EFFECT OF EXCLOSURE ON ENVIRONMENT AND ITS SOCIO ECONOMIC CONTRIBUTIONS TO LOCAL PEOPLE: IN THE CASE STUDY OF HALLA EXCLOSURE, TIGRAY,ETHIOPIA

HAILE GETSESELASSIE ASRES

NORWEGIAN UNIVERSITY OF LIFE SCIENCES
Department of ECOLOGY & NATURAL RESOURCE MANAGEMENT
Master Thesis 60 credits 2012

Effects of Exclosure on Environment and its Socio-economic Contributions to Local People: In the case of Halla exclosure, Tigray, Ethiopia

BY
Haile Getseselassie

A thesis submitted in partial fulfillment of the requirements for the Master of Science degree in tropical ecology
Norwegian University of Life Science,
Ås, Norway

Declaration

I, **Haile Getseslassie**, declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for award of any type of academic degree.

……………………………………………..
(**Haile Getseslassie)**

Abstract

*Though exclosure is sound for degraded land rehabilitation, mainly due to lack of quantitative environmental and socio-economical merits most exclosures are attributed negatively by local people and hence their sustainability left at risk. This study was held to identify and quantify effect of Halla exclosure on environment and its socio-economic contribution to local community at Kebelle Aynibrkekein, Woreda Degua Tembien,Tigray North Ethiopia. To do this, two mountains: closed and non-closed were selected. To measure important parameters of trees and shrubs, herbs and grasses, 8 plots having 10*10m, 4*4m and 1*1m (nested each other) were taken respectively in each mountain. And to assess actual contribution to the local people, 16 households under the closed and 22 under the non-closed were interviewed. On top of this, group discussion was held with focus group. Accordingly, 10 trees & shrubs (Shannon diversity index [H] =1.695934422) representing 93 individuals and 11 herbs representing 173 individual were found in the sample plots of the closed whereas 5 trees & shrubs (H =1.241125184) representing 41 individual and 7 herbs representing 149 individual were found in the non-closed. Height structure of trees and shrubs at the closed seems like bell shaped being most individuals concentrated to 1-2m while at the non-closed seems like inverted J shape being most individuals concentrated to less than 0.5m. Both the closed and the non-closed areas have inverted J shape diameter distribution but in the non-closed, maximum diameter were limited to less than 10cm while in the closed the range stretched up to 15cm. The closed area was significantly different over the non-closed in terms of tree and shrubs moist biomass, oven dry biomass, carbon dioxide sequestration, biomass of forage grass, and biomass of thatching grass ($p<0.05$) But not significantly different in terms of herbs moist biomass, oven dry biomass and carbon dioxide sequestration, trees and shrubs canopy coverage, herbs canopy coverage, honey bee flora and cactus fruit availability ($p\geq 0.05$). The closed area had 438108 kg moist biomass, 303600 oven dry biomass and 669240 sequestrated carbon dioxide of trees and shrubs, and 165000kg forage grass, and 132000kg thatching grass more than the non-closed area.*

All (16) of the respondents under the closed mountain responded they were getting benefits from the exclosure but under the non-closed, only 8 attributed the non-closed area is giving them some benefits. May using fuel wood from the exclosure is illegal, all respondents, said, they do not use fuel wood from it while 4 respondents under the non-closed said they fetch firewood from the non-closed. 4 respondents under the closure and 3 from the non-closed said their honey production is increasing due to their respective areas but at the bottom of the exclosure there were two bee keeping enterprises having 93 bee colonies producing about 4525kg/year but nothing was in the non-closed area. All of the respondents under the exclosure said that they get forage and thatching grass from the exclosure every year. About 13500kg and 64800kg forage and thatching grass respectively have been cut per year by the local people but nothing under the non-closed. 10 from the closure and 2 from the non-closure said their respective areas were contributing to their crop production and 80% of the respondents under the closure said they got cactus fruits from it but nothing under the non-closed. 65 % respondents under the exclosure identified the exclosure is also giving them environmental benefits such as decreasing erosion and increasing discharging potential of springs and wells whereas under the non-closed area, all except 1 (he said it protects torrential wind) did not attributed environmental benefits from it. In addition the respondents under the closure said they are getting social benefits like job opportunity and they feel proud of having such closure. On contrary the respondents under the non-closed were not attributed social benefits and hence some feel shame and envy of the neighbor's closure. Although the closure had environmental and socio-economical potential and all the residents under it are getting benefits (though not optimum), most of them were not happy with the benefits because of poor management and immediate benefit needs.50% respondents decided to be free accessed for animals and fuel wood. In addition, most of them could not quantify its benefits. Therefore, concerned body should interfere to manage appropriately and to persuade especially to the pessimistic people by giving quantitative evidence of its merits over if it were not closed and this study can be used as base.

Keywords: *, environment, socio-economy, carbon dioxide sequestration, closed area, non-closed area, trees and shrubs, herbs, forage grass, thatching grass, respondents*

Acknowledgments

First, I would like to thank my Almighty GOD. I wish to express my special sincere appreciation to my supervisor prof. Fred Midtgaard for his priceless advice, support and guidance throughout the paper work.

It is my great pleasure to thank to wereda Dogua Tembien administration, wereda bureau of agriculture and rural development and Tabia aynmbrkekin adminstration for their help in providing me with the necessary information and facilitation, and also I am very much indebted to Hagereselam wereda vice administration Ato Goitom Tafere for providing me a car.

I would like to express my deep sense of gratitude to Ato zenebe, Axum University, for his strong help during the field work of the data collection, technical support and also in my absence by leading the field crew in working efficiently and effectively to the end of the work.

I would like to appreciate and to thank the respondents for being voluntary to answer the questionnaires. I would like to thank to Mekelle University for helping me in oven drying samples and to Addis Ababa University for identifying scientific name of some species.

Thanks also to Ato hailemariam of MU, Teame a student of Norwegian university of life sciences for their comment and encouragement.

My stay in Norway was partly motivated by the loving friends in Norway and other friends outside Norway and I am deeply thankful for the time we had together.

Above all, I wish to express my deepest gratitude for my wife Rahel Abate for her all round help in all my works.

My late brother Gotom Getseselassie has special place in my heart as I have lost his at the start of my study. I am also pleased to my families without their encouragement, advice and moral I would not have gone thus far.

Finally, I wish to acknowledge the Norwegian university of life sciences for giving me the chance to study.

Contents

List of Figures

List of Tables

Acronyms and Abbreviations

REST	Relief Society of Tigray
WFP	World Food Program
MoA	Ministry of Agriculture
FAO	Food and Agriculture Organization
EFAP	Ethiopian Forest Action Plan
Mg	Megga
Ha	hectare
HH	Household
PPn	population
Masl	Meter above sea level

Chapter 1: Introduction

1.1 Back ground of the study

Land degradation refers to worsening of land resources (Stocking and Murnaghan, 2001) and hence decreasing of sustainable productive capacity of agricultural lands in the world (de-Queiroz, 1993, UNFPA and POPIN, 1995). Particularly land degradation is a severe problem across sub-Saharan Africa and Ethiopia is among the most affected countries. Deforestation (37%), overgrazing (35%), inappropriate agricultural practices such as over-cultivation, fertilization and nutrient depletion (28%) and industrialization (1%) are major human caused factors of land degradation in the world (Betru *et al*., 2005). Rangeland degradation is a widespread problem throughout sub Saharan Africa and its restoration is a challenge for the management of many semi-arid areas (Yaynishet, 2008). Land degradation affects livelihoods of the rural population which depend their life on agricultural land resources especially in developing countries it is a cause of poverty (Dasgupta and Maler, 1991). Land degradation in Ethiopia is triggered by population expansion and over-exploitation of the natural resources and degradation is a major threat to sustainable land uses (Hurni et al., 2005).

Tigray is one of the regions, which have fallen victim to the land degradation problem in the northern parts of Ethiopia. It is the severely degraded region which can be typically characterized by heavily eroded and nutrient deficient soils, hydrological instable, reduced primary productivity and loss of biological diversity (Emuru, 2006). In response of the land degradation, the government of Ethiopia has initiated a number of projects including soil and water conservation works and establishment of area closures (Betru *et al*., 2005). REST (1998) reported that the problem of land degradation in the semi-arid Tigray region in northern highlands of Ethiopia is addressed based on the succession model, in that in some communal areas livestock is completely excluded for an extended number of years.

Exclosures are a type of land management, implemented on degraded land for environmental restoration (Tucker and Murphy, 1997). Area exclosure in the Ethiopian context can be defined as the degraded land that has been excluded from human and livestock interference for rehabilitation (Betru *et al.*, 2005). Establishment of area closures has been an important strategy for the rehabilitation of degraded hillsides. This practice has become very common, especially in the highlands of Ethiopia, due to the impressive improvement of productivity and reduction in soil erosion in the areas enclosed in the early 1980s (WFP/MoA, 2002). Exclosures established in the semi arid region of northern Ethiopia are effective in restoring species composition, diversity, biomass and key woody structural attributes of degraded communal grazing lands, factors that normally lead to improved ecosystem function and health (Yayneshet et al., 2008). Exclosures have the potential to reduce water erosion (Mekuria *et al*., 2009). Exclosure is cheap and fast but productive degraded land rehabilitating mechanism (Emru *et al*., 2006).

1.2. Problem of the statement

Cumulative effect of soil erosion, deforestation and overgrazing caused the northern Ethiopia highlands to be a victim of land degradation (Kindeya, 2004). In response of the land degradation, different rehabilitation measures have been launched by government and non-government organizations jointly in the region. Among others, continuous setting-aside of degraded land for natural regeneration called area exclosure has been practiced (Yayneshet et al., 2009). More than 80,000ha of land has been protected in Tigray and Amhara regions (Mekuria et al., 2009). However, there are complaints especially local people regarding the economic benefits. Woldeamlak (2003) reported farmers do not like to be deprived from environmental resources where it is a means of pursuing their livelihoods. Betru et al. (2005) also reported that in spite of the impressive results of the ecological rehabilitation and improvements of productivity, many communities have had a bad experience with area closure due to: (i) uncertainty and the lack of clarity of land tenure and public land use policy in the country (ii) lack of consistent rules and regulations and hence lack of equity on utilization of resources (iii) lack of real ground community decision making in the management and resource utilization and (iv) lack of knowledge about the actual amount of benefits that can be derived from exclosures and not convinced about the advocated benefits. Hence they became pessimistic towards the closure and cut illegally and destructively. And he recommended data of productivity of exclosures must be documented.

Similar is happening in Halla exclosure some local people are pessimistic towards it. They do not believe that the closure is giving more benefits than non- closed areas around it or they are not sure that it is giving them more benefit than if it was not closed. The government protected them by guards but fuel wood, pole, forage grass, thatching grass ...etc encroachment illegally is common especially at night. As to Betru et al. (2005) this might be due to lack of quantitative scientific evidence of the merits of the exclosure. Despite the fact that exclosures have proved instrumental in the rehabilitation of degraded lands, knowledge on vegetation status and socioeconomic contribution to local people is lacking (Emru *et al*., 2006). Comprehensive empirical evidence on the success of restoring degraded communal livestock grazing lands using exclosure is meager and is not extensively researched (Yayneshet et al.,2008). Area exclosures are diverse in several ways: in terms of their ecological conditions, socio-economic, political, historical contexts, causes of land degradation and way of management. Generalization is both difficult and probably not so useful unless diverse and representative studies have taken Mekuria et al. (2005). Therefore, identifying and quantifying benefits of Halla exclosure scientifically might be important to be scientific and quantitative evidence especially for the pessimistic residents. For this reason, this study tried to identify and quantify some of its important environmental and socio-economical merits by comparing with aside non-closed area called Gidmi Degua Mountain

1.3. Objectives

1.3.1General objective

The overall objective of this research was to assess environmental and socio-economical merits of exclosure over non-closed area.

1.3.2. Specific objectives

- ✓ To compare tree species diversity and regeneration structure between closed mountain (Halla Hizati) and non-closed mountain (Gidmi Degua)
- ✓ To compare biomass, carbon dioxide sequestration, and canopy coverage potential between the closed and non-closed mountain
- ✓ To compare economical potential (honey bee flora, forage grass, human food (cactus fruit),thatching grass) between the closed and non-closed mountain
- ✓ To assess actual benefits the local people get from the exclosure compared to the non-closed.

1.4 Significance of the study

The aim of this study was to investigate the environmental and socio-economic returns of exclosure. The findings would hopefully enrich information on benefits and challenges of exclosure in the region in particular and northern highlands of Ethiopia in general. Moreover, the outcome of the study is believed to be an important source for policy makers and planners during further design and implementation of land resources management. More importantly, Woreda experts and Kebelle development agents can use this finding for local people awareness creation

Chapter 2: Literature Review

2.1. **History of land degradation and exclosure**

Land degradation traced back to 600AD and since then, agriculture sector failed to feed the growing population and resulted in escalated food shortages, hunger and famine in the region (Tigray) (Hurni, 1988). In 1980s, land degradation especially in the Ethiopian highlands has been identified as the most serious environmental problem (Aune et. al., 2001, Hagos and Holden, 2002). In 1986, it was estimated about half of the highlands were significantly eroded (FAO, 1986). The fastest rate of deforestation (150,000 to 200,000 hectares per year) exacerbated the scope and rate of land degradation in the regions (EFAP, 1994). Deforestation has been a major problem for quite a long time with serious consequences to Ethiopia. These consequences include decline or loss of biodiversity, degradation of land and water bodies, possible negative effects on the local, regional and global climatic conditions as well as negative impacts on the welfare of human beings. At the close of the twentieth century, the country found itself undergoing rapid and complete de-vegetation in some places. Forest clearances for crop cultivation, unsustainable exploitation of wood for timber, construction and fuel, overgrazing and civil unrest are among the main causes of deforestation in Ethiopia. Thus, at present, small remnant forests, woodlands or shrub lands have become restricted to inaccessible areas such as hillsides, mountaintops, and around churches, monasteries, mosques or graveyards, particularly in the northern parts of the country. Larger forest relics are only found in the southern parts of the country (Emru et al, 2006).

Area closure is land unit protected from some animals by appropriate barriers (Young, 1958). Similarly Mengistu et al. (2005) reveals that area closure is protecting the degraded land from tree cutting and free grazing of domestic animals. From these concepts it can be said that exclosures are former degraded lands protected from disturbing animal and human entrance for natural recovery. In most cases to be set a land as area closure, the area should be abandoned because of nothing with it for animal and human. The area is identified and set as exclosure by Woreda and Kebelle agricultural experts, and user groups who agreed to strictly protect them from any form of grazing, manual harvesting of grass and tree cutting. Area closure can be 20-700ha (Yaynishet et al, 2008).

In principle, human and animal interference is restricted in the area enclosures to encourage natural regeneration. In practice, however, cattle are allowed to free graze in several of the exclosures. Cutting grass and collection of fuel wood from dead trees and bee keeping is also allowed. In some areas, soil and water conservation activities are also being undertaken (Betru *et al.*, 2005). Area closure was started during *Derg* regime although activities were mainly planned and implemented using a top-down approach without any form of community participation and resource utilization which in turn adversely affected the sense of ownership (Dessalegn, 1994).

The inception of exclosure dates back to the early 1980s, which coincides with the beginning of large-scale land rehabilitation and soil and water conservation programs in Ethiopia. The establishment of exclosure has been one of the strategies for rehabilitating the degraded hillsides within the catchments delineated for the rehabilitation and soil and water conservation programs (Betru *et al.*, 2005) which was firstly for ecological rehabilitation but now recent studies found increased expectations of the community about economic benefits on exclosure and became major managemental challenges of the exclosure (Gebremedhin et. al., 2000). According to BoANR cited in Betru *et al*. (2005), the objectives of area enclosures are to:

- Halt and reverse land degradation.
- Check the adverse effect of run-off
- Create natural resources highly demanded by livestock, human beings and the land.
- Improve the micro-climate of respective places and thereby maintain environmental stability in the region.
- Create habitat for wildlife.
- Conserve the diminishing biological resources, mainly forest trees, shrubs, herbs and grasses.

Similarly, Raf et al. (2008) reported that area exclosure is instrumental for:

- Allowing native vegetation to regenerate as a means of providing fodder and woody biomass.
- Reduce soil erosion.
- Increase rain water infiltration.

From both scholars and other related evidences, the main objective of establishing exclosures is to improve the overall ecological conditions of degraded areas so that they can provide better socio-economic benefits to the local communities. In this regard, Bendz (1986) reported that establishing exclosures is considered advantageous since it is a quick, cheap and a lenient method for the rehabilitation of degraded lands.

2.2. Potential of exclosure

After Yaynishet at al. (2008), exclosures established 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 function in Tigray region of northern Ethiopia.

2.2.1 Environmental potential of exclosure

- ***Species diversity, regeneration structure, and ecosystem stability potential of exclosure***

In Iran (North Khorasan Province) Sisab Research Station, a total of 53 plant species were identified within the un-grazed plots containing 18 plants more than grazed plots (Dianati *et al*., 2010). In Wukro Aynalem Kebelle (Ethiopia), higher abundance, density and basal area were found in the exclosure and an expanding population structure in exclosure, but obstructed population structure in open area (Emiru *et al*., 2004). In Dogua Tembien and Wukro (North Ethiopia), species composition and diversity of herbaceous and woody plants were higher in the exclosures than in the grazed areas (Yaynishet,et al.,2008).

After the establishment of exclosures, acceleration of plant and animal diversity increase with time and where there is exclosure it is an inevitable to see green area (Tefera, 2001). Number of woody species decreases at higher diameter classes which could be due to the selective removal of woody species for fuel wood and construction. High number of woody species at lower diameter classes shows the potential of exclosures to restore degraded lands. However, unmanaged selective removal of big trees could also interrupt the continuous replacement of woody species (Mastewal et al., 2006) and Mekuria et al. (2005) spelled out: (i) loss of big trees which means loss of seeds and flowering plants which in turn damage the continuity of the generation (ii) with the depletion of big trees, communities forced to use young trees which in turn lead to destruction of woody species

❖ ***Biomass and carbon dioxide sequestration potential of exclosure***

After closed, capacity of degraded lands to produce vegetation greatly varies from area to area due level of damage and environmental managemental factors. In areas where the land is completely degraded and turned to barren/rock outcrops, the level of recovery has been very slow and the biomass production either from planted species or naturally regenerating species is found to be very low (Betru *et al*., 2005). In New Zealand, South Island Benmore Range, excluding grazing by sheep and rabbits for 15 years resulted in a two- to three-fold increase in the total biomass (roots, litter and herbage) relative to the grazed treatment. With the exception of Mg, total nutrient pools in biomass and soil are lowest in the grazed area (Peter *et al.*, 1996) and In Glencairn Station, upper Waitaki Valley excluded grazing animals for 16 years on seasonally-dry steep lands results in greater plant cover, approximately double the biomass of standing vegetation, greater biomass in roots, and more biomass nutrients relative to grazed areas (Mcintosh and Allen, 1998).

The mean aboveground biomass measured inside the exclosures was more than twice that of the adjacent grazed areas and more biomass was produced from the young than the old exclosures. Stem height, canopy height, canopy cover, and browsing capacity of woody species were higher in the exclosures than in the grazed areas (Yaynishet et al., 2008). The increase in biomass with age of exclosures shows the positive effect of exclosure to improve site quality (Mekuria et al., 2005). In exclosure the increase in biomass is apparent. As in many of the areas degradation was so severe that before intervention vegetation was nearly absent, the obvious increase in biomass has convinced both communities and the government about the great potential of the exclosures to restore vegetation in areas of extreme degradation (Betru *et al*., 2005).

More canopy cover sequestrates more carbon dioxide (Eskandari, 2008). Plants stems have the highest exchanging sequestration of organic carbon (Muller, 1974). 5 year, 10 year, and 15 year exclosures showed significant higher soil carbon and aboveground carbon stocks than respective adjacent grazing lands (Mekuria et al., 2009)

❖ ***Degraded land rehabilitating potential of exclosure***

In Eskelimroud basin (west of Savadkouh, Mazandaran province, Iran), a five-year exclosure increase vegetation cover, percentages of nitrogen, phosphorus, potassium, organic matter and electrical conductivity in the soil surface over unclosed area. Short time enclosures didn't influence on soil texture which is a perennial characteristic and it needs a long time to be affected (Hosseinzadeh *et al.*, 2010). At some places, local people report that species disappeared in the past have been restored as a result of the exclosures. For instance, in some parts of eastern Tigray, species that had long disappeared from the areas (e.g. *Olea europaea* subsp. Cuspidate and *Juniperus procera*) re-appeared, densities and diversities of the flora (particularly grasses) and fauna increased, the level of soil erosion decreased, and even springs started to flow after exclosures established(Emiru *et al*., 2004).

Soil organic matter, soil nutrients as well as soil physical and chemical properties of exclosures are significantly different compared to the adjacent free grazing lands. The improvement in soil properties and nutrients is a key factor for the enhancement of biomass production in exclosures (Mekuria et al., 2005). The major factors affecting the rate of recovery and productivity of the area exclosure are intensity of past land degradation, soil conditions, moisture, intervention. Remnants of the former vegetation, mainly trees and shrub species, are the dominant vegetation re-colonizing the niche after the establishment of exclosures. With increase vegetation cover, wildlife populations (e.g. porcupine and fox) have also increased (Betru *et al*., 2005).

In Woreda Dogua Tembien (northern highlands of Ethiopia), areas which are currently used as free grazing lands are affected more from water erosion than exclosures. Also agricultural lands located below the free grazing lands are strongly affected by erosion. Estimated weighted mean annual soil erosion in free grazing lands varied between 25 and 121.5 Mg ha-1y-1 but estimated weighted mean annual soil loss in exclosures varied between 2.6 and 98 Mg ha-1y-1. That is estimated soil loss from free grazing lands is higher by 47% than soil loss from exclosures which illustrated that exclosures are effective to control soil erosion (Mekuria *et al.*, 2007).

Though runoff depth is significantly correlated with event variables such as rain depth, rainfall intensity, storm duration and soil water content, total vegetation cover is the most important variable explaining about 80% of the variation in runoff coefficients. Increased vegetation density in exclosures results in increased infiltration and higher transpiration, which in its turn triggers vegetation restoration through increased biomass production. With vegetation restoration, water use for biomass production also becomes more efficient. Vegetation restoration is responsible for the high infiltration capacity of the exclosures, but as transpiration is not increased at the same rate, the surplus infiltration drains beyond the root zone and contributes to groundwater recharge (Mekuria *et al.*, 2009).

In the Tigray highlands of Northern Ethiopia, the establishment of exclosures (i.e., areas closed for grazing and agriculture) has become an important measure to combat land degradation and restore vegetative cover. Because of their high sediment trapping capacity, exclosures are a very efficient soil and water conservation measure. They accelerate fertile soil buildup and prevent important sediment loads from leaving the catchment or silting up water reservoirs (Descheemaeker *et al*., 2005).

2.2.2 Socio-economic potential of exclosure

For exclosures to continue playing their environmental conservation role, socio economic needs of local people is very important. A sustainable and socially fair harvesting system of the wood resources or a rotational grazing system initiates local people to have positive attitude towards exclosure (Descheemaeker *et al*., 2005). The vegetation in the exclosures most useful to the communities are mainly the herbaceous and woody plants, specifically grass, tree and shrub species (Betru *et al*., 2005).

In Ethiopia, Biyo Kelala and Tiya exclosures, land productivity is increased due to exclosures. Local farmers which were buying grasses for thatching are now selling. On average, a household share of thatching grass sells for 104 Ethiopian Birr annually (1 US$ = 8 Eth Birr) in Biyo Kelala and 38 Eth Birr in Tiya exclosure Implying the exclosures are boosting annual household income of local people (Tefera *et al*., 2005).

Chapter 3: Materials and Methods

3.1. Description of the study area

Location

Halla exclosure is found in *Got* Addis Alem, *Kebelle* Aynibirkekin, *Woreda* Degua Tembien, Tigray regional state, North Ethiopia (Figure 1). It is situated 35km West of Mekelle (capital city of Tigray) on the way to Hagereselam (capital town of the Woreda). It is located 13°39′00.15’’N, 39°15′12.07’’E. The terrain is undulating hills alternating with plains and valleys.

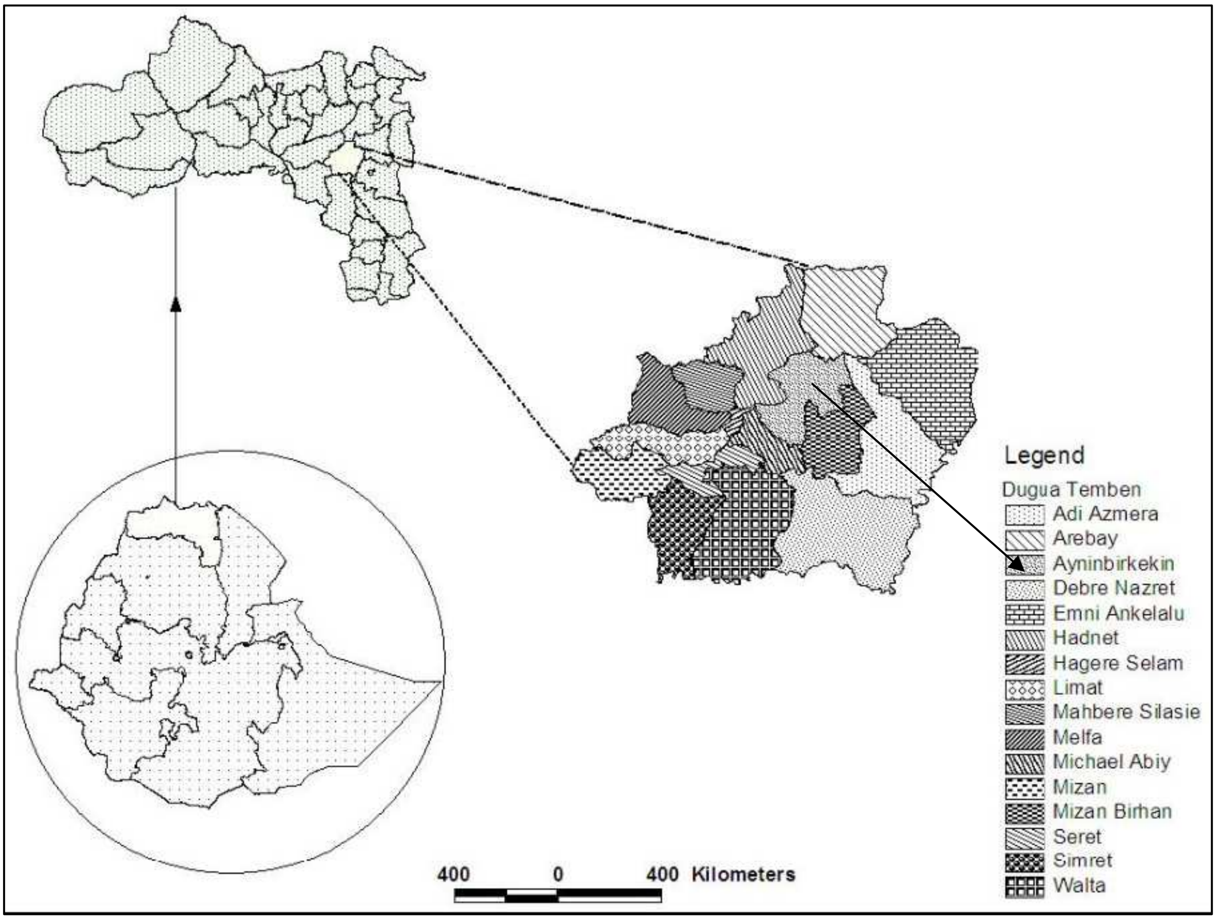

Figure 1. Location of the study area

Vegetation

Vegetation cover of the area is mixed of scattered acacia trees, riverine forests, and bush scrub. The vegetation is typical of the East African montane area that is part of the Sudano Sahelian transition subzone and common plant formations include mesophyllic deciduous woodland, mixed evergreen and deciduous open woodland (Le Houe´ rou, 1989). The study site is dominated by a diverse assemblage of grass and herbs, most of which are palatable for livestock (Yayneshet, 2008). But the exclosure is now enriched by exotic species typically *Eucalyptus camaldnesis* and *Schinus molle, Acacia saligna*

Agriculture

95% of the total population depends on agriculture using mixed farming system. Crops are mainly barley (*Hordeum vulgare*), tef (*Eragrostis tef*), and wheat (*Triticum aestivum*). Average crop yield around the study site 5qt/ha which is very low. Cattle and goats are the main livestock types reared. Honey production is also more common

3.2. Sampling techniques and experimental design (lay outing)

As can be seen from Figure 2a and b, the study area has two gentle to steep slope hillsides locally called Halla Hizati (closed mountain about 33ha) and Gidimi Degua (non-closed mountain about 34.5ha). They have similar aspect (towards west), climate, slope, lithology and soil type. They are about 2km apart each other.

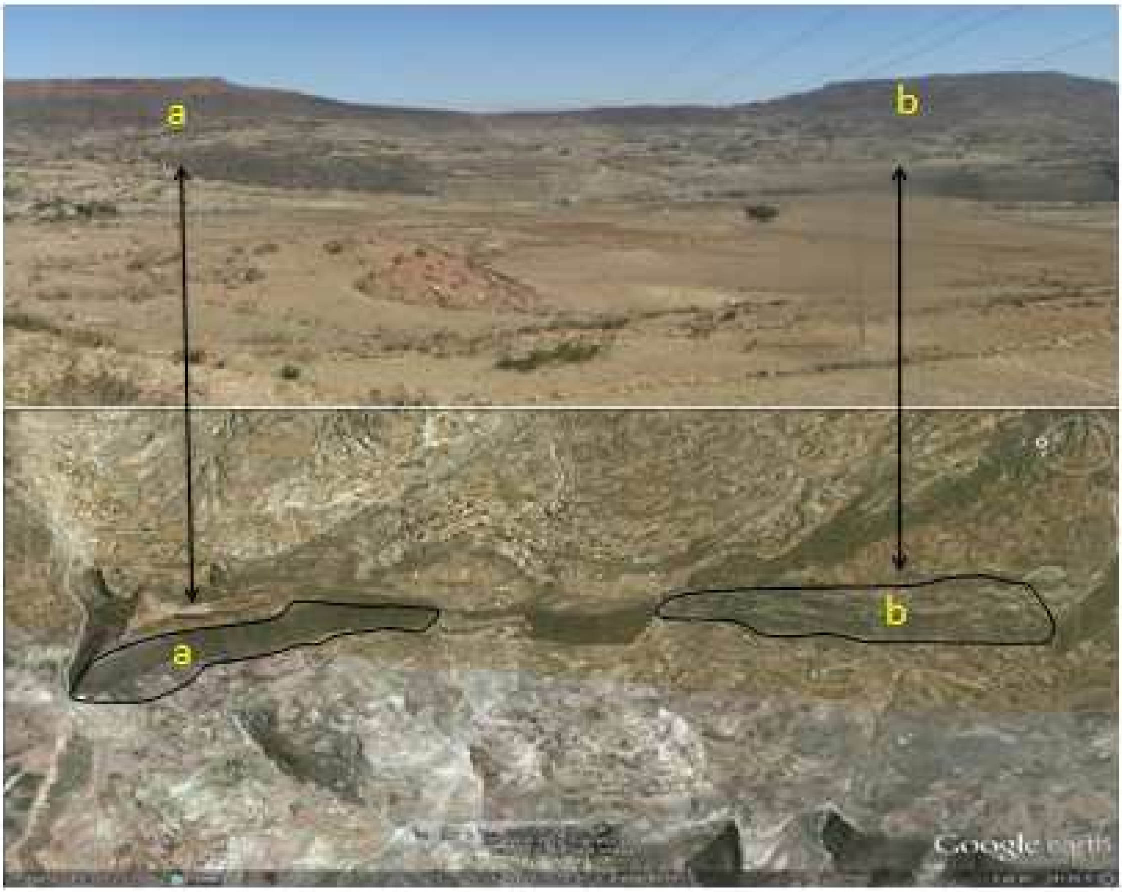

Figure.2. Halla exclosure (a) and Gidmi Dogua non-closed (b) using digital camera and Google earth image

On each mountain, three bottom-top extended (along the gradient) parallel transect lines with 400m spacing were assigned (being the middle transect line at the center of each). To measure important parameters of trees and shrubs, herbs, and grasses, eight 10*10m (Figure 3a) (Yayinishet et al., 2008), eight 4*4m (Emuru et al. 2006) and eight 1*1m (Figure 3b) (Yayinishet et al., 2008) quadrants (confined each other [Figure 4]) were assigned respectively along each transect lines with 100m interval.

a b

Figure .3. During Lay-outing 10m*10m (a) and 1m*1m (b) quadrants

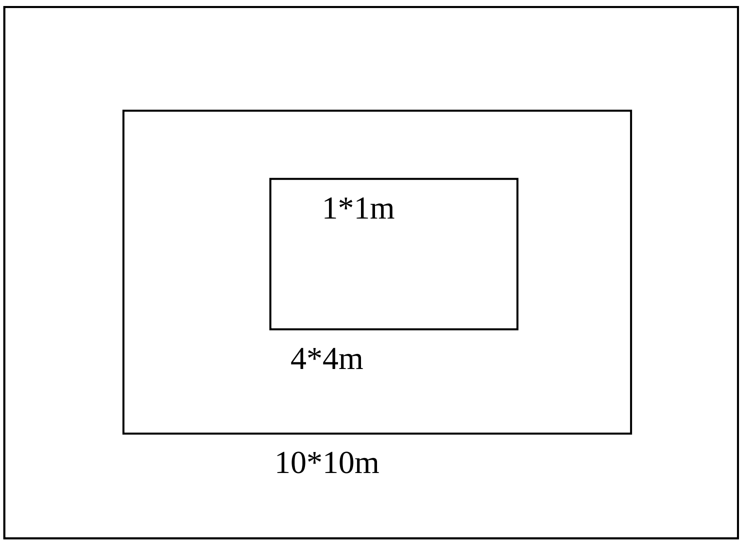

Figure .4. Quadrant lay-outing

At the bottom of the closed mountain there is one *Got* called *Got Addis Alem* and at the bottom of the non-closed called *Got Merhib* which have 160 (49 female headed) and 225 (40 female headed) households (HH) respectively. To assess the actual benefits obtained by the local people (compared to the non-closed), 10% households (Table 1) from each *Got* were selected from the *Kebelle* household's list name for interview (appendices 9&10) in systematic random. In addition, focus group discussion with key informants (elders, *kebelle* leader, *kebelle* developmental agent, *kebelle* women association leader, *Got* leader) was complemented to over view the status of the exclosure and the interaction of the community with the exclosure.

Table 1. Sample households for interview at bottom of the mountains

Households	Under closed Mt		Under Non-closed Mt	
	PPn HH	Sample HH	PPn HH	Sample HH
Female headed HH	49	5	40	4
Male headed HH	111	11	185	18

3.3. Data measurement and collection

From each 10*10 m quadrants for trees and shrubs and 4*4m quadrants for herbs, diameter at breast height (DBH) for trees and diameter at stump height (DSH) for shrubs and herbs was measured using caliper. And height, canopy diameter and canopy depth was measured using graduated stick (Figure 5). Species local name and 3 best honey bee floras were identified by two local elders. Scientific name was also verified by personal experience and by confirming with dendrology books (Azene, 2007). Species difficult to identify by local elders and by dendrology books were identified at Addis Ababa University national herbarium using leaf sample. From the 1*1m^2 quadrant forage grass and thatching grass was cut and weighed (Figure 5). From each mountain 3 dominant trees and shrubs and 3 dominant herbs were identified. From each species 1 small size, 1 middle size, and 1 large size were selected purposely, their diameter, and height was measured, then cut at their base and soon their moist weight was measured (Figure 6). For the trees and shrubs some samples from their stem, branches and leaves and for the herbs the whole (after cut into pieces) was oven dried (Figure 6) at Mekelle University at 65^{o}C for 24 hours (appendix 6).

Process continued…

Figure 2. Partial view of the measurement and data collection: height, canopy diameter, canopy height, grass weighing, tree felling, branching, branch and woody weighing

a b

Figure 3. During and after over drying of samples

3.4. Data analysis

The Shannon index has been a popular diversity index in the ecological literature (Krebs, 1999). Therefore, Shannon-Weiner Index was used for woody species diversity counted in each quadrant (t'Mannetje and Jones, 2000). Histogram was used for height and diameter regeneration structure after being classified at 0.5m and 5cm interval respectively (Emuru et al., 2006 and Yaynishet et al., 2008). ANOVA and Tukey's mean separation (using Jmp5 soft ware at 0.05 significant levels) was used for variation analysis (appendices 7&8). Descriptive statistics was used for the household survey part. Oven dry weight was converted into Carbon dioxide sequestration using the frequently applied model which stated as:

Sequestrated Co_2 = oven dry weight *1.2 *0.5*3.67 (**www.plant-trees.org/.../..)**

This is under the assumption that root weight is 20 % of above ground weight, half of oven dry weight is carbon, and ratio carbon dioxide to carbon to is 3.67.

Chapter 4: Results and Discussions

4.1. Species diversity and regeneration structure comparison between the closed and non- closed areas

In the closed area, 93 individual trees and shrubs and 173 herbs were found whereas in the non-closed area 41 individual trees/shrubs and 149 herbs were found (appendix 1 and Table 2). This shows that the closed area had more trees and herbs enriched than the non-closed. This is similar to the findings of Yaynishet et al. (2008) revealing that density of woody species in closure is more than twice that of adjacent browsed areas. Betru et al. (2005) also found average number of species per plot is higher in closed area than in open areas indicating that there was more species diversity in the exclosure. This difference could be due to the protection of human being and domestic animal disturbance and this might be motivated seed germinating and growing up (Demel, 1996). Therefore, it can be inferred that the area closure is more worthy than the non-closed in terms of tree, shrubs and herbs richness. This indicates that the closure is more worthy than if it were not closed.

Table 2. Number of trees and shrubs and herbs in the closed and the non-closed mountains

Tree and shrubs	Frequency	Herbs	Frequency
closed	93	closed	173
Non-closed	41	Non-closed	149

In the closed area, there were 10 trees & shrubs and 12 herb species but in the non-closed there were only 5 trees and shrub species and 7 herbs (appendix 2). It is known Shannon diversity index show the species diversity in a community by considering abundance and composition (Krebs, 1999). Diversity indices provide more information about community composition and relative abundances of different species. It provides important information about rarity and commonness of species in a community (Krebs, 1999). The result of this study showed that Shanon diversity index (H) for tree and shrubs of the closed and the non-closed area were 1.695934422 and 1.241125184 respectively. These shows in the closed area there are many different varieties and more abundant woody species than in the non-closed area. Similar to the present study Yaynishet et al. (2008) found higher herbaceous and woody species diversity in closure than free grazing. This might be due to soil fertility increment by the decomposition of earlier litters (Descheemaeker et al., 2006 and Mekuria et al., 2007). Having more woody trees diversity has multi-implication: there might be healthy, stable, productive and sustainable ecosystem in the exclosure than the non-closed implying productive area.

Examination of the population structure of plants, employing either height or diameter classes can be used to provide a rough idea about the status of regeneration of woody plants' (Emru et al., 2006).

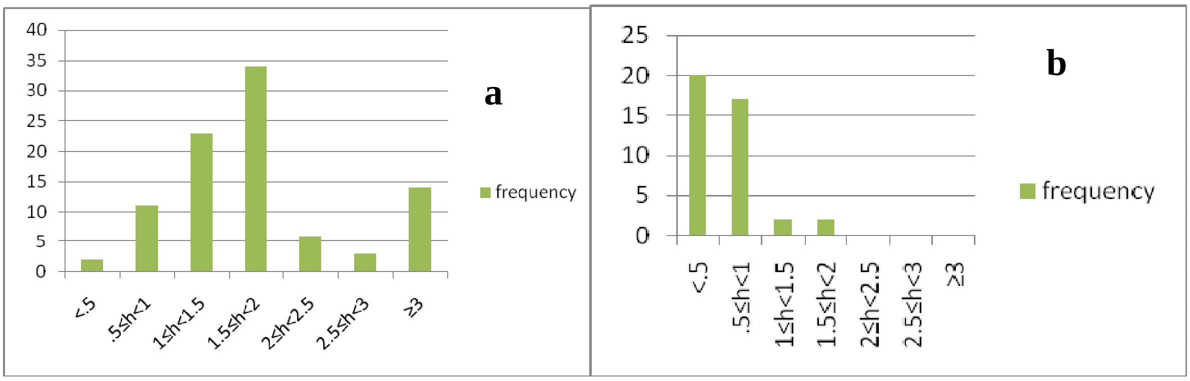

Figure 4. Frequency distribution of height classes (in meter) of trees and shrubs in the closed (a) and non-closed areas (b)

As it is seen in Figure 7 and appendix 3 height structure of trees and shrubs at the closed area seems like bell shaped (Figure 7a) while at the non-closed seems like inverted J-shape (Figure 7b). Consistent to this, Emuru et al. (2006) identified height structure of woody species of closed area in Wukro was bell shaped. At the closed area most of the individuals lie to 1-2 meter followed by lesser amount of younger generation (less than 1m) and following to elder generation (above 2m). This shows the area is dominated by young generation relatively implying there is stable, healthy and balanced regeneration structure.

Whereas at the non-closed area, most of woody individuals lie to less than to half meter following to some elders (greater than 0.5m). Many authors attributed inverted J-shape show healthy community justifying there are a lot of new coming generation. In this study it seems there are a lot of new rising seedlings but this is not the true. It is because of over browsing, over cutting, and the degraded land; they became stunted and dwarf but aged. Every extension and new rising branches might be always trimmed by cattle and by the local people because of it is free accessed. Therefore, in this study having inverted J-shape height structure does not show healthiness of the woody species in the non-closed mountain. In addition in the non-closed area there were no individuals greater than 2m. Yaynishet et al. (2008) also found trees taller than 1 m were present only in small numbers in the grazed areas. But in the closed area there were individuals even greater than 3m. This shows the area closure has relatively big trees which imply healthy regeneration structure (Emru et al., 2006) but the non-closed is limited to stunted bushes implying unhealthy regeneration structure. Therefore it can be deduced the closure has relatively healthy woody species regeneration structure implying sustainable vegetation cover than the non-closed.

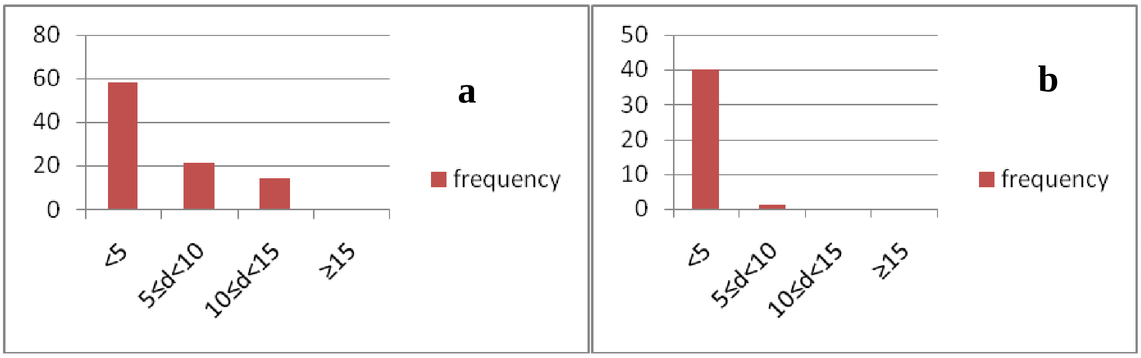

Figure 5. Frequency distribution of diameter classes (cm) of trees and shrubs in the closed (a) and non-closed areas (b).

Both the closed and the non-closed areas have inverted J-shape diameter distribution (Figure 8). The non-closed area was relatively limited its maximum diameter to less than 10cm where as in the closed there were individuals above 10 cm even though no more than 15cm. Similar to this finding, Emuru et al. (2006), Yaynishet et al. (2008), and Mekuria et al. (2009), Betru et al. (2005) found inverted J-shape diameter structure for closed and non-closed area. In the closed area having relatively large diameter shows the new rising individuals can step up to sapling and tree which in turn imply healthy and productive ecosystem (since bigger trees are indicators of stable and productive ecosystem). On the other hand, the reverse is true for the non-closed area because almost all individuals were concentrated to less than 5cm which imply they cannot step up to bigger because of the livestock and human intervention (Emuru et al, 2006 and Yaynishet et al, 2008). In addition, practical experience reveals that these individuals became thinner (less than 5cm), it is not because of their being new rising but became stunted due to frequent trimming by human and animal and the degraded land. From this it can also be derived the closure showed relatively continuing generation with big trees which can be biotope of many organisms and valuable tree could be recruited. Hence stable environment might be inevitable which the open access mountain could not.

4.2. Comparison of biomass, carbon dioxide sequestration, and canopy area coverage potential between the closed and non- closed areas

Table 3.ANOVA result for environmental potentials of the closed and non-closed areas

Sites	Mean trees & shrubs moist biomass/ plot	Mean trees & shrubs oven dry biomass/ plot	Mean trees & shrubs co_2 sequestration/plot	Mean herbs moist biomass/ plot	Mean herbs oven dry biomass/ plot	Mean herbs co_2 Sequestration/plot	Mean trees & shrubs canopy basal area/plot	Mean herbs canopy basal area/plot
+Closed	145.4[a]	100.8[a]	222.1[a]	22.2[a]	14.1[a]	31.3[a]	38.3[a]	4.5[a]
N-closed	12.64[b]	8.8[b]	19.3[b]	30.3[a]	17.8[a]	39.5[a]	0.3[a]	1.9[a]
P-value	0.0383	0.0383	0.0383	0.3565	0.4937	0.4937	0.0980	0.2500

Table 4. Significantly different environmental potentials per hectare and per total area

Sites	Trees & shrubs moist biomass kg/ha	Trees & shrubs moist biomass kg/total	Trees & shrubs oven dry biomass kg/ha	Trees & shrubs oven dry biomass kg/total	Trees & shrubs co_2 sequestration kg/ha	Trees & shrubs co_2 sequestration kg/total
Closed	14540	479820	10080	332640	22210	732930
N-closed	1264	41712	880	29040	1930	63690
D/ce	13276	438108	9200	303600	20280	669240

** Total closed area=33ha*

As shown in Table 3, the closed area is significantly different over the non-closed area in terms of moist biomass, oven dry biomass and carbon dioxide sequestration potential of trees and shrubs ($p<0.05$) but not significant in terms moist biomass, oven dry biomass, carbon dioxide sequestration potential of herbs, and canopy coverage of tree, shrubs and herbs ($p\geq 0.05$). The closed area had 13276kg/ha, 9200kg/ha and 20280kg/ha more tree and shrub moist biomass, oven dry biomass, and sequestrated carbon dioxide respectively than the closed area. This implies, the closed area might had 438108, 303600 and 669240 more tree and shrub moist biomass, oven dry biomass, and sequestrated carbon dioxide respectively than the same size of the non-closed area (Table 4). Yaynishet et al. (2008) found biomass of area closure twice of free grazing. Mekuria et al. (2009) found biomass of some species higher in closed than non-closed and he estimated aboveground carbon stocks increased by 39-68% through the conversion of degraded grazing lands to exclosures (Mekuria, et al., 2009). This significant amount of biomass accommodation and carbon dioxide sequestration might be due to the following facts:

1. In the area closure, young generations might be grew up but in the non-closed new rise seedlings might be always cut by cattle and the people and taken off from the area or might be physically damage them
2. In the closed, the environment might be modified by plants shed organic matter and this in turn might attracted other living organisms which can facilitate soil fertility like microorganisms, earth worms and these might be facilitated fast biomass increment
3. Organic matter accumulation in the closed area might be absorbed and conserved moisture which is a limiting factor in the area and this might boost biomass increments.

Having the closure significant trees and shrubs biomass potential over the non-closed also shows that there might be significant fuel wood and construction material potential which is among the factors for the local people to treat closures sustainably (Betru et al., 2005). In addition, such large amount of carbon dioxide sequestration difference also shows the closed area is contributing not only to the local microclimate modification but also to the global climate change mitigation. In the case of herbs, though no significant, the non-closed showed higher biomass and hence co_2 sequestration. Betru et al. (2005) also found free grazing had more herbs than area closure. Asefa. et al. (2003) identified protection for more than three years did not improve the diversity of herbaceous species and Yainishet et al (2008) attributed age of exclosure increase large trees shed and suppress herbs. Therefore the, herbs under the closed area might be shaded and suppressed by the upper layer species.

Canopy cover refers to the proportion of the ground area covered by the vertical projection of the canopy (yaynishet et al, 2008).Woody species cover is higher in exclosure than free grazed (yaynishet et al, 2008, Manier and Hobbs, 2007, Augustine and McNaughton, 2004) and herb ground cover (Emuru et al., 2006). Even though not significant, the present study also showed canopy basal area coverage by tree and shrubs and herbs was higher in the closed than the non-closed. This could be due to (i) human and animal intervention difference (ii) modification of the environment by pre successor organisms (iii) bigger tree and shrubs contribute more. This in turn might bring erosion control and further microclimate modification and organism attraction difference between the two sites since canopy intercept direct rain drop and direct sun blazing. But,one reason for the exclosure not having significant canopy coverage difference over the non-closed might be due to shed effect of big trees and shrubs over the herbs (Yaynishet, et al., 2008).

4.3. Economic potentials comparison of the closed and the non-closed sites

Table 5.ANOVA result for economic potentials of the closed and non-closed sites

Sites	Mean forage grass(kg)/plot	Mean thatching grass(kg)/plot	Mean honey bee flora/plot	Mean cactus fruit/plot
Closed	0.5[a]	0.4[a]	17.9 [a]	4.9 [a]
N-Closed	0.0[b]	0.0[b]	16.8 [a]	0.00 [a]
P-value	0.0001	0.0061	0.87	0.3206

Table 6. Significantly different economic potentials per hectare and per total area

Sites	Forage grass (kg)/ha	Forage grass (kg)/total	Thatching grass (kg)/ha	Thatching grass (kg)/total
Closed	5000	165000	4000	132000
N-closed	0	0	0	0
D/ce	5000	165000	4000	132000

The closed area is significantly different in terms of biomass of forage grass and thatching grass ($p < 0.05$), but not in terms of availability honey bee flora and cactus ($p \geq 0.05$).

The closed area had 5000kg/ha and 4000kg/ha more forage grass and thatching grass respectively than the closed area implying the closed area might had 165000kg and 132000kg more forage grass and thatching grass respectively than the same size of the non-closed (Table 6). Emuru et al., (2006) found area coverage of herb is high in closure than non-closed. This could be due to the relief from livestock grazing, trampling and human intervention. In most exclosure, short term benefit of local people are forage and thatching grasses and their care depend on the availability of these grasses (Betru et al., 2005). Therefore, the closure had significant short term local people stimulating resources which might stimulate them to maintain sustainably if they utilized it optimum.

Even though availability of cactus which is potential for food supplementary was not significant, there was some in the closed but nothing was in the non-closed. Similarly the sites were not significantly different in terms of 3 best honey bee flora species. As to the local elders honey bee flora identifier, 1st (*Becium ovovatum)*, 2nd (*Aloe macrocarpa*) and 3rd (*Echinops giganteus*) rank honey bee flora species were herbs. Therefore honey bee flora herbs under the closed might be suppressed by the big trees and hence might be came lesser amount (Betru et al. 2005, Yayinshet, et al., 2008). Therefore, this might made to be no more number of honey bee flora species difference. But one thing should be known is that even though there were honey bee floras in the non-closure; they had no flowering potential because of new rising branches and twigs always trimmed specially by animals.

Generally the closed mountain had more density, diversity, biomass, carbon dioxide sequestration, area coverage, forage and thatching grass, cactus and honey bee flora potential (Figure 9) than the non-closed mountain implying it is environmentally and economically more worthy than the free accessed. Therefore, undoubtfully the closure is environmentally and economically potential.

Figure 6. Partial view of environmental and economical potentials of the closed area

4.4. Actual socio economic contribution of the closed and non-closed areas to local people

As to survey, the entire (16) sample respondents under the closure said that they were getting benefits from the exclosure where as under the non-closed out of 22 sample respondents, 8 said they were getting some benefits from it (non-closed) but the rest (14 respondents) said nothing they got.

All respondents under the closed area responded they did not get firewood from the closure but as to the group discussion the local people especially near to the exclosure were highly depend their energy demand on it. As to their regulation, fuel wood collection from the exclosure is not allowed. Therefore this might be the reason that made all of them to respond as such. In most area closure of Ethiopia especially Tigray, access to fuel wood and other woody products is prohibited (Mekuria et al., 2009, Yaynishet,et al.,2008, Emuru et al.,2006, Betru,et al., 2005). But this is not right decision in most closure conditions because (i) big trees and shrubs can suppress herbaceous specially grass productivity which is typical and short term benefit of the local people (Yaynishet,et al.,2008 and Betru,et al., 2005). (ii) Local people become pessimistic towards the closure and cut illegally and destructively (Betru,et al., 2005). (iii) Since mostly firewood fetching is the role of women, they go long distance to fetch and hence became liable to lose their time and labor (Betru,et al.,2005). In addition, they might be also exposed to sexual violation.

The reverse, under the non-closed 4 respondents found they got firewood from it although they could not estimated quantitatively except one of them (she estimated about quarter of her energy demand is covered by the non-closed area) but as seen personally, what they used was herbaceous twigs for igniting fire during cooking their food and the rest said they did not get fuel wood from the non-closed. As seen in the inventory part the fuel wood potential (through the biomass potential) is higher in the closed area. In contrast as to the survey, actual firewood utilization by the local people is higher in the non-closed area. But this might not be true because the respondents under the non-closed fear not to tell the truth for the enumerators so that they informed to the concerned body. Therefore, it is not groundless to conclude the closure is more worthy than the non-closed in terms of energy contribution to the local people.

According to the survey 7 sample households under the closure were bee keepers and of these 4 said that their production is increasing year to year, 1 said decreasing and the rest (2) said they did not know. All (who said their production increasing) of them said the closure has contribution on their honey production increment and out of these 2 estimated above half of their production might be the contribution of the closure but the rest could not able to estimate quantitatively.

Under the non-closed 14 respondents were bee keepers and except 2 of them (who said they their production is decreasing) responded that their honey production is increasing but all of them except 3 (who said it has contribution even they could not able to estimate) did not believe the non-closed area is contributing to the increment of their honey production. As to the inventory part, the closure has more honey bee flora potential but as to the survey part, there are more bee keeper households under the non-closed even though contribution of production increment is higher under the closure respondents. This might be because the sites closeness (2km apart) which might be insignificant distance for bees to go to the closured area. But for further confirmation, at the bottom of the exclosure there were two bee keeping enterprises. The one called *Kumel* Bee keeping enterprise which is private enterprise. It has 56 bee colonies and produce 2525 kg/year. The second belongs to union of unemployed youth. They made their life by selling honey. As to their chair man they had about 37 bee colonies producing about 2000 kg/yr honey (personal communication). But at the non-closed area, there was no even one colony. Therefore the closure is contributing to the livelihood of the people especially it is giving job opportunity to unemployed youth (which is hot issue to Ethiopia because of the flood of landless and jobless youth) where the non-closed cannot accommodate implying the closure could not if it were not closed.

All of the respondents under the exclosure said that they got forage grass and thatching from the exclosure. As to the *Got Addis Alem* document, the local people cut forage and thatching grass about 13500kg/yr and 64800kg/yr respectively. Controlled forage and thatching grass are legally accessed resources in most exclosures (Yaynishet,et al.,2008, Emuru et al.,2006, Betru,et al.2005) and became decisive factors for local community to give value to exclosures and to maintain sustainably (Betru, et al.2005). Whereas under the non-closed, 20 % of the respondents said that they used the non-closed area for livestock free grazing during summer and only for herding space during winter and the rest did not use it for their livestock. All of them confirmed that they did not get any thatching grass throughout the year. In addition to this as it is seen at the inventory result, forage and thatching grass potential of the non-closed area was nil. There was no above ground grass that can be grazed even by small ruminants like sheep, goat..Etc. Therefore, it can be attributed these two areas are incomparable (Figure 10). in forage and thatching grass contribution to their respective nearby residents But one an inevitable question is the closed area is kept aside from uncontrolled livestock and human interference whereas the non-closed is always free for grazing and hence is not known how much it might be grazed. Of course yes but we have two evidences (i) plants are both the factory and the product, that is if all the biomass is taken off as product, the factory will go together. In the non-closed area, most of the ground was bare with no grass base implying without the factory and (ii) as the respondents, group discussion, and personal observation, it is uncommon to see livestock grazing there especially during winter and never people cut thatching grass from it.

Figure 7. Partial view of grass coverage of the exclosure (left) and non closure (right)

As to the inventory part, the closed area had 165000kg forage grass and 132000kg thatching grass whereas as to the kebelle document, the local people harvest only about 13500kg/yr and 64800kg/yr respectively which means 12.2 times forage grass and 2 times thatching grass left unused per year. This shows, though it was contributing more than it if it were not closed, it was not used optimum.

All of the sample households under both the sites have crop farms. 75% respondents from the closure and 63.6% from the non-closed said that their production is increasing year to year. 12.5% from the closure and 31.25% from the non-closed said decreasing and the rest from each said no change. Of those who said production is increasing, 83.3 % (10) from the closure and 14.3% (2) from the non-closure said that the respective areas (the closed and the non-closed) were contributing to their crop production. 1 from the closure, 11(50%) from the non-closure said the respective area might not have contribution and the rest (1 from each) were abstaining. But unfortunately, all in both areas, who said it is contributing, could not able to estimate its contribution quantitatively. From this though difficult to quantify, it can be attributed the area closure is contributing more to the crop production of the bottom farm than the non-closed area. Consistent to this, Betru, et al., (2005), found closures substantially reduced frequency of crop failures and significantly increased crop yields per unit area

80% of the respondents under the closure said that they got cactus fruits from the exclosure but they could not able to estimate since mostly their children used it and rest responded they did not get. All respondents under the non-closed did not get any cactus from the non-closed area. This result also fit to the inventory displayed above that there was no even one cactus in all the plots under the non-closed. This shows the though not recognized well the closure is supplementing and inputting additional calorie to the people where under the non-closed cannot obtain.

65 % of the respondents under the closed identified that the exclosure is giving them environmental benefits. It is decreasing erosion, gulley expansion, formation of rills and over flooding of farms and increasing discharging potential of springs and wells. Of these 3 respondents said their wells which were seasonal became annual, 2 respondents said long trees and honey bee floras are appearing which only bushes were and one elder respondent said that it was common dismissing of his teff *farms* due to torrential over flooding *before* the establishment of the closure but now is seldom. In addition, as it seen physically most of gullies in and out of the farms were passive that is they were recovering by growing some herbs and trees (Figure 11). Similarly, Tefera *et al*., (2005) ascribed, in many of closures springs have been revitalized and water table have been raised he also found, in Biyo Kelala and Tiya exclosures, land cover is improved appreciably and gullies are disappeared after the exclosures. However 4 respondents added even though, it changed the mountain into green, it is as the expense our animal and fuel wood cost and one respondent did not identify its environmental contribution. From the non-closed area, All except 2 (one said he do no and one said it is protecting us from torrential wind) respondents said they did not get environmental benefits from the non-closed area. This shows the exclosure and the non-closed area are incomparable their contribution to the local people environmentally.

Figure 8. Partial view of recovered gulley in the closed site (Halla)

All of the respondents under the exclosure said they proud of having such graceful and entertaining area, they also said they can fetch grasses and leaves for common and personal ceremonies. Example if a household has wedding, he can get permission from the *Kebelle* to cut some leaves and grasses. 2 respondents said that researchers and projects come to the area and employ them as daily workers and input some to their household for trial. One respondent said he used the closure as source of local herbal medicines for his family and cattle. Emuru et al. (2006) also found local people regard exclosure for aesthetic value. Where us under the non-closed, all except 2 (they said their children get herbs for making *chibo* for religious ceremony called *Meskel*) said that it is not giving them any social benefits and 3 respondents express they feel shame and envy when they see the nearby *Halla* exclosure in *Got Addis Alem*

Out of the 16 respondents under the closure, 6 said the exclosure did not have side effect on them, 8 responded it occupied their animal free grazing, and fuel wood source and they said it should be freely accessed for their animal and fuel wood (4 respondents), it should be freely accessed for their animal during animal feed scarce time and always for dead fuel wood (3 respondents), one said half of it should be allowed free access to all resource utilization. Similarly Emuru, et al. (2006) found in Wukro, majority of the community want to improve bylaws and need the exclosure to use as source of fuel wood and 98% need for source of fodder in bad rainy season. Some respondents said it hosted wild animals such as hyena, fox, and rodents and those eat their domestic animals and destroy nearby crop farms, and they said the government should allow them to kill these or should give those options. Betru et al. (2005) also reported local community seen wildlife population in closures as a threat to crops and domestic animals and they complain for solution

Under the non-closed, 8 said torrential erosion came to their farms from the non-closed and 5 said physical conservation like terracing can weaken torrential erosion to their farm and the rest (3) said it should be closed as the nearby *Halla* exclosure. The rest 14 respondents said it did not affect them. All of them except those who recommended to be closed, were asked to close the area or not but all except 3 who responded positively said it should not and they reason out rodents will host there and destroy their crop farms.

Under the closed area, all except 4 said that the exclosure has managemental problem. There is:(i) in consistent and subjective punishment for trespasses (10 respondents) and they recommended being consistent and deserved punishment, (ii) no optimum resource utilization which is limited to forage and thatching grass (8 respondents) and they recommended the local people should harvest all the resources optimum.

6 respondents said they participate in the management of the exclosure and 5 of them added their participation is through their representatives and confirmed the representatives did not satisfy their interest. One respondent said even the representatives did not have decisive power. They dominated by the *kebelle* Agricultural developmental agent. The rest (10 respondents) said they did not participate. And all except 2 respondents said they are interested to involve actively even in day to day issues about their closure. Emuru et al. (2006) and Betru et al. (2005) also found similarly that people’s participation is autonomous and are eager to participate. The present study shows, even the respondents who said no managemental problem and who said they are participating through their representatives need to participate actively by themselves. This shows the same to Betru findings which decisions and managements on the closure did not satisfying the majority. This is also a danger for the continuity of the closure since people respond to closures depend mostly on their immediate interest (Betru et al., 2005)

As to the group discussion, the closure is giving environmental, economical and social benefits to the local people directly and indirectly. In the area ecological and socio economical indicators of sustainability are increasing and indicators of unsustainability are decreasing year to year. Above to all, the kebelle is considered as model and innovator and hence the government, NGos and researchers come and invest their project in the kebelle for demonstration. Though not more quantify, most of the people are aware of its benefits and they need the area not to touch but some they need it to be freely accessed especially for their cattle and fuel wood. Due to this, encroachment for forage grass, fuel wood and pole is common. Every the community member has chance to participate on big decisions but since involving the whole community is difficult for every activity the community nominated some representatives. With the help of the government experts especially for technical and cross cutting issues, they developed their local bylaws and make their decision without inference of outside body. But what a problem mostly appear specially at shortage of forage and fuel wood season is most of the community need it to be free accessed forgetting the ecological consequences and hence increase illegal access mostly at night. They (the group) also added productivity trend of the site is still increasing although it was not as the first 7 years especially height of tree and shrubs left constant. Yaynishet et al., 2008) also found exclosures left intact for extended period of time (more than 12 years) do not linearly increase in woody vegetation height

Chapter 5: Conclusion and Recommendation

5.1. Conclusion

From this study, it can be deduced:

- The closure had higher woody species diversity, healthier regeneration structure than the non-closed mountain.
- The closure showed significant difference in terms of woody biomass and carbon dioxide sequestration over the non-closed mountain which imply the closure might be higher woody biomass and carbon dioxide potential than the non-closed or if it were not closed. But it did not show significant difference in terms of herbs biomass and carbon dioxide sequestration. This could be due to shed effect of big trees over herbs.
- Even though Canopy basal area coverage which has close implication with soil erosion was not showed significance difference between both sites, there was higher coverage in the closed area.
- The closure had higher forage and thatching grass potential than the non-closed which is the most reliable and short term benefit of local people from exclosures.
- Actual contribution of the closure were higher than the non-closed in terms of honey bee production, forage grass and thatching grass utilization, farm crop production, cactus fruit utilization but not in terms of fuel wood because of not allowable in the closed area
- There was wide difference between the forage and thatching grass potential and the actual forage and thatching grass utilization by the people which imply under utlization
- Generally, though difficult to quantify for most of respondents, the closure were giving more environmental, and socioeconomically services than the non-closed area. but there were residents who were un happy with it due to (i) immediate need for energy and livestock feed (ii) poor decisions and un participatory or poor local people participation and (iii) its hosting rodents (iv) due to lack of recognizing its benefits quantitatively over if it were not closed

5.2. Recommendation

- Though, the closure is giving more actual forage grass and thatching grass, than the non-closure, compared to its potential, its actual contribution is small, therefore optimum utilization of these grass should be done
- The closure is sequestrating indispensable carbon dioxide; therefore, since this sequestration is as the expense of the local people's woody biomass need, the government should facilitate them to get benefit from the international carbon trade.

- Controlled access should be extended to optimum resource especially fuelwood and forage utilization since shortage of energy source and animal feed are critical for most illegal households.
- The government should help them to incorporate solutions for the rodents either by mitigating their impacts or by giving compensations for victim households
- Active local people participatory on basic decisions especially on resource utilization and trespassers punishment should be done. Above all equitable and unbiased decision making should be exercised which has close implication for its sustainability.
- Generally, the closure was more worthy environmentally and socio economically and it is serving the people. Therefore, the government, optimistic local people and other concerned body should aware and understand to the pessimistic people on its worthiness.
- This research should be used as evidence for awareness creation of local people around exclosures about worthiness of exclosure quantitatively over if it were free accessed

Reference

Asefa, D. T.; Oba, G.; Weladji, R. B. and Colman, J. E. (2003). An assessment of restoration of biodiversity in degraded High Mountain grazing lands in northern Ethiopia. Land degradation and development 14: 28-34.

Augustine, D.J., McNaughton, S.J., 2004. Regulation of shrub dynamics by native browsing ungulates on East African rangeland. J. Appl. Ecol. 41, 47-49.

Aune, J. B.; Bussa, M. T.; Asfaw, F. G. and Ayele, A. A. ,2001. The ox ploughing systems in Ethiopia: Can it be sustained? Outlook on Agriculture 30: 275-278.

Bekele-Tesemma, A. 2007. Useful trees of Ethiopia: identification, propagation and management in 17 agroecological zones. Nairobi: RELMA in ICRAF Project

Bendz M,1986. Hill side closures in Wello. Ethiopian Red Cross society: Mission report. Vaxjo, Sweden.

Betru N., Jawad A., and Ingrid N., 2005. Exploring ecological and socio-Economic issues for the improvement of area enclosure management: A Case Study from Ethiopia. DCG Report No. 38

Dasgupta, P. and Maler, K. G. 1994. Poverty, Institutions and the environmental resource base, World Bank Environment paper 9. World Bank. Washington D.C.

Demel Teketay (1996): Seed ecology and regeneration in dry Afromontane forests of Ethiopia: Dissertation. Umea, Sweden.

De Queiroz, J. S., 1993. Range degradation in Botswana: Myth or reality. Pastoral Development Network 35b.

Dessalegn, R. ,1994. Land Policy in Ethiopia at the Crossroads. Working papers on Ethiopian Development No. 8. University of Trondheim.

Descheemaeker K., Nyssen J. Rossi J., Poesen J., Mitiku H., Raes D., Muys B., Moeyersons J., Deckers S.,2005. Sediment deposition and pedogenesis in exclosures in the Tigray highlands, Ethiopia. Elsevier B.V.

Descheemaeker, K., Muys, B., Nyssen, J., Poesen, J., Raes, D., Haile, M., Deckers, J.,2006. Litter production and organic matter accumulation in exclosures of the Tigray highlands, Ethiopia. For. Ecol. Manage. 233, 21–25.

Dianati Tilakia, A.A. Naghipour Borjb, H. Tavakolic, M. Haidarian A., 2010. The effects of exclosure on plants in the semi-arid rangeland of North Khorasan province, Iran. DESERT 15 (2010) 47 Online at http://jdesert.ut.ac.ir

EFAP (Ethiopian Forest Action Programme),1994. Ethiopian Forest Action Programme Final report. Ministry of Natural Resources, EFAP secretariat, Addis Ababa.

Emiru B., Demel T. and Barklund P, 2004. Actual and potential contribution of exclosures to enhance biodiversity of woody species in the drylands of Eastern Tigray. Journal of the Drylands 1(2): 136-141

Eskandari, N., A.Alizadeh & F.Mahdavi, 2008. Range management policies in Iran. Poneh publications.Pp: 191.

FAO,1986. Highlands Reclamation Study. Ethiopia. Final Report, Volumes 1 and 2. Food and Agriculture Organization, Rome.

Forester, H. ,2002. Guidelines for the Development of Management Plans for Area Closures in Tigray. Bureau of Agriculture and Natural Resources. Tigray, Ethiopia.

Gebremedhin, B.; Pender, J. and Tesfaye, G. ,2000. Community natural resource management: the case of woodlots in northern Ethiopia. EPTD Discussion Paper No. 60. Enviornment and Production Technology Division (EPTD). International Food Policy Research institute. Washington D.C.

Hagos, F. and Holden, S.,2002. Incentives for Conservation on Tigray, Ethiopia: Findings from a Household Survey. Department of Economics and Social Sciences, Agriculture University of Norway, unpublished.

Hosseinzadeh, G., H. Jalilvand and R. Tamartash, 2010. Short time impact of enclosure on vegetation cover, productivity and some physical and chemical soil properties. J. Applied Sci., 10:2001-2009.http://scialert.net/abstract/?doi=jas.2010.2001.2009

Hurni, H., Kebede, T., Gete, Z., 2005. The implications of changes in population, land use, and land management for surface runoff in the Upper Nile Basin area of Ethiopia. Mt. Res. Dev. 25, 145–149.

HURNI, H. 1988a. Degradation and Conservation of the Resources in the Ethiopian Highlands. *Mountain Research and Development,* 8**,** 123-130.

KINDEYA, G. 2004. Dryland agroforestry strategy for Ethiopia. *Drylands Agroforestry Workshop.* Nairobi- Kenya,.

Krebs, C.J., 1999. Ecological Methodology. Addison Wesley Longman Inc., California. Lambers, J.H.R., Harpole, W.S., Tilman, D., Knops, J., Reich, P.B., 2004. Mechanismsresponsible for the positive diversity–productivity relationship in Minnesotagrasslands. Ecol. Lett. 7, 668–670.

Le Houérou, H.N., 1989. The grazing land ecosystems of the African Sahel. Springer-Verlag, Berlin.

Manier, D., Hobbs, N., 2007. Large herbivores in sagebrush steppe ecosystems: livestock and wild ungulates influence structure and function. Oecologia 152,739–743.

Mastewal, Y., Kindeya, G., M. Stein, & Wolde, M. 2006. Impact of Area Enclosures on Density,Diversity, and Population Structure of Woody Species: the Case of May Ba'ati-Douga Tembien, Tigray, Ethiopia. Ethiopian Journal of Natural Resources 8 (1): 100 – 110.

Mcintosh and Allen, 1998. Effect of Exclosure on Soils, Biomass, Plant Nutrients, and Vegetation, on Unfertilised Steeplands, Upper Waitaki District, South Island, New Zealand. New Zealand Journal of Ecology, Vol. 22, No. 2 Landcare Research, Private Bag 1930, Dunedin, New Zealand.

Mekuria, Edzo Veldkamp E., Mitiku H 2009. Carbon stock changes with relation to land use conversion in the lowlands of Tigray,Ethiopia

Mekuria W., Edzo Veldkamp E., Mitiku H., Kindeya G., Muys B., Jan Nyssen J.,2009. Effectiveness of exclosures to control soil erosion and local community perception on soil erosion in Tigray, Ethiopia. African Journal of Agricultural Research Vol. 4 (4):365-369

Mekuria, W., Veldkamp, E., Haile, M., Nyssen, J., Muys, B., Gebrehiwot, K., 2007.Effectiveness of exclosures to restore degraded soils as a result of overgrazing in Tigray, Ethiopia. J. Arid Environ. 69, 273–277.

Mengistu, T., Teketay, D., Hulten, H., Yemshaw, Y., 2005. The role of enclosures in the recovery of woody vegetation in degraded dryland hillsides of central and northern Ethiopia. J. Arid Environ. 60, 265–280.

Muller, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. New York: john Wiley & sons. 577 p.

Nyssen J., Getachew S. and Nurhussen T., 2008. An upland farming system under transformation: Proximate causes of land use change in Bela-Welleh catchment (Wag, Northern Ethiopian Highlands). Soil Tillage Research. 8-10.

Nyssen J., Moeyersons J., Poesen J., Deckers J., Mitiku H., 2002. The environmental significance of the remobilisation of ancient mass movements in the Atbara– Tekeze headwaters, Northern Ethiopia. Elsevier Science- Geomorphology .49; 303–311.

Peter D., Ralph B., Neal S., 1996. Effects of Exclosure and Management on Biomass and Soil Nutrient Pools in Seasonally Dry High Country, New Zealand. Journal of Environmental Management Volume 51, Issue 2 :170-173

Raf A., Jan N., Mitiku H., 2008. On the difference between "exclosures" and"enclosures" in ecology and the environment

REST (Relief Society of Tigray), 1998. Soil andWater Conservation Programme. REST, Mekelle, Ethiopia.

Stocking, A. M. and Murnaghan, N., 2001. Handbook for the field assessment of land degradation. Earthscan. London.

Tefera M., Demel T., Håkan H., and Yonas Y., 2005. The Role of Communities in Closed Area Management in Ethiopia. Mountain Research and Development Vol 25 No 1 Feb 2005: 44–45

t'Mannetje, L., Jones, R.M., 2000. Field and Laboratory Methods for Grassland and Animal Production Research. CABI.

Tucker, N.I., Murphy, T.M., 1997. The effects of ecological rehabilitations on vegetation recruitment: some observations from the wet Tropics of North Queensland. Forest Ecology and Management 99: 133 – 144.

UNFPA and POPIN (1995). Population and Land Degradation. http://www.undp.org\popin\faol\land\land.html

Woldeamlak Bewket, Stroosnijder, L., 2003. Effects of agroecological land use succession on soil properties in Chemoga Watershed, Blue Nile basin, Ethiopia. Geoderma 111, 88-93.

World Food Program/Ministry of Agriculture (WFP/MoA),2002. Impact assessment of the ETH-2488/MERET Project (Interim Report). Ministry of Agriculture. Addis Ababa, Ethiopia.

Yayneshet T, 2008. Restoration of Degraded Semi-Arid Communal Grazing Land Vegetation Using the Exclosure Model. Department of Animal, Rangeland and Wildlife Sciences, Mekelle University, Mekelle, Ethiopia

Young, S., 1958. Exclosures in big game management in Utah. J. Range Manage. 11,185–189.

(N.A,n.d).How to calculate carbon dioxide sequestration. Harvested from:

(**www.plant-trees.org/.../..**)

Appendices

Appendix 1. Trees & shrubs and herbs in the closed and non-closed areas

No	Scientific name	**Life form**	**Frequency**	**No**	**Scientific Name**	**lifeform**	frequency
1	*Eucalyptus camaldulensis*	tree	20	1	*Acacia etbaica*	tree	5
2	*Acacia etbaica*	tree	11	2	*Carissa edulis*	shrub	4
3	*Schinus molle*	tree	1	3	Maytenus arbatifolia	shrub	9
4	*Euclea shimperi*	shrub	4	4	*Dodonaea angustifolia*	shrub	1
5	*Rhus vulgaris*	tree	2	5	*Euclea shimperi*	shrub	22
6	*Dodonaea angustifolia*	shrub	10	6	*Gravila bicolor*	herb	17
7	*Rhus retinorrhoea*	shrub	2	7	*Becium ovovatum*	herb	49
8	*ficus indica*	shrub	39	8	*Aloe macrocarpa*	herb	33
9	*Acacia saligna*	shrub	3	9	*Echinops giganteus*	herb	20
10	*Maytenus senegalensis*	shrub	1	10	*Cynodon dactylon*	herb	25
11	*Echinops giganteus*	herb	23	11	*Jasminum abyssinicum*	herb	4
12	*Aloe macrocarpa*	herb	44	12	*Digitaria velutina*	Herb	1
13	*Chloris amethystea*	herb	1				
14	*Becium ovovatum*	herb	61				
15	*Bidens macroptera*	herb	2				
16	*Chloris amethystea*	herb	1				
17	*Rumex usambarensis*	herb	11				
18	*Parkinsonia aculeata*	herb	1				
19	*Ficus sycomorus*	herb	4				
20	*Gravila bicolor*	herb	18				
21	*Asystasia gangetica*	herb	1				
22	*Jasminum abyssinicum*	herb	6				

Appendix 2. Shannon diversity indices for trees & shrubs of the closed and non closed areas

	Closed site					
No	Sc name	life form	Frequency	**Pi**	**Ln(pi)**	**-(Pi*ln(pi)**
1	*Eucalyptus camaldulensis*	tree	20	0.21505376	-1.53686722	0.330509079
2	*Acacia etbaica*	tree	11	0.11827957	-2.13470422	0.252491897
3	*Schinus molle*	tree	1	0.01075269	-4.532599493	0.048737629
4	*Euclea shimperi*	shrub	4	0.04301075	-3.146305132	0.135324952
5	*Rhus vulgaris*	tree	2	0.02150538	-3.839452313	0.082568867
6	*Dodonaea angustifolia*	shrub	10	0.10752688	-2.2300144	0.239786495
7	*Rhus retinorrhoea*	shrub	2	0.02150538	-3.839452313	0.082568867
8	*ficus indica*	shrub	39	0.41935484	-0.869037847	0.364435226
9	*Acacia saligna*	shrub	3	0.03225806	-3.433987204	0.110773781
10	*Maytenus senegalensis*	shrub	1	0.01075269	-4.532599493	0.048737629
			93			**1.695934422**
	Non- closed site					
No	Sc name	Life form	Frequency	**Pi**	**Ln(pi)**	**-(Pi*ln(pi)**
1	*Acacia etbaica*	tree	5	0.12195122	-2.104134154	0.256601726
2	*Carissa edulis*	shrub	4	0.09756098	-2.327277706	0.227051483
3	Maytenus arbatifolia	shrub	9	0.2195122	-1.516347489	0.332856766
4	*Dodonaea angustifolia*	shrub	1	0.02439024	-3.713572067	0.090574928
5	*Euclea shimperi*	shrub	22	0.53658537	-0.622529613	0.33404028
			41			**1.241125184**

Appendix 3. Frequency distribution of height classes (m) of trees and shrubs in the two areas

Closed		Non- closed	
height(m)	frequency	height(m)	frequency
<.5	2	<.5	20
.5≤h<1	11	.5≤h<1	17
1≤h<1.5	23	1≤h<1.5	2
1.5≤h<2	34	1.5≤h<2	2
2≤h<2.5	6	2≤h<2.5	0
2.5≤h<3	3	2.5≤h<3	0
≥3	14	≥3	0

Appendix 4. Frequency distribution of diameter classes (m) of trees and shrubs in the two areas

Closed		**Non -closed**	
diameter(cm)	**frequency**	**diameter(cm)**	**frequency**
<5	58	<5	40
5≤d<10	21	5≤d<10	1
10≤d<15	14	10≤d<15	0
≥15	0	≥15	0

Appendix 5. Tree ,shrubs and herbs Moist to oven dry conversion of the exclosure

Name	size	height (m)	diameter (m)	height* diameter	moist weight (kg)	oven dry weight(kg)
Eucalyptus camaldulensis	large	8.25	0.12	0.99	69	43.977
	middle	5.2	0.055	0.286	35	21.665
	small	1.5	0.035	0.0525	4.4	2.5858
Acacia etbaica	large	4.57	0.12	0.5484	76	58.328
	middle	2.44	0.05	0.122	19	14.183
	small	0.62	0.012	0.00744	4	2.7979
Dodonaea angustifolia	large	1.8	0.025	0.045	3.5	2.6405
	middle	1.46	0.014	0.02044	2	1.44
	small	0.94	0.015	0.0141	1.5	1.0913
				0.23176444	**23.8222222**	**16.523**
Becium ovovatum	large	1.3	0.012	0.0156	1	0.7746
	middle	0.73	0.015	0.01095	0.5	0.3628
	small	0.5	0.025	0.0125	0.25	0.2003
Echinops giganteus	large	1.38	0.022	0.03036	0.5	0.2918

	middle	0.64	0.012	0.00768	0.325	0.1853
	small	0.4	0.035	0.014	0.12	0.0703
Aloe macrocarpa	large	1.5	0.1	0.15	6	3.8897
	middle	1.1	0.09	0.099	4.25	2.378
	small	0.45	0.04	0.018	2	1.2501
				0.03978778	**1.66055556**	**1.0448**

Appendix 6. Tree and herbs Moist to oven dry conversion of the non-closed area

Local name	Size	Height (m)	Diameter (m)	height* diameter	Moist weight (kg)	Oven dry weight (kg)
Maytenus arbatifolia	large	0.7	0.03	0.021	3.25	2.2894
	middle	0.55	0.028	0.0154	1.75	1.3475
	small	0.15	0.005	0.00075	1	0.6375
Euclea shimperi	large	1.5	0.04	0.06	12	8.6397
	middle	0.75	0.03	0.0225	7	4.6777
	small	0.43	0.005	0.00215	0.75	0.4761
Acacia etbaica	large	1.5	0.032	0.048	6.5	4.709
	middle	1.3	0.013	0.0169	3	1.9423
	small	0.6	0.02	0.012	1.2	0.8073
				0.02207778	**4.05**	**2.8363**
Becium ovovatum	large	0.55	0.005	0.00275	0.5	0.2894
	middle	0.45	0.002	0.0009	0.205	0.1111
	small	0.7	0.005	0.0035	0.15	0.0812
Cynodon dactylon	large	0.33	0.008	0.00264	0.068	0.0532
	middle	0.14	0.002	0.00028	0.04	0.0307
	small	0.35	0.001	0.00035	0.04	0.0277
Echinops giganteus	large	0.85	0.005	0.00425	0.118	0.0663
	middle	0.95	0.0032	0.00304	0.84	0.4832
	small	0.6	0.003	0.0018	0.64	0.3576
				0.00216778	**0.289**	**0.1667**

Appendix 7. Plot inventory data for environmental and economical parameters of the closed and non-closed mountains

Plots	trees & shrubs moist biomass (kg)	trees& shrubs oven dry biomass (kg)	trees& shrubs co2 seqn (kg)	trees& shrubs moist bio mass (kg)	herbs oven dry biomass (kg)	Herbs co2 seqn (kg)	tree& shrubs cannopy basal area	herbs cannopy basal area	forage grass (kg)	That hcing grass (kg)	number of cactus tree	number of 3 best honey bee flora
closed	61.97	42.98	94.6	4.44	2.81	6.2	10.09	0.8	0.18	0.3	0	5
closed	425.04	294.78	649.1	2.99	1.89	4.2	44.31	0.31	0.1	0.5	0	8
closed	379.42	263.14	579.4	4.5	3.4	7.6	35.14	0.65	0.83	0	38	11
closed	132.1	91.62	201.8	15.32	9.69	21.5	183.97	4.93	0.55	0.4	0	15
closed	20.93	14.52	31.9	33.6	21.26	47.2	5.33	0.6	0.78	0.18	1	16
closed	77.88	54.01	118.9	58.35	36.9	81.9	13.82	11.34	0.65	0	0	44
closed	8.65	6	13.2	31.37	19.85	44.1	2.26	1.52	0.33	0.6	0	18
closed	57.23	39.69	87.4	26.85	16.98	37.7	11.7	15.96	0.62	0.95	0	17
N- closed	4.5	2.84	6.3	38.1	22.33	49.6	0.15	2.4	0	0	0	56
N- closed	8.03	5.3	11.7	13.67	8.02	17.8	0.13	0.54	0	0	0	15
N- closed	10.85	7.6	16.7	55.34	32.47	72.1	0.23	0.97	0	0	0	17
N- closed	54.37	38.12	83.9	37.8	22.17	49.2	1.24	1.66	0	0	0	15
N- closed	5.5	3.86	8.5	34.09	19.98	44.4	0.15	1.2	0	0	0	15
N- closed	11.35	7.9	17.4	33.24	19.49	43.3	0.22	1.92	0	0	0	7
N- closed	2.7	1.9	4.2	15.69	9.2	20.4	0.11	1.55	0	0	0	9
N- closed	3.8	2.68	5.9	14.67	8.6	19.1	0.23	5.09	0	0	0	9

Appendix 8. SAS/Jmp5 results

Table 1. ANOVA for trees & shrubs moist biomass of closed and non- closed areas

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	70506.18	70506.2	5.2313
Error	14	188689.29	13477.8	Prob > F
C. Total	15	259195.47		0.0383

Table 2.Tukey's mean separation for trees & shrubs moist biomass of closed and non- closed areas

Level			Least Sq Mean
closed	A		145.40250
non closed		B	12.63750

Levels not connected by same letter are significantly different

Table 3. ANOVA for trees & shrubs oven dry biomass of closed and non- closed areas

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	33905.70	33905.7	5.2287
Error	14	90784.09	6484.6	Prob > F
C. Total	15	124689.79		0.0383

Table 4.Tukey's mean separation for trees & shrubs oven dry biomass of closed and non- closed areas

Level			Least Sq Mean
closed	A		100.84250
non closed		B	8.77500

Table 5. ANOVA for trees & shrubs co_2 seqn of closed and non- closed areas

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	164402.09	164402	5.2287
Error	14	440194.25	31442	Prob > F
C. Total	15	604596.33		0.0383

Table 6.Tukey's mean separation for trees & shrubs co_2 seqn of closed and non- closed areas

Level			Least Sq Mean
closed	A		222.05518
non closed		B	19.32255

Table 7. ANOVA for herbs moist biomass of closed and non- closed areas

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	265.5270	265.527	0.9091
Error	14	4088.9562	292.068	Prob > F
C. Total	15	4354.4832		0.3565

Tables 8.Tukey's mean separation for herbs moist biomass of closed and non- closed areas

Level		Least Sq Mean
non closed	A	30.325000
closed	A	22.177500

Table 9. ANOVA for herbs oven dry biomass of closed and non- closed areas

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	54.3169	54.317	0.4939
Error	14	1539.6299	109.974	Prob > F
C. Total	15	1593.9468		0.4937

Table 10.Tukey's mean separation for herbs oven dry biomass of closed and non- closed areas

Level		Least Sq Mean
non closed	A	17.782500
closed	A	14.097500

Table 11. ANOVA for herbs co_2 seqn of closed and non- closed areas

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	267.6954	267.695	0.4939
Error	14	7587.9120	541.994	Prob > F
C. Total	15	7855.6074		0.4937

Table 12.Tukey's mean separation for herbs co_2 seqn of closed and non- closed areas

Level		Least Sq Mean
non closed	A	39.477150
closed	A	31.296450

Table 13. ANOVA for trees & shrubs canopy basal area of closed and non- closed areas

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	5782.082	5782.08	3.1430
Error	14	25755.395	1839.67	Prob > F
C. Total	15	31537.477		0.0980

Table 14.Tukey's mean separation for trees & shrubs canopy basal area of closed and non- closed

Level		Least Sq Mean
closed	A	38.327500
non closed	A	0.307500

Table 15. ANOVA for herbs canopy basal area of closed and non- closed areas

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	26.98802	26.9880	1.4406
Error	14	262.26858	18.7335	Prob > F
C. Total	15	289.25660		0.2500

Table 16.Tukey's mean separation for herbs canopy basal area of closed and non- closed areas

Level		Least Sq Mean
closed	A	4.5137500
non closed	A	1.9162500

Table 17. ANOVA for forage grass of closed and non- closed areas

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.0201000	1.02010	27.5809
Error	14	0.5178000	0.03699	Prob > F
C. Total	15	1.5379000		0.0001

Table 18.Tukey's mean separation for forage grass of closed and non- closed areas

Level			Least Sq Mean
closed	A		0.50500000
non closed		B	0.00000000

Table 19. ANOVA for thatching grass of closed and non- closed areas

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.5365562	0.536556	10.4072
Error	14	0.7217875	0.051556	Prob > F

Source	DF	Sum of Squares	Mean Square	F Ratio
C. Total	15	1.2583438		0.0061

Table 20.Tukey's mean separation for thatching grass of closed and non- closed areas

Level			Least Sq Mean
closed	A		0.36625000
non closed		B	0.00000000

Table21 . ANOVA for cactus frequency of closed and non- closed areas

Source	**DF**	Sum of Squares	Mean Square	F Ratio
Model	**1**	95.0625	95.0625	1.0606
Error	**14**	1254.8750	89.6339	Prob > F
C. Total	**15**	1349.9375		0.3206

Tables 22.Tukey's mean separation for cactus frequency of closed and non- closed areas

Level		Least Sq Mean
closed	A	4.8750000
non closed	A	0.0000000

Table 23. ANOVA for honey bee flora frequency of closed and non- closed areas

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	5.0625	5.063	0.0258
Error	14	2750.3750	196.455	Prob > F
C. Total	15	2755.4375		0.8748

Tables 23.Tukey's mean separation for honey bee flora frequency of closed and non- closed areas

Level		Least Sq Mean
non closed	A	17.875000
closed	A	16.750000

Appendix 9. Questioners for households at the bottom of exclosure

Name------------------------------sex---------------age------

1. Is this closed mountain giving you benefits? Yes----, No----

1.1 If yes, what benefits it is giving you?

1.1.1. Economically

1.1.1.1 Dou you use fuel wood from it? Yes --------, No-------. If yes how much of your total energy demand it complimented (0-1/4, 1/4-1/2, 1/2-3/4, ¾ -1, 1, not known)

1.1.1.2 Are you keeping bee? Yes ----, No---. If yes, is your honey production: increasing-----, decreasing---------, no change ----------not known-----------. If increasing: do you believe, the non-closed mountain has contribution? Yes ----, No------. If yes, how much may it contribute (0-1/4, 1/4-1/2, 1/2-3/4, ¾ -1, 1, not known)

1.1.1.3. Do you get forage grass from the closed? Yes --------, No-------.

1.1.1.4. Do you get thatching grass from the closure? Yes --------, No----

1.1.1.5 .Do you have crop farm? Yes ----, No---. If yes, is your crop production: increasing-----, decreasing---------, no change ----------not known-----------. If increasing: do you believe, the closure has contribution? Yes----, No------. If yes, how much may it contribute (0-1/4, 1/4-1/2, 1/2-3/4, ¾ -1, 1, not known)

1.1.1.6. Dou you get cactus fruit from the closure? Yes --------, No-------. If yes, estimate it ?

1.1.1.7 Others ?---

1.1.2. Environmentally/Ecologically

1.1.2.1 What environmental benefits is the closed mountain giving you? -------------------------

----

1.1.3. Socially

1.1.3.1 What social benefits it is giving you? ---

----

2. Is the closure has side effect on you? Yes----, No---

2.1 if yes, what are the side effects? --

--------2.2. What should be done to tackle the side effects? ---

3. Is there any managemental problem on the exclosure? Yes ----, No----.

3.1. If yes what are the problems--

3.2 What do you recommend to solve the problem? ---

4. Do you participate in the management of the closure? Yes---No---- if No who manage it? --and do you want to participate in the management? Yes---No----

Thank you

Appendix 10. Questioners for households at the bottom of non-closed area

Name------------------------------sex---------------age------

1. Is this non-closed mountain giving you benefits? Yes----, No----

1.1 If yes, what benefits it is giving you?

1.1.1. Economically

1.1.1.1 Dou you use fuel wood from it? Yes --------, No-------. If yes how much of your total energy demand it complimented (0-1/4, 1/4-1/2, 1/2-3/4, ¾ -1, 1, not known)

1.1.1.2 Are you keeping bee? Yes ----, No---. If yes, is your honey production: increasing-----, decreasing---------, no change ----------not known-----------. If increasing: do you believe, the non-closed mountain has contribution? Yes ----, No------. If yes, how much may it contribute (0-1/4, 1/4-1/2, 1/2-3/4, ¾ -1, 1, not known)

1.1.1.3. Do you get forage grass from the non-closed? Yes --------, No-------. If yes how much? ------------

1.1.1.4. Do you get thatching grass from the non-closed? Yes --------, No-------. If yes how much? ---------

1.1.1.5. Do you have crop farm? Yes ----, No---. If yes, is your crop production: increasing-----, decreasing---------, no change ----------not known-----------. If increasing: do you believe, the non-closed has contribution? Yes ----, No------. If yes, how much may it contribute (0-1/4, 1/4-1/2, 1/2-3/4, ¾ -1, 1, not known)

1.1.1.6. Dou you get cactus fruit from the non-closed? Yes --------, No-------. If yes, estimate it?

1.1.1.7 Others ?---

1.1.2. Environmentally/Ecologically

1.1.2.1 What environmental benefits is the non-closed mountain giving you? --------------------
----

1.1.3. Socially

1.1.3.1 What social benefits it is giving you? ---
----

2. Is the non-closed has side effect on you? Yes----, No---

2.1 If yes, what are the side effects? --

--------2.2. What should be done to tackle the side effects? --
----

3. Do you want the mountain to be closed? Yes ----, No---- If no, why? -------------------------
----

Thank you