinia lucosophala* were among others.

60.5% of the respondents rated survival rate of seedlings planted on rehabilitated lands as 21.5%. While, respondents reported that *Chamaecytisus proliferus*, *Eucalyptus globulus*, *Eucalyptus saligna, Leucaena leucocephala*, *Sesbania sesban*, *Juniperus procera, Cupressus lusitanica*, *Olea europaea, Hagenia abyssinica, Podocarpus falcatus, Acacia saligna, Grevillea robusta, Acacia albida* and *Acacia decurrens* had better survival rates. Moreover, *Chrysopogon zizanioides* and *Pennisetum purpureum* were among plant species that were planted/used/ to rehabilitated highly degraded sites. Some professionals reported that *Ficus vasta, Jacaranda mimosifolia,* and *Cordia africana* were among plant species planted to rehabilitated degraded land. However, poor species-site matching, poor site preparation, poor handling of seedlings, weather fluctuation, frost, moisture deficiency, inadequate follow up, pest and free grazing influenced the survival of seedlings. Similar results were reported in northern Ethiopia (Reubens et al. 2011). Therefore, planting and rehabilitation must consider selection and survival of seedlings like agro ecology, community needs, vigor of seedlings to be planted and proper post-planting follow up and protection from human and animal disturbances. However, inappropriate plant species might be selected for planting when both ecological suitability and preferences of local stakeholders are not properly taken into account (Simons and Leakey 2004). However, selection of species for rehabilitation is much more complex and the group of stakeholders' are very heterogeneous (FRANZEL et al. 2008). To increase species survival a broad and appropriate group of ecological, economic and social selection criteria describing species traits in terms of growth characteristics, site requirements and potential products and services, needs to be defined (Simons and Leakey 2004; FRANZEL et al. 2008). Besides, performance on each of these criteria needs to be thoroughly understood for each of the considered species (FRANZEL et al. 2008).

An implications of degraded land rehabilitation for livelihood and ecosystem services improvement

Land degradation, low soil fertility and agricultural production are particular problems in Sub-Saharan Africa (Nkonya et al. 2008). It is estimated that losses in productivity of cropping land in sub-Saharan Africa are in the order of 0.5–1% annually, suggesting productivity losses of at least 20% over the last 40 years (Djenontin et al. 2018). There are an estimated 180 million people affected by land degradation with an estimated annual economic loss of $68 billion in Sub-Saharan Africa (Falkenmark and Rockström 2008). Similarly, Ethiopia experiences the most severe land degradation with an annual cost of $4.3 billion (Mekuria et al. 2018; Abera et al. 2020).

According to a recent assessment, Ethiopia's 14.3 million acres (or 50% of the highlands) of land are highly degraded (Gashaw and Bantider 2014). Therefore, when people lack access to alternative sources of livelihood, there is a tendency to exert more pressure on the limited available resources (Amede 2003; Koo et al. 2010; Mganga et al. 2010; Tatek and Barkarson 2015; Miheretu and Yimer 2017). In addition to reduced productivity, land degradation leads to socio-economic problems such as food insecurity and migration (Toosey 1988; Ashenafi and Leader-Williams 2005; Zubair and Garforth 2006; Simane and Zaitchik 2014). For example, enclosure supports and regulating ecosystem services such as pollination for bee keeping (Mekuria et al. 2018; Manaye et al. 2019). The intervention and practices in rehabilitation such as planting of vegetable, fruit, small chicken farms and animal fattening can significantly improve the livelihoods of communities (Lemenih et al. 2007). Cultivation of marginal lands and intensification of agriculture are the ever-growing threats of low productivity of the land, population pressure and the lack of alternative livelihoods (Amsalu et al. 2007; Lemenih et al. 2007).

Land rehabilitation increases carbon storages or avoids greenhouse gas emissions and provide more than one third of the most cost-effective greenhouse gas mitigation activities required by 2030 to keep global warming to below 2°C (Mekuria et al. 2018). Thus, investing in avoiding land degradation and in the rehabilitation of degraded land makes sound economic sense; the benefits by far exceed the cost (Ezeaku and Davidson 2008). However, except for some successful studies related to area enclosures (Pendleton et al. 2012), there are no clear/quantitative/ evidence about the performance of the rehabilitation efforts and information on their contribution to improvement of livelihoods and ecosystem services in Ethiopia (Lemenih et al. 2007; Mekuria et al. 2018). Therefore, though land rehabilitation practices had been carried out in Ethiopia for many years, the spatial distribution of the interventions has not been documented, and there is no systematic, quantitative evidence on whether rehabilitation efforts have achieved the desired ecosystem service and livelihoods to local communities (Ezeaku and Davidson 2008; Pendleton et al. 2012; Mekuria et al. 2018). The results of the prevailing few studies that have been done are less-comprehensive and based on limited spatiotemporal analyses (Lemenih et al. 2007; Yirdaw et al. 2017). Besides, there is a variability of effects of land rehabilitation practices on ecosystem services between agro ecological zones and human factors (Ezeaku and Davidson 2008; Lemenih and Kassa 2014; Hussein et al. 2021). Thus, agro ecology can be considered as broader context that can help to fine adjust land rehabilitation interventions for a targeted ecosystem services (Perfecto and Vandermeer 2008). However, many factors such as the design of the interventions, the socio-economic system, and the specific types of ecosystem for which services are targeted, etc. should be considered for optimized land rehabilitation techniques (Feoli et al. 2002a; Ezeaku and Davidson 2008; Mganga et al. 2010; Chirwa et al. 2015; Abera et al. 2020).

The extent of land resources degradation in Ethiopia, especially the degree of soil erosion, nutrient depletion and deforestation in highland areas of the country is very high (Bojo and Cassells 1995). A significant amount of arable land in the highlands of the country is lost due to land degradation (Abera et al. 2020). Due to high degree of degradation, important renewable natural resources such as soil, water, forest, and biodiversity are highly deteriorating in the Ethiopian highlands (Gedefaw and Soromessa 2015; Report 2016; Hussein et al. 2021). This problem is further aggravated by the expansion of agriculture to marginal areas (Fenetahun and Yong-dong 2019).

Land degradation particularly soil degradation has significant negative impact on productivity of land because soil degradation and soil productivity are inversely related (Taddese 2001; Abera et al. 2020; Damptey et al. 2020). That is, where degradation is taking place at a higher rate, the productivity is low and vice versa (Mganga et al. 2010). The productivity of soil is significantly affected in Ethiopia due to the serious soil degradation in the country (Oldeman 1992; Taddese 2001; Bredemeier 2002; Sci 2004).

Land resource degradation is considered to be one of the major threats to food security and natural resources conservation in the Amhara regional state (Amede 2003). Besides, land degradation is recognized as a major bottleneck of agricultural productivity and natural resources management by farmers and policy makers (Tefera and Sterk 2010; Simane and Zaitchik 2014; Wolka 2014; Miheretu and Yimer 2017). However, reversing land degradation in a short period requires a strong policy support through increasing credit access to farming communities (Amede 2003; Ashenafi and Leader-Williams 2005; Tefera and Sterk 2010; Jha et al. 2020). Besides, the impacts of land rehabilitation practices on ecosystem services have been drawn from a range of conditions including agro-ecology, land use type, topography, and soil types (Meseret 2016). Regardless of specific conditions, the average effect has demonstrated the substantial benefits of different types of land rehabilitation practices on soil loss (45-80%) and runoff (38-90%) reduction (Lemenih and Kassa 2014; Meseret 2016). While, the average effect on soil organic carbon and productivity vary on the type of land rehabilitation practices (Wolka 2014). This indirectly implies that low consequence of physical land rehabilitation practices on SOC and productivity might be attributed by depletion of soil nutrients and marginal topography to serve for crop production (Watson et al. 2002). Thus, we have understood from the analysis of average effect size of land rehabilitation practices drawn from the range of studies that multiple ecosystem services can be enhanced through integrated land rehabilitation interventions including structural, biological/vegetative, agronomic and soil management practices (Lemenih et al. 2007; Abera et al. 2020). Therefore designing land rehabilitation strategies and practices targeting different contexts (agro-ecology, rainfall regimes, and land use types) is helpful (Reubens et al. 2011; Alefew 2016). Therefore, land rehabilitation practices affects ecosystem services soil organic carbon, soil erosion, productivity and runoff (Manaye et al. 2019).

Degraded land rehabilitation has been changed diversity of flora and fauna, reduced soil erosion, and soil amelioration (Perfecto and Vandermeer 2008). Thus rehabilitation intervention has also had a positive impact on the livelihoods of local people; providing access to fodder, construction materials, and income from cattle fattening and sale of wood and grass (Ezeaku and Davidson 2008; Tekalign 2010). Thus rehabilitation practice will be effective when integrated measures with multipurpose tree species are included (Reubens et al. 2011; Simane and Zaitchik 2014; Baumgartner and Cherlet 2015; Ali et al. 2016). This could be due to the compound effect of integrated options in improving soil moisture, reducing soil loss and enhancing soil fertility that could ultimately benefit crop production (Mulugeta and Stahr 2010; Damptey et al. 2020). Area enclosures played a significant role in reducing soil erosion and runoff by 53% and 91%, respectively, while enhancing SOC by 90% (Feoli et al. 2002a; Tekalign 2010; Chirwa et al. 2015).

The use of conservation agriculture techniques in Ethiopia demonstrated multiple advantages, with a notable reduction in soil erosion and runoff of 45% and 46%, respectively (Simane and Zaitchik 2014; Gedefaw and Soromessa 2015). A significant increase of SOC and productivity by 24% and 18%, respectively (Watson et al. 2002; Damptey et al. 2020). Rehabilitation increased food production; enhanced soil carbon sequestration; reducing soil erosion; improved moisture and nutrient storage and improvement in the water and nutrient cycle) (Feoli et al. 2002b; Ezeaku and Davidson 2008; Wolka 2014). Moreover, land rehabilitation measures are reported as the main tool to maintain the livelihood of community as land degradation threated farming practices, agricultural yield, ecosystem goods and services (Eweg et al. 1998; Ali et al. 2016; Fenetahun and Yong-dong 2019). For example, preventing soil erosion could add about 1.5 million tons of grain to the country's annual harvest (Abera et al. 2020). This shows that soil erosion is a determinant factor contributing to food insecurity and poverty in the rural community (Eweg et al. 1998; Ezeaku and Davidson 2008). Therefore, proper land management practices, significantly increase proper exploitation of the land (Bredemeier 2002; Tefera and Sterk 2010; Lemenih and Kassa 2014; Miheretu and Yimer 2017). By considering multidimensional impact of land degradation on food security and economic development, integrated land conservation and rehabilitation are vital to maintain biodiversity, livelihoods, ecosystem services, and for the protection of off-site ecosystems (Palmer et al. 1997; Perfecto and Vandermeer 2008; Graham et al. 2014; Manaye et al. 2019; Coelho et al. 2020). Unquestionably, efficient land management policy should include promotion of multi-purpose woody species through afforestation, reforestation and/or natural regeneration, as a means to enhance rural livelihoods while providing a wide range of environmental services reversing land degradation (Lemenih and Kassa 2014; Alefew 2016; Manaye et al. 2019).

Conclusion

It is concluded that rehabilitation efforts could not be successful unless those challenges that affect its success are addressed. Soil erosion, gully formation, deforestation, overgrazing, and reduction of land productivity are as the main forms of land degradation in the study area. Besides, there is a recognition by community members that deforestation, over grazing, over cultivation, land fragmentation and population pressure are contributors of land degradation. However, low socioeconomic and socio cultural benefits from rehabilitation work, difficulties of getting access to credit or financial support and high opportunity costs and long gestation period of rehabilitation works impeded householders' from participating in rehabilitation practices. Besides, though degraded land rehabilitation measures were introduced before a long time ago, the perception of local communities towards practicing it in a sustainable way is not at the expected level in the study area. Thus, understanding the socioeconomic and cultural situation of the communities and the need of sufficiently involving them in degraded land rehabilitation practices are helpful for successful rehabilitation. Thus, land tenure, institutional issues, low quality in planting material, site and species selection problem, lack of frequent supervision, tending and management activities, free grazing and low sense of ownership on rehabilitated areas are among challenges to rehabilitate degraded land in the area. However, it is sensible to study and address the challenges of land degradation in different areas as it require different dealings. Moreover, high opportunity costs and long gestation period of rehabilitation works and a limited market for many of the products arising from rehabilitation practices impeded householders' from participating in rehabilitation practices. Accordingly, though degraded land rehabilitation have received attention, most of the rehabilitated land has been destroyed because of free grazing, lack of frequent supervision, and maintenance. Moreover, incorporating or addressing socioeconomic, environmental, institutional, and biological aspects are highly needed for success of land rehabilitation. In fact, moisture deficiency, frost, fluctuation of weather events, plant species selection, and quality of planting materials are reported to affect success of rehabilitation measures in the study area. Besides, lack of follow-up by the implementing agency, lack of watering, tending, and protection of rehabilitated site from free grazing as the first challenges that makes degraded rehabilitation practice unsuccessful in the study area. However, government officers prioritized free grazing while communities argued that the priority problem was associated with lack of follow-up, supervision and ownership. Besides, there are lack of adequate information about successes and failures of the rehabilitation efforts which requires planning and decision-making before carrying out the rehabilitation. However, presence of multi-purpose plants, willingness of communities to participate, government attention, involvement of various stockholders, presence of diversified types of agro-ecologies for plant survival and large degraded areas to be rehabilitated are among opportunities for rehabilitation of degraded land.

Following the results of the present study, further studies on total size of rehabilitated areas and their impact on ecosystem and livelihood is suggested. Moreover, rehabilitation activities should not restricted to a certain mass planting season. Instead it should be a continuous practice until the site is fully rehabilitated and communities obtained benefits from it. Therefore, planning of activities is critical for plant survival and success of rehabilitation site. Besides, pilot planting before mass planting, species trial test and research on releasing improving varieties that can withstand high frost and moisture deficiency stress is important. Since the return from rehabilitation is long term (long gestation period), it is important to consider short term benefits through planting multipurpose and edible fruit trees so that farmers can obtain a livelihood and consequently reduce the pressure on natural resources. Moreover**,** ensuring participation of communities at all stage is helpful than the current top-down approaches. Therefore**,** continual monitoring, follow-up, and applying tending operations and control of free grazing at rehabilitation increases success of restoration practices. Besides, planning and reporting rehabilitation outcomes via hectares instead of tree number is helpful. In this regards, the focus should be how much land (ha) have rehabilitated instead of how many plants are planted. For a complete understanding of land rehabilitation works, studies are needed to assess the cost effectiveness, net social benefits, and trade-off analysis among ecosystem services for each intervention types. Moreover, planting plants resistant to drought, water logging, grazing, browsing, trampling, frost and planting plants that can better performance on nutrient poor soil is helpful. Therefore, rehabilitation should not considered as an implementation means of plan and focus an organization, instead it should be considered as a fulfillment of societal needs for multidimensional benefits. Accordingly, perception and multidimensional benefits of communities should be considered for successful of rehabilitation work. In this regards, plant species to be planted in the rehabilitated land must encounter the interests and needs of surrounding communities.

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Declaration of conflicts of interest
The authors have no Ethical or conflicts of interest to declare that are relevant to the content of this article.

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