COMPARABLE ASSESSMENT ON WOODY VEGETATION RECOVERY OF ALLOCATED DEGRADED HILLSIDES, IN ATSBI-WOMBERTA DISTRICT, TIGRAY, ETHIOPIA

M.Sc. THESIS

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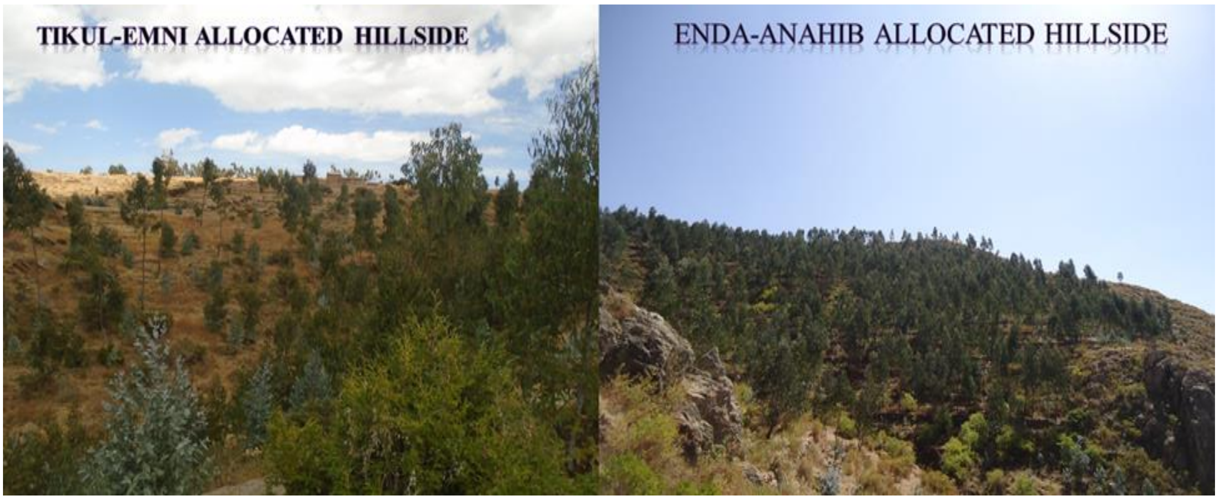

HAWASSA UNIVERSITY, WONDOGENET COLLEGE OF FORESTRY AND NATURAL RESOURCE, WONDOGENET, ETHIOPIA

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A THESIS SUBMITTED TO THEDEPARTMENT OF GENERAL FORESTRY, WONDO GENET COLLEGE OF FORESTRY AND NATURAL RESOURCES, SCHOOL OF GRADUATE STUDIES, HAWASSA UNIVERSITY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREEMASTER OF SCIENCEIN FOREST RESOURCE ASSESSMENT AND MONITORING

OCTOBER, 2019

APPROVAL SHEET-I

This is to certify that the thesis entitled "Comparable Assessment on Woody Vegetation Recovery of Allocated Degraded Hillsides, in Atsbi-Womberta District, Tigray, Ethiopia " submitted in partial fulfillment of the requirements for the degree of Master's with specialization Forest Resource Assessment and Monitoring, Graduate Program of the Department of General Forestry, and has been carried out by **Aregawi Birhane, Id. NoMsc/FrAm/Roo5/10** under my supervision. Therefore, I recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

Amare Tesfay (Ph.D.) ____________________ __________________

Signature Date

APPROVAL SHEET-II

We, the Undersigned, members of the board of examiners of the final open defense by Mr. AREGAWI BIRHANE ATSBAHA have read and evaluated his thesis entitled "Comparable Assessment on Woody Vegetation Recovery of Allocated Degraded Hillsides, in Atsbi-Womberta District, Tigray, Ethiopia, and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of Master of Science in Forest Resource Assessment and Monitoring.

Members of the Examination Board

Name of the Chairman	Signature	Date
Name of the Internal Examiner	Signature	Date
Name of the External Examiner	Signature	Date
Graduate school coordinator	Signature	Date

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Aregawi Birhane Atsbiha

CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the thesis entitled "Comparable Assessment on Woody Vegetation Recovery of Allocated Degraded Hillsides, In Atsbi-Womberta District, Tigray, Ethiopia" in partial fulfilment of the requirements for the award of the degree of Master of Science and submitted to the School of Graduate Studies, Wondo Genet College of Forestry and Natural Resource, Hawassa University is an authentic record of my own work carried out during the period from November, 2018 to October, 2019 under the supervision of Amare Tesfay (Ph.D.).

The work contained in this thesis has not been previously submitted for similar or for other purpose at any higher institution or elsewhere to the best of my knowledge.

AREGAWI BIRHANE ATSBHA	___________	____________
Student Name	Signature	Date

ABBREVIATION AND ACRONYMS

A. decurense	*Acacia decurense*
Ahs	Allocated hillsides
E. globules	*Eucalyptus globulus*
DAs	Development agents
Dbh	Diameter at Breast Height
Dsh	Diameter at Stump Height
Ha	Hectare
H_s terrace in m	Hillside terrace in meter
H_s + trench in m	Hillside terrace plus trench in meter
i.e.	That is
IVI	Importance Value Index
KOARD	Kebelle Office of Agriculture and Rural Development
LDAHPC	Livestock Development and Animal Health Protection Core process
m.a.s.l	Meters above sea level
NAhs	None allocated communal hillside
NGO	Non-Governmental Organization
NRMFPUC	Natural Resource Management, Forest and Utilization Core process
REST	Relief Society of Tigray
SWC	Soil and Water Conservation
Tig	Tigrigna
WOARD	Woreda office of Agriculture and Rural Development
WOFED	Woreda office of Finance and Economic Development
WOLPP	Woreda office of land use planning and Environmental protection

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ABSTRACT

The decline of vegetation cover is one of the most challenges overall the world. Vegetation degradation is, also one of the crucial issues in mountainous areas of Ethiopia. In northern high lands of Ethiopia, degraded hillsides have been allocated to youth groups for tree planting since the mid-1990s. Rehabilitation through allocating hillside is an approach of vegetation recovery of degraded hillsides via tree planting and construction of physical conservation structures. However, the effect of the allocation of degraded hillsides on vegetation recovery has got less in attention. Hence, the study was conducted in Atsbi-womberta District, Tigray, Ethiopia; to investigate the contribution of allocated hillsides on woody vegetation recovery. The field survey was conducted using transect lines of 100 meters interval from which sample plots of 20m×20m were laid at 40 meters interval keeping 20 meters open space to avoid border effect. The result revealed that the average physical SWC structures constructed per hectare were higher under-allocated hillsides than the adjacent non-allocated communal hillsides. The seedlings' survival rate of allocated hillsides was greater than that of the non-allocated communal hillsides. The number of woody species composition encountered in the study sites were 16 woody species representing 12 families in the allocated hillsides, while in the non-allocated communal hillsides, 14 species representing 10 families were recorded. The density of woody species 214 trees, 2471 saplings, and 4471 shrubs per hectare in allocated hillsides, while 25 trees, 1466 saplings, and 6416 shrubs per hectare were obtained in non-allocated hillsides. Eucalyptus globulus, Eucalyptus camadulensis, and Euclea schimperi were the most dominant woody species in allocated hillsides, while Euclea schimperi, Becium grandiflorum, and Rumex nervosus were in non-allocated hillsides. The Shannon diversity index was recorded as 1.75 and 1.65 in Tikul-emni, 1.36 and 0.91 in Enda-anahb and 1.77 and 1.07 in Adefa both for allocated and adjacently non-allocated communal hillsides, respectively. The regeneration status of woody species based on diameter class distribution shown inverted J-shaped for allocated hillsides however bell-shaped for non-allocated communal hillsides. The overall results from this study indicate strongly that allocated hillsides are very advantageous to ensure good vegetation recovery in all districts of the region that have similar agro-ecological zone as the study area. Based on this fact, it is strongly recommended that such practice should be scaled-up to other sites within as well as outside the study area.

Keywords*:* Communal hillside, Regeneration, Species diversity, Survival rate, User-group

1. INTRODUCTION

1.1. Background

At the global level, natural resource degradation on mountain slopes is widely believed to be one of the causes of environmental damage and has led to habitat and species losses (Melaku Berhe and Hoag, 2014). Such a problem is mainly caused by population pressure and lack of agreement on the management of mountainous lands by applying over-exploitation of the resource (Mukankomeje, 2010; Mganga *et al.*, 2015). To address natural resource degradation requires a strong awareness of those ultimate causes and should needs a high level of world-wide agreement to find a solution.

In Africa, land and forest degradation are very severe in highly populated countries and having a high scarcity of land (Mitiku Haile *et al.*, 2006). Ethiopia is one of the several African countries faced with problems of environmental degradation due to its alarming population growth and deficient vegetation cover natural resource that is leading to low productivity and extreme poverty (Jagger and Pender,2003;T. G/ hiwet and Veen, 2014).

Common lands that are owned and managed by a given community are the main sources of fuel wood, timber, and grazing in many developing countries like Ethiopia (Berhanu Gebremedhin *et al*., 2015). However, these resources tend to be over-exploited due to the absence of the use of rules and regulations (Rodriguez *et al.*, 2018). Several alternative solutions have been proposed to avert the problem of the degradation of common resources in developing countries(Shari *et al.*, 2015). These include privatization, state ownership, imposition and enforcement of use rules and regulations by an external force at different levels (Berhanu Gebremedhin *et al.*, 2015). Besides this, to overcome these problems, efforts have been made to launch a forestation and conservation programs, however success to date has been limited (FAO, 2000).

Moreover, deforestation accelerated soil erosion, land degradation, and soil moisture stress are the main problems in the highlands of Tigray (Shari *et al.*, 2015).In addition to this, landless people contributed to the existing land degradation by exploiting the economic possibilities of natural resources from communal hillside areas (Oniki and Gebremichaael Negusse,2012).Even though, tree planting is activated on communal land where grazing to be prevalent, as the conversion of land from grazing to tree planting requires a lot of negotiation and hence is difficult (Oniki and Negusse Gebremichael, 2012). Due to this, the free and uncontrolled communal grazing land is assumed as a major cause of land degradation in Tigray (Shari *et al.*, 2015). Based on this, the issues of hillside handling have become priority worried on these degraded lands (Tesfaye Alefew, 2016). Thus, allocating and protecting hillsides to private holders is a key method to bring together with the whole community and private stakeholders to join hands, to identify and participate in developing and conserving the natural resource (USEPA, 2003; Prizzia, 2005).

Tigray Regional State also introduced different types of conservation measures to rehabilitate the degraded lands that have been carried out by community mobilization (G/hiwet Gebru,2017). Besides this, in 1991 the idea of dividing the degraded and unproductive communal hillsides into smaller plots and allocating them to individuals for tree planting was initiated by local communities in Tigray (Hailemariam Meaza*et al*.,2016). Then, this idea was accepted as a structure for the development of a policy to plan natural resource management at the local and regional level (G/hiwet Gebru, 2017). Seen now, hillsides are stabilized and farmers are happy with a good initial survival rate of the tree species and expect to get wood for fuel and construction poles both for household consumption and market (Shimelse Samson *et al*., 2017).

Communal resources management in Atsbi-womberta, as in other parts of the region Tigray has been challenged by multiple problems, including increasing population and poverty (Shari *et al.*, 2015). Due to, more rugged topography and recurrent droughts, the Atsbi-womberta district is the most severely degraded area in the region (Berhanu G/hin *et al.*, 2010). The livelihood of most farmers is influenced by their restricted landholding, which is affected by degradation which makes them unproductive and unable to fulfill the basic needs of their family (Shirkhorshidi, 2013).Thus, any resource to be sustained, the community must agree on a common decision on how to utilize and treat resources as a whole(Gregorio *et al*., 2015).Based on this fact, many efforts have been made to reverse land and forest degradation in Atsbi-womberta (Berhanu G/hin*et al.*, 2010;Kirubel Mekonnen and G/sus Brhane, 2011).

In 1997 the Tigray regional administration passed the 'Hillside Guideline' planned to manage degraded hillsides Sarah Tewle-Birhane *et al*. (2016),which is the most promising policy options involving increased allocation of degraded hillsides for private tree planting based on the interest of local people (Berhanu Gebremedhin *et al*., 2015).In the context of the local government, hillsides allocated to local farmers who have not farmland can have a benefit through making an eco-friendly intervention (Berhanu Gebremedhin *et al*., 2015;Hailemariam Meaza*et al*., 2016). Based on this direction, the Atsbi-womberta district has constructed 3,470.70 hectare coverage of soil and water conservation, through 47 co-operatives that are organized to get a benefit by conserving hillsides (WOLPP, 2019). Out of the total, 15 cooperatives are involved in forestry, 16 on the bee-keeping, and 16 are on sheep and goat fattening (WOARD, 2019).

Therefore, the present study has investigated the woody vegetation recovery of degraded allocated versus non-allocated communal hillsides in the district of Atsbi-womberta, Tigray, Ethiopia.

1.2. Statement of the problem

Deforestation is the main problem in Tigray, due to cutting trees for fuel, timber, agricultural implements, and clearing forests to expand agricultural land (Kidane Giday *et al.*, 2018).As poverty and lack of alternative energy sources had created pressure to use deeply natural resource products(Shari *et al.*,2015).About 85% of the energy used in the region comes from biomass (Yohannes Gebremichael and Waters-Bayer, 2007). As a result, the sources of tree biomass are shrinking in Tigray (Berhanu Gebremedhin *et al*., 2015;Abenet Mengistu *et al*., 2016).Thus, to tolerate such a problem, important strategies and policies on how to conserve tree diversity for sustainable development are needed. Allocation of degraded hillsides as one of the strategies has been practiced since 1991 in the Tigray region. It has been introduced in the study area since 2000 (WOARD, 2018).

However, many farmers are reluctant to accept the allocation of degraded hillsides comparing with the demands of grazing purposes (Abenet Mengistu *et al*., 2016;Shimelse Samson *et al*., 2017). Thus, the attention provided to the hillside allocation by user farmers is minimal. Even the level of understanding of the new practice of the private management of degraded hillside in the study area is still very low. Hence, in the Atsbi-womberta district, including the study sites, there was no well-organized and documented research result which can indicate that the contribution of allocated hillsides on vegetation recovery. Indeed, there are some reports prepared by governmental and non-governmental organizations based on short visit observations. However, these reports are not based on a systematic analysis and are not sufficient to show the true contribution of privately managed degraded hillsides in the Tigray region in general and in the Atsbi-womberta district in particular.

Therefore, this study was attempted to address the gaps and aimed at finding out the woody vegetation recovery of degraded allocated hillsides by comparing adjacently non-allocated communal hillsides.

1.3.Objectives of the Study

1.3.1. General Objective

The overall objective of the study was to Assess the Woody Vegetation Recovery of Allocated Degraded Hillsides, in Atsbi-Womberta District, Tigray, Ethiopia.

1.3.2. Specific Objectives

- To identify the physical soil and water conservation measures implemented
- To evaluate the status of plantation activities and seedlings survival rate
- To investigate the woody species diversity and natural regeneration status

1.4. Research Questions

1. Is there any difference in the amount and type of physical soil and water conservation measures practiced on both adjacent hillsides?

2. What tree species are predominantly selected to be planted and what is their survival rate?

3. How much are the status of diversity and natural regeneration of woody species?

1.5. Significance of the Study

Knowing the overall contribution of allocated versus non-allocated communal hillsides as a means of conserving and improving vegetation cover on a similar background land history is a basic task. It helps as a way of re-arranging, the management practices of the local community to their environment. To meet the goal, a vegetation survey should be held. So, assessing and comparing the impact of both communities based managing (private and communal) approaches of the degraded hillsides on vegetation cover is help-full for better decisions and to make more sustainable forest development interventions. Hence, this study provided relevant and timely information on the woody vegetation recovery of degraded allocated hillsides of the Atsbi-Womberta district.

This study could also serve as base line information for further research and academic communities, planners and decision-makers in their planning and implementation of allocating of degraded hillsides to enhance the vegetation cover of deforested areas.

1.6. Scope and Limitation of the Study

The study was focused on three Kebelles, due to the limitation of resources in terms of time, budget and transport facility. In addition to this, it did not include the ground cover of herbs, examining soil seed banks and soil samples to see the effect of allocation of degraded hillsides on soil characteristics. Lack of detail information on the type of seedlings planted per year and per site, was also a limitation of the study. But, it takes into account only the condition of physical soil and water conservation implemented, trees planted, and species diversity that existed there.

2. LITERATURE REVIEW

2.1. Community-based environmental protection

Human activities may lead to several different types of problems for the environments and the species that live within them (Mutia, 2009). These problems may be physical, such as erosion, forest degradation, and deforestation (Leul Kidane *et al*., 2018). Thus, creating awareness and organizing local people, how to manage eroded hillside is needed for the recovery of deforested hillsides (Shari *et al.*, 2015; Shimelse Samson *et al.*, 2017).

Community-based environmental protection is an action that local individuals and group stake to address their environmental concerns (Prizzia, 2005;Rodriguez *et al.*, 2018).That means that people work together to develop plans and to set goals according to their perfect interest (Lakew Desta *et al*., 2005). Devi and Mishra (2015) defines, community-based natural resource management as a term for managing, maintaining and controlling resources such as cultivable, un-cultivated hilly lands, and forests, e.t.c. by common agreement through local institutional norms for local advantage and benefit.

Environmental protection plans developed in this way can be very effective; because they take into account local people, economic, and environmental conditions as well as community beliefs and principles (Shirkhorshidi, 2013). They create a sense of property ownership of issues, solutions and encourage long-lasting community support and accountability (Gordon, 2017). Community-based efforts are initiated locally, they consider the views, interests, role, and values of local stakeholders (Leul Kidane *et al*., 2018).

2.2. Private versus communal land

2.2.1. Private land

Private is easily understood as belonging to a person or a family, but many works of literature recognized that co-operative-owned property is also considered just as much as private (James, 2004).All the land registered in the name of an individual or the form of a user-group through co-operating serves as a private entity (Gebeyehu Belay *et al*., 2014).Preservation of biodiversity and continued provision of ecological services increasingly relies on environmental conservation on private lands (Drescher *et al.*, 2017). Hence, the development of private land ownership is particularly important in conservation, concern globally (Rodriguez *et al.*, 2018). Hillsides that are allocated to private as sole or group form should have to use properly unless the right of use may be revoked (WOARD, 20018).So, good management of hillside is valued by the group itself as they expect to get benefit from it (Yohannes Gebremichael and Waters-Bayer, 2007;Shimelse Samson *et al*., 2017).

2.2.2. Communal land

Practically, commons generally referred to a property that is owned communally by a Kebelle or a village (James, 2004). All land under the local government, managed by the public and mostly not registered is also called communal land (MEDIWR,2009;Andersen,2011). Such land usually includes community forests, grazing lands, and water-holes and may be allocated by the traditional experience and registered with the local government, in the name of the community for their livelihoods, not for commercial purposes (Andersen, 2011).

The commons have a limited-access managed by a distinct community according to their social norms they omitted individual benefit at the expense of the community, whether referring it to grazing rights e.t.c (James, 2004; Andersen, 2011). These are out of proper management activities and turn into what generally is called open access areas (Andersen, 2011).In this case, there are no workable rights and rules to exclude anyone (Berhanu G/hin *et al*., 2015). Thus, everyone can use the resource based on the interest of each individual (Andersen, 2011). Thus, such resource usage leads often to highly degraded situations.

2.3. Woody vegetation

According to Gardiner (2010), vegetation can be described as a collection of plants that involves all the structural layers of trees, shrubs, lianas, and herbs. In other word to mean that any plant material that has developed a woody stem (Gandiwa *et al.*, 2012).This includes trees, saplings, shrubs, brush, and vines (Pereki *et al.*, 2013). However, for the title woody vegetation cover represents land covered with tree life forms of sapling, tree, and shrub of woody species structure to an easy the evaluation process of allocated possessed by users and non-allocated hillsides owned by the community.

Vegetation is considered from the plant community point of view as the total of its parts and this idea guides plant ecologists to develop the concepts of tree composition, dominance, and diversity in the study of vegetation ecology (Eba Muluneh Sorecha and Lenjisa Deriba, 2017). Vegetation provides different important services to living things found in our universe (Zerihun Tadesse, 2015). It serves as a source of food for both humans and animals, shelter for wildlife and source of different materials that humans can use for various purposes and gives protection against soil erosion (Tropisch and Bos, 2009). In addition to these, it plays an important role in regulating the environmental climatic conditions and makes the environment suitable for a living (Devi and Mishra, 2015). Vegetation can play to treat the present-day global warming issue, thus anybody should have to focus on conserving and developing vegetation to create the green world (Negasi Solomon *et al*., 2018).

2.4. Conservation of uncultivated hill lands

An extensive area of the hillsides in the highlands of Ethiopia is unsuitable for crop production and instead is used as a grazing site (Hailemariam Meaza *et al*., 2016). The influence of unwise utilization in the past exposed most of the highland areas to land degradation (Hailemariam Meaza *et al*., 2016; Sisay Damtie, 2017). In Ethiopia, where almost everyone's survival is interrelated to the soil, the difference in participation and soil conservation has contributed persistence of the problem (Mitiku Haile *et al*., 2005).

Assessments for improvement of the vegetation cover are vital to combat soil erosion and to reverse the degradation of these uncultivated areas in the high lands (Abonesh Tesfaye *et al.*, 2016). Most of the time the way of improvements is done in the form of physical and biological conservation (Amanuel Negassi *et al*., 2002).Conservation measures are done in the interest of both individual and the community (UNDP, 2012). Thus, the support and collaboration of community and local government are needed, whenever conservation measures are applied (Berhanu Kebede *et al*., 2016).

Biological soil conservation practices include vegetation strips, protective tree stands, and permanent grass cover and a forestation efforts (Abenet Mengistu *et al*., 2016). Vegetation cover can be improved in different ways (Amanuel Negassi *et al*., 2002). The cheapest and usually effective option for achieving better vegetation cover is the establishment of exclosures to enhance the recovery of naturally regenerated woody species diversity, composition, and structure Ashenafi Manaye *et al*.(2019), unless a forestation is the next preferable one (Amanuel Negassi *et al*., 2002).The word exclosure here represents the exclusion of unwanted practices from degraded sites, such as human and animal interference until re-growth of natural vegetation has occurred (Aerts *et al*., 2008). Therefore, exclosures for rehabilitation of degraded land has been now widely implemented throughout most regions of the country (W. Mekuria and E. Aynekulu, 2011).

Fast-growing species that quickly develop an extensive root system are preferable since they quickly cover and bind the soil (Amanuel Negassi *et al*., 2002; Mukankomeje, 2010).

From the ecological point of view, indigenous species are preferred to exotic once (Amanuel Negassi *et al*., 2002). It is particularly important to select species that will be able to survive in the first long dry seasons (Aerts *et al.*, 2006). Trees to be planted must also fit the interest of the local people and meet the intended objectives (G/hiwet Gebru, 2017). Mixing several species reduces the risk of damage caused by drought, pests e.t.c (Yemiru Tesfaye *et al.*, 2015). It is also desirable to obtain diverse of products such as timber, poles, fodder and bee forages, in addition to the services the trees provide for soil and water conservation (Tesfaye Alefew, 2016). It is important to choose the right species for the climate, soil and purpose and the right pattern for mixing them *(*Amanuel Negassi *et al.*, 2002*).* For instance, if *Eucalyptus* species are planted, a block planting system with an indigenous tree is a good option. Hence, mixed species plantation with proper planting is better than monoculture (Amanuel Negassi*et al*, 2002).

Physical soil and water conservation practice are applied to soil management using knowledge or art with the aim protection of soil resource form exploitation (Adugnaw Birhanu, 2014). It is a conservation measure that usually consists of engineering works involving the construction of earth works Amanuel Negassi *et al*. (2002), such as terraces, micro-basin, e.t.c. those measures reduce the effect of slope length and angle (Amanuel Negassi *et al*., 2002). Mostly hillside terrace, locally called "kujetawi-zalla[1](Tig) is an inward sloping narrow benched structure which is constructed along the contour of degraded hillsides to conserve soil and water are usually constructed on degraded hillsides (Amanuel Negassi *et al*., 2002). Physical soil and water conservation is a physical structure mostly constructed by leveling a strip of lands in steep degraded slopes and shallow soils to allow the planting of trees and shrubs (Amanuel Negassi *etal*., 2002; Haftamu Ertiro, 2006). Since hillside terrace structures construction is usually associated with tree planting, the spacing

[1]Kujetawi-zalla: A word of Tigrigna language which means that terraces did on hillsides.

between the tree seedling will influence the difference between the hillside terraces (Zenebe Gebregziabiher, 2015). It commonly is made in regular and multiple spaced terraces, in regular spaced terracing, each row of trees is planted on a terrace (Lakew Desta *et al*., 2005). A spacing of 2.5×2.5m is widely accepted (Amanuel Negassi *et al*., 2002).Regularly spaced terracing is recommended when the vegetation cover of the area is very low, i.e. 0-10% Amanuel Negassi *et al*.(2002),whereas multi spaced terracing is recommended in areas where the existing vegetation cover is 10-30% (Lakew Desta *et al*., 2005). In this case, some trees are planted in line between the terraces (Haftamu Ertiro, 2006). The implementation of physical measures should always be considered carefully since they are costly to construct and also require maintenance (Amanuel Negassi *et al*., 2002).

Another is micro-basin which is a small physical soil and water conservation structure with the shape of a half or a full circle, excavated to obtain a small basin for planting a tree (Amanuel Negassi *et al*., 2002; Haftamu Ertiro, 2006). The primary purpose is to harvest and retain enough water for the seedlings to survive the long dry seasons which seedlings planted in the degraded hill middle steeply sites (Mulubrhan Balehegn *et al.,* 2019). For the construction of micro-basin, the soil is excavated in 1m diameter to conserve water for plantation (Hilger *et al.*, 2013). The spacing between basins along the contour line is normally 2.5 m and the distance along the slope is 2.5 m (Amanuel Negassi *et a*l., 2002).In most sites, the standard diameter of a micro-basin is 3m and it is usually re-enforced by paving stones on the lower and steeper sides (Amanuel Negassi *et al*., 2002).

However micro basins vary in size according to their designation to conserve water, they are small in moist agro-ecological zones and large in dry once (Lakew Desta *et al*., 2005).The, the main objectives of the above mentioned and another type of soil and water conservation Structures are important to improve soil texture and water quality, provision of timber, non-timber forest products and biodiversity conservation (Amanuel Negassi *et al*., 2002;

Haftamu Ertiro, 2006). This is clearly demonstrated the advantages of using SWC measures for environmental rehabilitation (Kirubel Mekonnen and Gebreyesus Brhane, 2011).

2.5. Community-based reforestation and hillside management practices in Ethiopia

As a result of its long history of farming practice on hillsides by its mainly rural agriculture-dependent population, Ethiopia is challenged with high rates of deforestation and land degradation (Yemiru Tesfaye *et al.*, 2015; Abenet Mengistu *et al*., 2016). Ethiopia has faced deforestation combined with a high rate of land degradation with a continuing heavy demand for woody biomass for fuel and construction (Emiru Birhane, 2002;Abenet Mengistu *et al*., 2016). A major strategy to satisfy the increasing demand for woody biomass is to increase supply through plantation (Carlsson *et al*., 2004). Now, the Ethiopian government has a good stand to implement the program of community-based reforestation and hillside recovery practices with the local community (Tesfaye Alefew, 2016).

One of the main areas of focus for Ethiopia has been tree planting efforts which have targeted on hillside areas and degraded lands (Melaku Berhe and Hoag, 2014). The rehabilitation of severely degraded mountain and hillsides has also one solution to reducing poverty (Hailemariam Meaza *et al*., 2016). Besides this, sustainable and renewed resource management practices need to address the widespread land degradation to balance the human fuel wood consumption demand (Achenef, 2015). In the Ethiopian highlands, plantation on communal land has been rising because of active implementation of various sustainable land management projects Onikiand Negusse Gebremichael (2012), but tree planting requires negotiation among the users of communal land, because as it excludes other activities like grazing of livestock and collection of wood for fuel consumption (Mastewal Yami *et al*., 2006).Mostly, the conversion of land use from grazing to plantation should require a lot of negotiation and can be difficult (Oniki and Negusse Gebremichael, 2012). Thus, deep discussion and taking action is necessary. In response to the problem of land degradation, different resource conservation, and rehabilitation interventions have been carried out in the highlands of Ethiopia, particularly in Tigray (Wondie Mebrat, 2015).

According to the report of Mulugeta Lemenih and Habtemariam Kassa (2014), about three million hectares of degraded forest land is under area exclosure, over 0.8 million ha under smallholder plantations, and 0.25 million ha are under state-owned industrial plantations in Ethiopia. Generally, Ethiopia is very experienced in different forest development strategies that need to be scaled-up (Yemiru Tesfaye *et al.*, 2015; Zenebe Gebregziabiher, 2015).

2.6. Private management in the recovery of hillsides and initiatives in the Tigray

Most community-owned hillsides, especially steeper uncultivated land are highly degraded because of the removal of vegetation and lack of care of proper land management over many years (Araya Kiros, 2014). In the Tigray region, 62% of the total hillside area is used for free grazing, but not produce much vegetation biomass (Kisambo, 2016). The only exceptions are those available as exclosures where community members are well organized and have formulated binding bylaws to practice the strategy (T.Mengistu *et al.*, 2005).

The success of the rehabilitation of degraded lands mainly depends on clear land-tenure, well defined and secure property rights for land and trees (Yemiru Tesfaye *et al.*, 2015). Studies in northern Ethiopia showed that the community strongly preferred private over communal and divided the hillside among private individuals, in other ways also farmers prefer a community-level management system over private ownership (T.Mengistu *et al.*, 2005). Such an idea is created in the absence of a pure and clearly defined form of land-tenure arrangement that better suits a community to manage the hillside and maintain equitable benefit-sharing among the private members (Zenebe Gebreegziabher, 2010).

The eroded land restoration practice has direct and indirect roles from the closed hillsides through getting considerable income from the selling of gathered grass, downstream irrigation, treats the gully and used fattening for cattle (Benin and Pender, 2002;Abenet Mengistu *et al*., 2016).

Moreover, area exclosure is an intervention measure that boosts land productivity and plays a key role in carbon sequestration, and mitigating climate change as well (Abenet Mengistu *et al*., 2016).Up to 2016 about 143,000 ha of area exclosures were established in Tigray (Kidane Gidey*et al*., 2018). Yet, there are some gaps regarding the future management and utilization of the closed areas (Demel Teketay *et al.*, 2018). Intensive silvicultural practices are needed to manage and improve the productivity of the closed areas, to achieve environmental sustainability and the demands of the local people (Kidane Gidey *et al*., 2016). The regional state of Tigray has started to distribute the closed area, to motivate the community and to develop the re-greening process (Hailemariam Meaza *et al*., 2016). Out of the total area closed about 72,858 ha were allocated to 109,508 males and 38,297 youth female farmers, but the remaining have been still protected and managed with the support of REST and the community themselves (G/hiwet Gebru, 2017). Local communities have also developed a sense of ownership as they gain confidence in authority over direct use, participation in decision making and in establishing their bylaws (Kidake, 2014; Mulubrhan Balehegn *et al.*, 2019).

2.7. The role of hillside recovery in livelihood and resource conservation

According to Gibson (1996), hilltops were designated as a conservation area which allows for the conservation of indigenous tree species and medicinal plants. In several areas of Ethiopia, forestry and reforestation were confined on-farm and to the hill slopes (Wondie Mebrat, 2015). The on-farm planting was in the form of woodlots, hedgerows, fodder banks, boundary markers, fruit orchards and other agro-forestry techniques with private ownership, while trees planted on the hill slopes were under the control of the regional government (Tesfaye Alefew, 2016). For rural people in Ethiopia, the environment is closely linked to their livelihoods (Zenebe Gebreegziabher *et al*., 2010). Hence, some districts decided with allocating youth-groups to give the right to use small pieces of common land (Gebregziabher Gebreyohannes, 2011).

Reforestation and hillside management should only be attempted when the local communities are in agreement with the reforestation proposal (Tesfaye Alefew, 2016).Through strengthening the sense of ownership the value of the hillside vegetation recovery has been raised and owners started to secure their livelihood (Gebregziabher Gebreyohannes, 2011). Communities living in the lower potential of farm areas, where agricultural production is difficult, developing and managing community woodlots may be a key element for effective development strategy (Abrham Abiyu *et al.*, 2019). In addition to this, planting and protecting, hillside trees will have to help to fight against global climate change and protect endangered species from extinction (Ject, 2016;Tesfaye Alefew, 2016).

2.8. Level of hill side allocation in the Atsbi-womberta district

The main causes of the disappearance of forests, as expressed by elders in the district are repeated drought, cutting trees for cooking, the habit of house construction that consumes large wood products, low level of awareness and poverty. As a result, it is hard to see forest coverage in most parts of the district (NRMFPUC, 2018). However, degraded hillside distribution is considered as the hot spot in which a large cover of vegetation can be seen in the area after management intervention has been done (Berhanu G/hin *et al*., 2015).The establishment of privately managed the allocation of hillside is a method of recovery of degraded hillsides through protecting and planting trees with the integration of SWC activities done within full investing force power of user-groups (WOLPP, 2018). Communal hillside which is to be transferred into private or group users is selected first for plantation (NRMFPUC, 2018). The degraded hillside to be distributed also selected and identified first by development agents, development committee, and the local administrators (Hailemariam

Meaza *et al*., 2016). After in-depth discussion, the final decision of the hillside to be allocated will be decided by a general meeting of the community members, based on the interest of the local people (Emiru Birhane, 2002).As an example, such allocation of degraded hillsides was first started at Kebelle Hayellom, village Gergera, and the name of the particular hillside called Adefa. It allocated into 80 users, by the estimation of 0.25 ha per each landholding system (WOLPP, 2018).

The degraded steep area which is allocated recovered quickly and used for both tree growth and to be as a source of income for farmers via producing other resources. So, the main goal of the allocated degraded hillside is for rehabilitation and to solve the land scarcity for farmers to invest individually or group interest (Hailemariam Meaza *et al.*, 2016; WOLPP, 2018). Another advantage is also users who are allocated and formed co-operative can get a lot of services, such as technical, material and loans to invest environmentally-related actions based on their common business plan. Hence, according to the report of the district (2018), a total area of 3,470.70 ha of hillside has been relocated from the community-owned into private user-groups as a co-operative form. From the total area owed 1709.85ha, 1013ha, and 747.85 into bee-keeping, fattening and forestry purpose; for 5632, 2697 and 1680 users, respectively (WOLPP, 2018). As a result, *E. globules*, *E. camadulensis*, *A. decurense, A. saligana*, *Dodonea angustifolia, Euclea schimperi*, *A. etbaica*, *A. seyal, Junipers procera*, *Maytenus senegalensis, and Olea europaea*are clearly visible as a dominant woody species found in different privately allocated hillsides of the district now (NRMFPUCP,2018).

3.MATERIALS AND METHODS

3.1. Description of the study area

3.1.1. Location

The study was carried out in Atsbi-womberta district and which is one of the seven districts in the eastern zone of Tigray Region. It is found at about 65 km north east of "Mekelle (the regional capital city)". The district is geographically located at $13^{0}33'0''$N to $14^{0}6'0''$N and $39^{0}36'0''$E to $39^{0}54'0''$E. It is bordered on the south by the Enderta, on the west by kiltie-awulaelo, on the north by Saesi-tsaeda-emba districts and on the eastern by the Afar region. The district is administratively divided into 18 Kebelles. Out of these Kebelles the study was particularly undertaken in Ruba-felleg which is found in north, Dibab-akorean, found south west and Hayellom found in south direction of the district, as well as the specific study sites were Tikul-emni (Ruba-felleg), Enda-anahb (Dibab-akorean) and Adefa (Hayellom) were assessed.

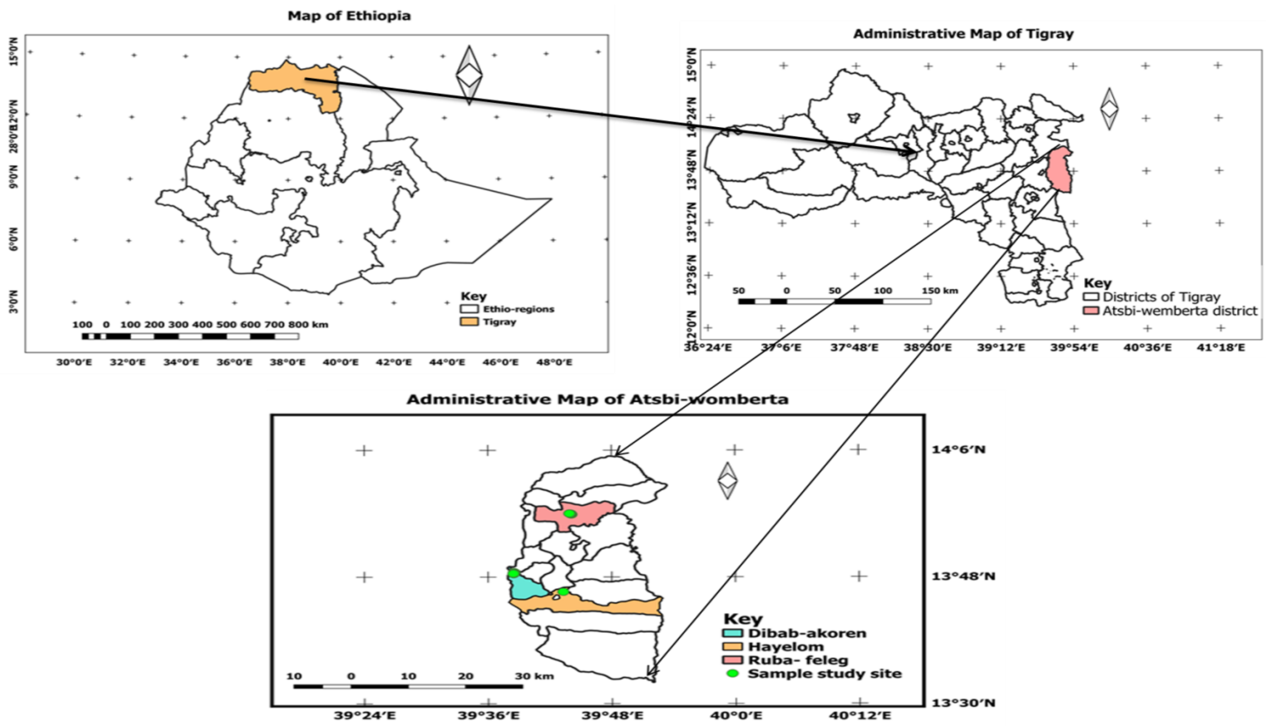

Figure: 1.Map of the study area in Atsbi-womberta district, Tigray, Ethiopia

3.1.2. Population

Based on the 2019 population projection of the district, it has a total population of 133,813, of whom 63,609 are (males) and 70,204 are (females). The total numbers of house hold heads are29,089, of this 15,261 are male-headed house hold, while 13,828 are female-headed house hold. Out of the total number of households 11,144 are urban inhabitants (WOFED, 2019). The total area of the district is about 147,096 ha (WOLPP, 2018). As well as the specific study Kebelles area is, Ruba-felleg (6738.54 ha), Dibab-akorean (3327.32 ha), and Hayellom (9020.92 ha) with having a total population 7,664, 4,891, and 7,079, respectively (WOLPP, 2018). The particular study site Tikul-Fmni was distributed into user-groups in 2016 to 17 youth groups, of which 7 are males and 10 are females through forming legal co-operative called "SEGENAT" (KOARD, 2016). The 2nd sample site Enda-Anahb was allocated in 2011, to 48 youth groups, of which 31 are males and 17 are females with forming a co-operative known as "SEGISELAM" (KOARD, 2012) and the 3rd site which is called Adefa was allocated in 2000, to 80 users, 60 are males and the rest 20 are females, with forming legal co-operatives called "FIRE-SELAM"(KOARD, 2003).

3.1.3. Climate

The climate of Atsbi-womberta ranges from cool to warm (WOARD, 2018). The annual average temperature of the area is 18^{o}C. Rainfall is usually intense and short in duration, with an annual average (2008-2017) of about 667.8 mm (WOARD, 2018). The elevation/altitude of the study district ranges from 918 to 3069 m.a.s.l.

The climate of the area is characterized by 75% as highland ('Dega') and 25% as middle land ('Waynadega') (ILRI and MoA, 2004). All the specific study sites are found at the range of elevation 2035–2470 m.a.s.l under "Dega" climatic condition.

3.1.4. Livestock population

Livestock is the main component of the farming system of the district(ILRI and MoA, 2004).According the official report of the district (2018), it possessed 354,957 livestock population consisting of 64,419 cattle, 111,655 sheep, 42,902 goats, 162 horses, 781 mules, 12,432 donkeys, 603 camels, and 122,003 poultries. Based on the report, Ruba-Felleg owned 25,369 livestock population consisting of 6,369 cattle, 9,147 sheep, 592 goats, 26 horses, 65 mules, 620 donkeys, 10 camels and 8,540 poultry and Dibab-Akorean totally owned 17,141 of which 3,269 cattle, 4,561 sheep, 2,429 goats, 85 mules, 682 donkeys, 15 camels and 6,100 poultry as well as Kebelle Hayellom possessed 20,326 of which 5,350 cattle, 5,662 sheep, 2,504 goats, 30 mules, 500 donkeys, 180 camels and 6,100 poultries. Most parts of the land are currently faced shortage of grazing and browsing land, as well as livestock diseases are the main problems for the livestock population in the district (LDAHPC, 2019).

3.1.5. Crop production

The agricultural office of the district explained that different types of crops are cultivated by the farmers. Nine of the 18 Kebelles in Atsbi-womberta have an elevation greater than 2600 meters and are planted in *Hordeum vulgare* (barley), *Triticum aestivum* (wheat), pulses like *Vicia faba* (Fabian-bean) and small ruminants are raised (ILRI and MoA, 2004). The other nine Kebelles have an elevation below 2600 meters and are planted in *Eragoristic tef* (Teff), *Triticum aestivum* (wheat), and *Hordeum vulgare* (barley). Apiculture is cultivated. 2,726 bee colonies are reported in the district (WOoARD, 2018). A major cash crop is *Vicia faba* (Feba-bean) and the district is an important supplier of sheep and goats for meat to the nearby towns of Wukro and Mekelle (ILRIand MoA, 2004). Most of the above mentioned economic characteristics are inclusive for the specific study Kebelles, specially, Hayelom, is mainly famous in apiculture farming system in the district (ILRI and MoA, 2004)

3.2. Research Methods and Data collection

3.2.1. Reconnaissance survey

A reconnaissance survey was conducted during the first week of January 2019 to have information on accessibility and availability of allocated with adjacently non-allocated communal hillsides and some other socioeconomic activities of the local community that were found in each of the study site.

3.2.2. Data types and sources

To obtain all important data for this study, both qualitative and quantitative data were collected. All the collected data were checked, coded and entered into a computer, to make statistical analysis. In this research, field surveys and measurements were the major sources of primary data. To ensure the reliability and validity of the data collection, a parallel transect line method was employed for the assessment of woody species resource and existed SWC measures in each study site (Kirubel Mekonnen and Gebreyesus Brhane, 2011). These methods include observation, focus group discussion and key informants' interview. Secondary sources of information used for this study were published materials such as books, journals, annual reports, plans, official records, census records, project reports, research papers, and web pages.

3.2.3. Sampling design and data collection methods

3.2.3.1. Primary data collection

Primary data were collected through various data collection method including field survey, focus group discussion and key informant interview.

1) Site Selection and Field Survey

Out of the 18 "Kebelles" of the district, three "Kebelles" namely, Ruba-Felleg, Dibab-Akorean, and Hayellom were selected systematically in which three sites based on the presence of allocated and adjacent non-allocated communal hillsides. The assumption in this study is that the allocated and adjacent non-allocated communal hillsides had similar conditions before the establishment of allocated hillsides has been occurred. Those specific study sites have difference in age of allocated and managed by users. Adefa which was the oldest with nineteen years, Enda-Anahb with eight years and Tikul-Emni with three years since managed and regulated via youth group-users.

Table: 1. Sample plot distribution of each study site

No	Study site	Sample plots on both land categories				Total	
		Ahs		NAhs			
		ha	plots	ha	plots	ha	plots
1.	Tikul-Emni	2.68	7	2.68	7	5.36	14
2.	Enda-Anahb	6.37	13	6.37	13	12.74	26
3.	Adefa	9.18	17	9.18	17	18.36	34
	Total	18.23	37	18.23	37	36.46	74

Source: Field survey, 2019

Levels of vegetation recovery of allocated hillsides were determined through studying and comparing the species composition, diversity, density, and regeneration status of woody species with the adjacent non-allocated communal hillsides (T. Mengistu*et al*., 2005; Sarah Tewle-Birhane *et al.*, 2016). In the field survey, sample plots were selected systematically through a transect line with 100 meters interval between lines and 40 meters interval between plots keeping 20 meter open space to avoid border effect (Markos Kuma and Simon Shibru, 2015; Abrham Abiyu *et al.*, 2019). Sample plot was square-shaped (20m×20m) and contained three nested compartments of different size (Mastewal Yami *et al*., 2006; Markos Kuma and Simon Shibru,2015;Sarah Tewle-Birhane *et al*.,2016)(Figure: 2.).

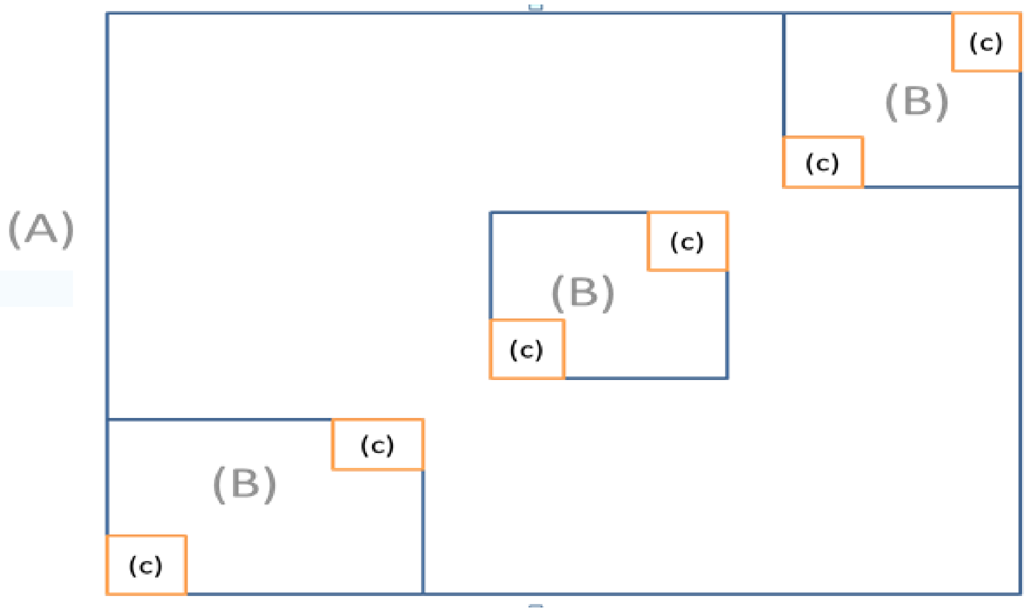

Figure: 2.Sample plot design

Compartment (A) = 20m×20m (0.04ha)

On this compartment, three tasks were assessed and data were recorded.

1) The types and measurements of physical SWC structures were conducted and recorded.
2) Planted and naturally grown woody species were counted and measured with ≥ 10 cm dbh and greater than 2 m in height (Mastewal Yami *et al*., 2006).
3) Planted seedling with height<1m, only their number was counted (Emiru Birhane, 2002).

Compartment (B) = 5m×5m (0.0025ha)

Both planted and naturally grown sapling trees with 2≥dbh<10cm which found in the sub-plot were counted and recorded (Sarah Tewle-Birhane *et al*., 2016). In addition to this, shrubs with ≥ 2 cm diameter at stem height of 30 cm above the soil surface was measured and counted (T. Mengist *et al*., 2005; Mastewal Yami *et al*., 2006).

Compartment (C) = 2m×2m (0.0004ha), naturally regenerated seedling woody species with less than one meter height was measured and counted(T. Mengistu*et al*., 2005;Sarah Tewle-Birhane *et al*., 2016).

Species that were difficult to identify in the field was solved by referring to the Arboretum of Seniti-Merry College of wukro and by using identification manuals and books.

2. Focus group discussion (FGD)

According to Gill and Chadwick (2008), a focus group discussion composed of between six and fourteen members is enough. Thus, in this study, three (one in each Kebelle) FGD was conducted to obtain qualitative and quantitative information. A checklist was prepared for discussion that helped in addressing the objective of the study.

Hence, one focus group discussion composed of the twelve respondents (six from youth group allocated hillside, and six from non-users group) were selected from each study site purposively in consultation with the Kebelle development agents. In total, 36 participants (18 users and 18 non-users) were selected and the discussion was held in their respective farmers' training center. The focus group discussion was accomplished by the researcher to capture the general and specific information on over all the effect of allocation of degraded hillsides on vegetation recovery easy to compare the allocated with the adjacent non-allocated communal hill side.

3. Key informant interview (KII)

In this study, KII was used for the purpose of obtaining a lot of information to strengthen for qualitative and quantitative data. In addition to this, to get more experience how the success and failure of vegetation cover exist in the study area. Hence, participants were selected from the governmental office structure of the district that were related and concerned in this subject and the discussion was held in the center of the district.

Those were;

- From land administration and environmental protection…………………………….. 1
- From natural resources management, forest protection and utilization core process… 2
- From livestock development and animal health protection core process………………2

3.2.4. List of materials used during field survey and data analysis

Different field measurement techniques and materials were used to measure woody vegetation and SWC structures existed in allocated and non-allocated communal hillsides under each study site.

Table:2. List of materials and their description

No	List of materials	Descriptions
1	GPS	For specifying and navigating the location of sample plots
2	Meter tape	To measure the SWC structures existed in each of the study sites
3	Caliper	For measuring dbh (dsh) of woody vegetation
4	Clinometers	For estimating slop and height of woody species
5	Hypsometer &"5"meter pole	For measuring height of woody vegetation
6	Pegs and Riven	For fixing and shaping plots and each quadrant in a sample plot
7	Digital camera	For capturing information in a photo manner
8	Qgis v.3.4.1	For mapping the study area and sample plots
9	MS Words and Excel	For arranging, summarizing and preparing all the research paper
10	IBM SPSS V.20	For statistical analyzing of the data collected from the field
11	Laptop	To run soft ware’s and to prepare and save the research structure in written soft copy manner

3.2.5. Data Analyses

All quantitative data were collected and the data were checked and coded in a computer based on the data source, which was then analyzed to extract meaningful information. The quantitative data obtained through field survey was analyzed by using SPSS as well as the qualitative data that were obtained through focus group discussion and key informant interview were described and summarized. Descriptive statistics such as mean, percentage and frequency were used to present the results.

The difference between the two land use (allocated and non-allocated communal hillsides) for each specific objective was analyzed via using independent t-test, the dimension measured of SWC structures implemented, survival rate, dbh, density as responsible variable and land use as a group (Melkamu Terefe & Abdella Gure, 2019). Independent sample t-test was used due to the reason sample plots were taken from unrelated site population allocated and none allocated communal hillsides. Depending on the type of information collected from the field survey, the data collected were organized, analyzed and summarized using Microsoft excel, SPSS version-20 and the result of analysis were summarized, generalized and presented using table and graph. The information was systematically presented keeping the order of data collected from the field.

1. Soil and water conservation activities

The systematic transect line method was employed for the assessment of existing SWC measures in each study site (Kirubel Mekonnen and Gebreyesus Brhane, 2011) and 20 m length of terrace was taken to measure the dimension of structures implemented in each sample plot (Haftamu Ertiro, 2006) . Then, the implemented Physical SWC structures were identified, counted and measured by meter tape. The length, height and width of each structure were measured and recorded to differentiate structures implemented in quantity.

2. Planted seedling types were identified and counted to calculate survival rate

At the time of field survey tree and shrub seedlings were accomplished through counting and taking the number only. Small seedlings with less than one meter height through asking local guidance and observing with naked eye, excluding naturally appearing seedlings were done to obtain clear data. Then, survi**v**al rate was estimated by the following equation.

$$\textbf{Survival rate (\%)} = \frac{\text{Number of seedling living}}{\text{Total number of seedligs planted}} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{(1)}$$

Data obtained from the field survey were compared and cross-checked with the secondary data provided as a report from the WOARD of the district.

3. Level of woody vegetation status

The woody vegetation status in each site was described in terms of species diversity, species evenness and Simpson's diversity index (Zerihun Tadesse, 2015). A diversity index is a mathematical measure of species diversity in a given community, based on the species richness, and species abundance(Kent and Coker, 1992). The more species exist, the more diverse is the area (Misganaw Meragiaw *et al.*, 2018). Diversity indices provide more information about woody species composition than simply species richness (Eba Muluneh Sorecha *et al*., 2017). Thus, it is necessarily to consider over it.

3.1. The Shannon-Wiener indices of species diversity (H')

The Shannon index is statistic index information, which means it assumes all species were represented in a sample and was calculated following (Kent and Coker, 1992).

$$H' = -\sum_{i=1}(pi)\ ln(pi) \qquad \textbf{(2)}$$

H' = Shannon-Wiener index of species diversity

"Pi" is the proportion (n/N) of individuals of one particular species found

To mean that (n) divided by the total number of individuals species found (N).

"Ln" is the natural log, and "Σ" is the sum of the calculations.

3.2. Shannon evenness (Krebs, 1985; Maguran, 1988, Kent and Coker, 1992)

$$\text{Pie Lou evenness (E)} = H'/H_{max} = \text{or } \frac{\sum_{i-1}^{s} pi \times lnpi}{Ln\ s} \qquad \textbf{(3)}$$

Where;

E = Pie Lou evenness

H' = calculated Shannon-Wiener diversity

H' max = ln (s) [species diversity under maximum equitability conditions]

S= number of species

i= 1, 2, 3…………S

3.3. Simpson's diversity index was calculated as

$$\mathbf{D = 1 - \sum_{i-1}^{s} \frac{ni(ni-1)}{N(n-1)}} \text{ .... } \mathbf{(4)}$$

Where;

D = Simpson's diversity index

n i = number of individual of species

N = Total number of species in community

S = the number of species

4. Vegetation structure of wood species in the study sites

4.1. Density of woody species

The density of woody species of the study area was calculated by the formula to capture the number of species per collection area.

$$Density = \frac{Total\ number\ of\ individual\ of\ all\ species}{Sample\ area}$$

4.2. Abundance of woody species

The abundance of each woody species, here is the total number of all individuals of a species in all the quadrates either within the allocated or non-allocated communal hillsides (Emiru Birhane, 2002).

$$\mathbf{Relative\ abundance = \frac{number\ of\ individual\ of\ a\ species\ in\ all\ quandrants}{Total\ number\ of\ individual\ of\ all\ species} \times 100} \text{..............} \mathbf{(5)}$$

4.3. Basal area of woody species

The basal area of each species was calculated using the formula

$$\mathbf{Basal\ area\ \left(\frac{m^2}{ha}\right) = \sum \frac{\pi D^2}{4}} \text{ } \mathbf{(Kent\ and\ Coker,\ 1992)} \text{.....................................} \mathbf{(6)}$$

Where; $\pi = 3.14$

D = DBH (m).

The density of woody species and basal area of the vegetation were computed on hectare basis. Relative dominance is the dominant of species is determined by the value of the basal cover. It is the coverage value of a species with respect to the sum of coverage of the rest of the species in the area.

4.4. Importance Value Index of woody species

This index is used to determine the overall importance of each species in the community structure (Markos Kuma and Simon Shibru, 2015). Important value index was computed for all woody species based on relative density (RD), relative dominance (RDo) and relative frequency (RF) to determine their dominance position.

Important Value Index **(IVI) = (RD) + (RDo) + (RF)…………………………………… (7)**

Where;

Relative Density (RD) = $\frac{\text{Total number of all idividual of a species}}{\text{Total number of individuals of all species}} \times 100$

Relative Dominance (RDo) = $\frac{\text{Total basal area of a species}}{\text{Total basal area ofall the species}} \times 100$

Relative Frequency (RF) = $\frac{\text{Number of quadrants in which aspecies occurs}}{\text{Total number of qudrants examined}} \times 100$

4.5. Sorensen similarity coefficient

Calculating community similarities, tell us what the communities have in common in terms of similarity species to comparing two or more sites (Misganaw Meragiaw *et al.*, 2018). Sorenson's coefficient gives a value between 0 and 1, the closer the value is to 1, the more the communities have in common.

$$K\,d = \frac{2\sum \text{ci}}{\sum \text{ai} + \sum \text{bi}} \times 100 \ldots\ldots\textbf{(8)}$$

Where;

K_d = similarity coefficient

$\sum \mathbf{a}_i$= total number of individuals investigated in the first site

$\sum \mathbf{b}_i$= total number of individuals investigated in the second site

$\sum \mathbf{c}_i$= sum of the number of individuals of the species common to both sites

4.6. Level of regeneration status of woody species

Based on, khumbongmayum *et al*. (2005), Dhaulkhandi *et al*. (2008), and Tiwari *et al*, *(*2010) the regeneration status of individual of woody species were analyzed by comparing the population size of seedlings, saplings and mature trees.

To assess the level of natural regeneration; naturally re-appearing seedlings only counted on each sub-plot 2m×2m and counting, their number was done.

That is, if seedlings > saplings > adults; → Good regeneration

Seedlings > or ≤ saplings ≤ adults; → the status was fair regeneration

Species survives only in sapling stage (saplings may be ≤ or ≥ adults) → the status was poor regeneration, and if a species is present only in an adult form it is considered as not regenerating.

4. RESULTS AND DISCUSSION

4.1. Status of physical soil and water conservation measures

4.1.1. Description of physical soil and water conservation implemented

The FGD respondents replied that the age of 35% of the SWC measures in the study site ranged from 10–19 years and 65% of the structures were ranged from 1–9 years. Those different structures have mainly constructed in 2000 in the oldest sample (Adefa) by the users' effort as soon as it allocated to them. These two sample study sites were first implemented by free mobilization of the community and food for work programs since 2008 (Enda-Anahb) and 2015 (Tikul-Emni). After that, the partial Part of the hillside was distributed into group-users in the year of 2011 and 2016, in Enda-Anahb and Tikul-Emni. Then, the new construction of structures, plantation of trees and the rest maintenance of earthworks were implemented through owners' interest and power based on their action plan. The study investigated that the main SWC measures implemented were hillside terrace, hillside terrace plus trench, micro-basin and micro water pond were constructed rankly. This finding is similar to the finding of Belay Asnake and Eyasu Elias (2017). This might be due to the goals of the SWC effort made to control soil and water loss from the degraded hillsides and to promote as a precondition for the establishment of trees and shrubs to boost the re-vegetate status of the site.

4.1.2. Assessing and comparing of common physical SWC existed in the area

From the field observation figure 3 below shows that structures in the allocated hillsides were better than non-allocated communal hillsides, which are leading to destruction. This is similar to the idea which was reported by Kirubel Mekonnen and Gebreyesus Brhane (2011),which justified that the local community did not adopt participatory feelings to repair these community resources, structures become destructed year after year. Hence, structures under non-allocated hillsides exposed to damage via the negative interference of humans and animals with access to uncontrolled free exploitation of resources. In complementary to the assessment and evaluation of erosion problems at field and hill land topographic structure, assessing the existing SWC structures might allow comparing allocated versus communal managing hillsides. Thus, it may provide a better way for future planning.

Figure:3.Structures implemented on allocated versus non-allocated communal hillsides

Based on the availability of physical soil and water conservation made in each study site, those which mainly cover the study site were taken as comparison way in this thesis. Table 2 below specifies that, a total of 74 plots (2.96 ha) were assessed, where 37 plots (1.48ha) from allocated hillsides and the rest 37 plots (1.48 ha) from adjacent non-allocated communal hillsides. The assessment was targeted on the physical observation (type and measure) of the physical SWC structures carried out on both categories of the land of each sample site. From the total conducted plots, four plots (5.4%) were found out of any physical SWC structures implemented. Those bare plots were found only in the community-owned hillsides, while hillside terrace, hillside terrace plus trench, micro-basin, and ponds were perfectly found under-allocated hillsides. Only ten plots (13.5%) have been covered with the availability of a modified structure called Hillside terrace plus trench which were found under the allocated hillside managed by youth-groups. Therefore, 37 plots have existed with the availability of hillside terrace in the allocated hillsides. That is, 27 plots by hillside terrace and 10 plots by hillside terrace plus trench under-allocated, whereas 33 plots covered with hillside terrace only in the non-allocated communal hillsides. Hillside terraces were widely practiced and covered almost common all over the plots of the study site. From the evaluated plots, sixty plots (81.1%) were found with coverage of the structure called hillside terrace. This finding is consistent with the finding of, Belay Asnake and Eyasu Elias, (2017)revealed that the extent of adoption of hillside terrace was 81.5% on hilly and mountainous areas of Guba-Lafto Woreda, North Wollo, Ethiopia. This might be due to the similarity of steepness and topographic structure.

Table: 3**.** Number of plots and availability of SWC activities of the study sites

SWC structures	Tikul-Emni		Enda-Anahb		Adefa		According to land feature					
	Ahs	NAhs	Ahs	NAhs	Ahs	NAhs	Ahs	%	NAhs	%	Total	%
None of SWC	0	2	0	0	0	2	0	0	4	10.8	4	5.4
H_s terrace	7	5	4	13	16	15	27	73	33	89.2	60	81.1
H_s terrace+trench	0	0	9	0	1	0	10	27	0	0	10	13.5
Total	7	7	13	13	17	17	37	100	37	100	74	100

Source: Field survey, 2019

From the field observation, the hillside terraces plus trenches were constructed purposely as a modified stricture for full effective to catch-up both soil and run of water. This makes it convenient for areas suffering from moisture stress. However, in practice, people dislike it since it needs more power and cost compared with a simple hillside terrace. This might be the reason it accounts for less percentile cover of plots in this study. However, there was some variation among types of structures that have been done in the three study sites based on the land type, availability of materials, and commitment of the user-groups' work strength. The result findings below in table 4 indicate that the total soil and water conservation measures implemented on the assessed sample plots were 125,000 meters, which 76,500 and 48,500 meters were constructed in the allocated and non-allocated communal hillsides, respectively. The result also indicates that the mean of physical SWC measures constructed in the allocated hillside ($\mathbf{2067 \pm 459}$) was higher than hillsides owned under the community with mean value ($\mathbf{1310 \pm 593}$). Therefore, comparatively, structures constructed in the allocated hillsides are better in amount and quality than that of non-allocated hillsides.

Table: 4.The amount ($\boldsymbol{Mean \pm SD}$) of SWC implemented in the study sites

SWC Structure	Tikul-Emni		Enda-Anahb		Adefa		Total	
	Ahs	NAhs	Ahs	NAhs	Ahs	NAhs	Ahs	NAhs
H_s terrace in m	16,500	8,500	7,500	20,500	33,000	19,500	57,000	48,500
H_s+trench in m	0	0	18,000	0	1,500	0	19,500	0
T.amount in m	16,500	8,500	25,500	20,500	34,500	19,500	76,500	48,500
Mean h^{-1}	2,357	1,214	1,961	1,576	2,029	1,147	2067	1310
S.Dev	244	447	431	187	514	606	459	593
T-value	3.22		2.95		4.58		6.14	
P-value	0.015		0.009		0.000		0.000	

Source: Field survey, 2019

The study results in table 4 above show that the physical soil and water conservation structures implemented under each study site were significantly different ($P < 0.05$) in Tikul-Emni, ($P < 0.01$) in Enda-Anahb and ($P < 0.001$) in Adefa when comparing the allocated with non-allocated communal hillsides in each of the study site. The study's finding is contradicted to the investigation reported by Melaku Berhe and Hoag (2014), that revealed amount of soil and water conservation structures done in the hillside area indicates that landless people who have obtained land grants did not perform sufficient hillside conservation as compared to the hillside given to them. Therefore, the difference may be occurred due to the sense of ownership developed among youth-groups allocated to accomplish S.W.C structures.

4.1.3. The main dimension requirements of structure existed

To compare the land covered with the structure, width and length were considered and measured. The coverage sizes of the structures implemented under the allocated and non-allocated hillsides of the study area showed significantly difference (P< 0.01). Since table 5 below shows, the average area of SWC structures covered is 0.06 and 0.017 per each hectare of the study site of allocated and non-allocated communal hillside.

Table: 5. Coverage of SWC structures in the study sites

	Tikul-Emni		Enda-Anahb		Adefa		Average	
	Ahs	NAhs	Ahs	NAhs	Ahs	NAhs	Ahs	NAhs
Coverage of structures in ha	0.036	0.013	0.10	0.02	0.045	0.019	0.06	0.017
T-value	3.66		11.76		5.123		7.04	
P-value	0.003		0.000		0.000		0.000	

Source: Survey result, 2019

From the finding of the study, allocated hillsides were more superior based on the soil and water conservation structures implementation. Therefore, the type of structures constructed on both the allocated and non-allocated communal hillsides of the study sites was different in type and quantity. However, as KII concluded that in each land category of the study sites, terraces did not make the bench as expected even if they were aged. This might be due to the wide spacing of terraces and lack of timely maintenances.

4.2. Level of Plantation Activities Carried-out and Their Survival Rates

4.2.1. Seedling sources of the study sites

Ninety percent of the FGD respondents replied that the primary purpose of the plantation was to meet household needs for house construction materials, fuel wood, and marketing purpose. Due to this reason, the allocated hillsides are covered with *Eucalyptus* species. This finding supports the idea of Zenebe Gebreegziabher *et al.* (2010), as clarified that *Eucalyptus* trees are relatively fast-growing and helps users to gain profit in northern Ethiopia. Furthermore, the link between tree planting and rural livelihoods, timber, fuel wood, fodder, and fruit production directly satisfy household needs.

Ninety-five percent of the FGD respondents and all KII replied that planting *Eucalyptus* on private hillside contributes as an income source and biological conservation purpose. However, users planted seedlings through buying, from the government nurseries, since the user-groups are less to produce seedlings.

4.2.2. Survived rate of seedlings provided by the district

Usually, plantation activities might be done whether privately or altogether the local community in non-allocated common hillsides to restore the vegetation degradation problems in the study area. However, the finding indicates that privately planted seedlings had the highest chance to be grown-up. The survival status of seedlings in allocated and non-allocated communal hillsides was not the same because of differences in pre and post-management activities. Therefore, the survival rate of planted seedlings was better in the allocated hillsides than non-allocated communal hillsides. Tables 6 and 7 below, demonstrates a trend in the increasing survival rate of seedlings for *Eucalyptus* plantations. The average survival rate of seedlings planted in the community and allocated hillsides during the 2014–2018 plantation years was about 64.6 % and 72.9 %, respectively. The variation might happen due to the carrying out of SWC and some best management practices.

Table: 6.Seedlings inventory of the district under-allocated hillsides of the study area

No	Year	Planted	Counted	Survived (%)
1	2014	50,000	35,000	70
2	2015	35,000	23,401	66.8
3	2016	45,000	27,346	60.8
4	2017	375,000	279,832	74.6
5	2018	20,000	17,000	85
	Total	525,000	382,579	72.9
	Average	105,000	76,516	72.9

Source: WOARD, 2019

According to the district's five years, cumulative progressive report directed that demand for allocation of degraded hillside became increased from time to time. Similarly, seedlings production and planting activities also increased. The awareness and interest of the farming community in planting trees developed and the local people come-up to be benefited both environmentally and economically from the plantation comparing with the previous years.

Until, the year 2019, a total of 3470.7 ha were distributed into 10,009 beneficiaries in the district. Out of this 747.7 ha was distributed to 1680 users for plantation purposes only. However, plantation activities have faced problems, such as poor management practices and frequent droughts. Based on the official report of WOARD in 2016 the survival rate was low compared with 2018, 2017 and 2015 year's seedling survival rate. According to the idea of the experts, this was happened due to the stress of moisture during the plantation season. Usually, experts reported that every year problems have happened due to lack of setting proper management planning activities and less attention in all of the planting strategies.

Table: 7.Seedlings inventory of the district in the non-allocated communal hillsides

No	Year	Planted	Counted	Survived (%)
1	2014	22,500	12,825	57
2	2015	52,500	34,125	65
3	2016	45,000	24,390	54.2
4	2017	42,500	31,025	73
5	2018	12,500	10550	84.4
	Total	175,000	112,915	64.5
	Average	35,000	22,583	64.5

Source: WOARD, 2019

Obviously, from the report, anybody can judge non-allocated communal hillsides receive fewer management activities because of lack of ownership feelings. The study's finding supported the idea reported by, Oniki and Gebermicael Negusse (2012), which explained that no communities voluntarily planted trees on communal land to pursue economic benefits, except small-scale homestead areas where the majority of households planted trees for sales or domestic use. This is happened due to less attention and sometimes the local community assumes that communal hillsides are only belonging to the local government.

In the discussion, experts forwarded that at the time of communal hillside seedling plantation, improper action regularly happens like incorrect planting and throwing-out of seedlings into the surrounding. Thus, such a habit may force to record less survival rate than user-groups running a forestation program.

4.2.3. The survival rate of seedlings from the field survey

During the field survey, three sites were assessed to know the survival potential of seedlings planted yearly. Simply to do the comparison seedlings planted in the same year 2018 was taken. In all of the study sites, *Eucalyptus* species was well performed. The inventory was also done based on the existence of seedlings in the study of the site. Therefore, the survey result shows that the total seedling survival rate in the allocated hillsides was 25% greater than that of the non-allocated communal hillsides and the difference was significant ($P < 0.01$) in general.

Table: 8. Summary of the survival rate of the study sites from the field survey

	Tikul-Emni (2018)		Enda-Anahb (2018)		Adefa (2018)		Average (2018)	
	Ahs	NAhs	Ahs	NAhs	Ahs	NAhs	Ahs	NAhs
Av. planted ha^{-1}	2,100	2,010	1,800	1,900	3,900	3,910	2,600	2,607
Av. counted ha^{-1}	1,655	1,000	1,150	820	2,820	1,835	1,875	1,218
Survived (%)	78.8	50.05	64.05	43.2	72.3	46.9	72	46.7
P-value	0.006		0.01		0.009		0.001	

Source: survey result, 2019

The data obtained from the field indicates that the survival rate of allocated and non-allocated communal hillsides for the year 2018 plantation was less than the districts have recorded, i.e. 72% and 46.7% which varies from the district that has been recorded. The official report for the year 2018 plantation season is much higher 85% and 84.4% for allocated and non-allocated hillsides of the district, respectively) than the finding obtained from the field survey. This might be due to the inclusion of better-performed sites in the report. But the field data indicate that seedlings' survival is better in the allocated hillside than non-allocated communal hillsides. This result was similar to a study by Jagger *et al*.(2015), Kebelle managed woodlots have the lowest survival rates, whereas household managed woodlots, with the lowest labor inputs have much higher survival rates. This might be occurred due to the intention of responsibilities on how to manage seedlings in private. Generally, KII replied that the planting activity has failed and the reasons were lack of proper pre and post-planting management tasks, moisture stress, poor soil and site condition, planting the unmanageable number of seedlings, and lack of monitoring and controlling mechanism. Hence, the unsuccessful survived rate is forced for repeated planting activity every year.

4.3. Level of Diversity and Regeneration Status of Woody Species

4.3.1. Woody species composition of the study sites

The compositions of woody species were determined after carefully identifying each species from the sampled quadrant and follow grouping to their respective life forms and family. Based on the field survey nine families with nine species in the allocated, while eight families with seven species in the non-allocated communal hillside, were identified in Tikul-Emni. Seven families with six species in the allocated and three families with four species in the non-allocated communal hillside in Enda-Anahb, and again eleven families with twelve species were found in the allocated, whereas nine families with nine species under non-allocated hillsides of the study site of Adefa were recognized (Appendix:2.1).

In general, the total numbers of woody species encountered in all of the study sites were sixteen species. Fourteen species were naturally grown and two were planted (*E. globulus* and *E. camadulensis*).The total abundance of woody species was 2,521. Out of those, 215 (8.5%) trees, 401(16%) saplings, and 1,905 (75.5%) shrub obtained in all of the study sites that were assessed in general. Particularly, out of the total woody species encountered in the sample quadrates, 214 (8.5%) trees, 346 (13.7%) saplings, and 775(30%) shrubs were found in the allocated hillsides, while one tree (0.04%), 55 (2.2%) saplings, and 1148 (45.5%) shrubs were recorded in the non-allocated communal hillsides. Therefore, species composition was better in the allocated than non-allocated communal hillsides. This finding of the study supported the idea concluded by T. Mengistu *et al*. (2005),vegetation composed by the woody species was denser in the exclosure than in the open area. This phenomenon is created when areas become free from external disturbance and woody species start to sprout out from the ground level.

4.3.2. Species diversity, richness, and evenness

From the field survey 215 mature trees, 401 saplings, and 1905 shrubs were completely counted in the three study sites. From the total individuals of the woody species, 209 mature trees and 299 saplings were found planted, while 6 mature trees, 102 saplings, and 1148 shrubs were naturally grown woody species.

The Shannon diversity index was recorded (table 9) as 1.75 and 1.65 in Tikul-Emni, 1.36 and 0.91 in Enda-Anahb and 1.77 and 1.07 in Adefa both for allocated and adjacently non-allocated communal hillsides, respectively. The allocated hillsides scored H'= 2.22 and non-allocated communal hillsides valued H'= 1.48. As 2.22 is greater than 1.48, allocated hillsides were more diverse than non-allocated communal hillsides. Then, the study result in table 9 indicated those land categories which have large value were more diverse than comparing with a small number. In addition to this (Appendix: 2.2.), data provided indicates that species with large value were distributed uniformly than the others, i.e. *E. globulus* was the most dominantly dispersed under the allocated hillside with the highest value of 0.32.On the contrary, *Olea europaea* was the smallest one valued 0.02, with a small number displayed and then needs more attention to recover it from extinction. *E. globulus*, *Rumex nervosus*, *Euclea schimperi*, *E. camadulensis*, and *Beciumgrandiflorum* were more distributed in the sampled plots of the allocated hillsides.

The Shannon diversity index in the non-allocated hillside ranges from 0.01 up to the highest number of 0.37 (Appendix: 2.3.).The number 0.01 indicates that species were less dispersed in the study area. The data obtained from the non-allocated communal hillside shows that*Rumex nervosus*, *Becium grandiflorum*, *Euclea schimperi*, and *Salvia officinalis* were diverse than the others found on the study site plots' where assessed.

Moreover, the result also ideates that the numbers of individuals of all species were recorded higher on each site category of the allocated hillsides than non-allocated communal hillsides.

Then, allocated hillsides are richer in the number of species than non-allocated communal hillsides.

Evenness measures the relative abundance of different species present in each of the study sites. Then the result of the survey in table 9 below shown that evenness values of 0.82 and 0.79 in Tikul-Emni, 0.70 and 0.66 in Enda-Anahb, and again 0.72 and 0.49 in Adefa both for allocated and adjacently non-allocated communal hillsides, respectively. Besides, the total result indicates, 0.79 relatively implies that almost the distributions of the species were nearly uniform but, the result 0.56 in the non-allocated communal hillsides reveals that species were not uniformly distributed.

Even though, the Shannon diversity index point to nearly similar, the allocated sample site of Adefa was more diverse than the other study sites. Therefore, allocated hillsides are more diverse in species composition than non-allocated hillsides. The finding of the study supported the idea concluded by Melkamu Terefe & Abdella Gure (2019), exclosure sites had higher species diversity, species composition, and density of woody species than the adjacent open grazing lands. This might be due to comparatively good management and protection of the sites than non-allocated communal hillsides.

Table:9.Shannon–Wiener diversity index of species under study sites

No	Index	Tikul-Emni		Enda-Anahb		Adefa		Total	
		Ahs	NAhs	Ahs	NAhs	Ahs	NAhs	Ahs	NAhs
1	Shannon diversity	1.75	1.65	1.36	0.91	1.77	1.07	2.22	1.48
2	Simpson diversity	0.75	0.74	0.68	0.50	0.75	0.58	0.86	0.72
3	Evenness	0.82	0.79	0.70	0.66	0.72	0.49	0.79	0.56
4	Abundance	171	148	568	558	578	498	1317	1204

Source: Field survey, 2019

The result in table 10 below indicates that the diversity of planted trees were more in the allocated hillsides than non-allocated hillsides. The same also, density of planted trees were more in allocated hillsides with having mean value 744$\pm\mathbf{655}$ per hectare than non-allocated with having mean value of 625$\pm\mathbf{244}$. Whereas, in table 11 the density of naturally grown trees were more in number in the non-allocated hillsides with having mean value of 2005$\pm\mathbf{300}$ than the allocated hillsides which scored 1025$\pm\mathbf{225}$. Thus, allocated hillsides were more on planted trees than non-allocated hillsides because of the exotic plantation intervention of the users.

Table: 10. Planted trees ($\mathbf{Mean} \pm \mathbf{SD}$) diversity

No	Index	Land feature	
		Ahs	NAhs
1.	Shannon diversity	0.65	0.55
	$Mean \pm sD$	0.325$\pm$0.49	0.275$\pm$0.077
	T-value	0.767	
	P-value	0.523	
2.	Simpson diversity	0.49	0.39
3.	Evenness	0.94	0.81
4.	Density ha^{-1}	1712	1241
	$Mean \pm sD$	744$\pm$655	625$\pm$244
	T-value	1.14	
	P-value	0.000	

Source: Field Survey, 2019

Table:11. Naturally grown trees ($\mathbf{Mean} \pm \mathbf{SD}$) diversity

No	Index	Land feature	
		Ahs	NAhs
1.	Shannon diversity	2.06	1.39
	$Mean \pm sD$	0.15±0.104	0.12±0.15
	T-value	0.622	
	P-value	0.54	
2.	Simpson diversity	0.82	0.73
3.	Evenness	0.73	0.55
4.	Density ha^{-1}	2514	3360
	$Mean \pm sD$	1025±225	2005±300
	p-value	0.81	

Source: Field survey, 2019

4.3.2. The similarity between the study sites

The data collected reveals that 14 species were found common in terms of the land categories of the study sites. But an individually different type of woody species was obtained, i.e., trees, saplings, and shrubs in life form. Therefore, there were considerable differences in the species composition of the woody vegetation between the allocated and non-allocated communal hillsides in each of the study sites. The result in table 10 below shown that,82%, 72% and 76% similarity between land categories of Tikul-Emni, Enda-Anahb, and Adefa study sites. The similarity between allocated and non-allocated hillsides is expected to decrease with the age of allocation of hillsides and this is true for Enda-anahb and Adefa study site, but not for Tikul-Emni. The dissimilarity between adjacent sites is due to differences in ownership status and management which becomes observable over the years. However, the little difference between allocated and non-allocated communal hillside in Tikul-Emni (the youngest one) might be due to the presence of alternative grazing lands that reduce pressure on the studied site.

Table: 12.The similarity of the study sites

Land use category	Tikul-Emni		Enda-Anahb		Adefa	
	Ahs	NAhs	Ahs	NAhs	Ahs	NAhs
Allocated hillside	1	0.82	1	0.72	1	0.76
Non-allocated hillside	0.82	1	0.72	1	0.76	1

Source: Field Survey, 2019

4.3.3. Vegetation Structure

4.3.3.1. The density of woody species in the study area

From the total conducted plots 214 trees, 346 saplings, and 757 shrubs were encountered in the allocated hillsides, however one tree, 55 saplings, and 1148 shrubs of individual counted woody species were noted in the non-allocated communal hillsides. Then, this is equivalent to 214, 2,471and 4,471 densities per hectare for trees, saplings, and shrubs in the allocated hillsides, whereas 25, 1,466 and 6,416 densities per hectare for trees, saplings and shrubs in the non-allocated communal hillsides, respectively (Fig- 4). This study's findings supported the studies that were concluded by, Mengistu *et al*. (2005); Mengesha (2011); Mekuria & Aynekulu (2013), which indicated that natural resource management strategies like area exclosures showed significantly higher improvement in woody vegetation composition and density. This might be due to less cutting down of trees and shrubs in the study area.

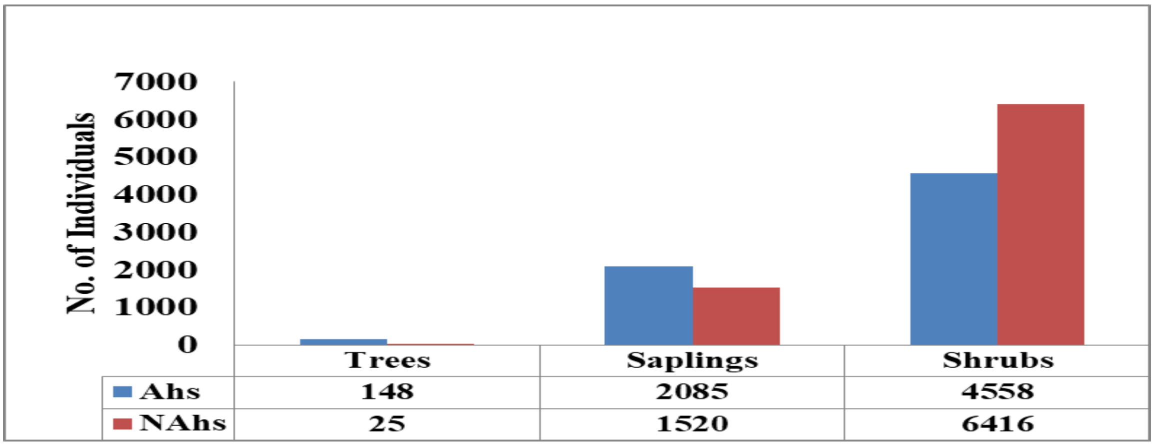

Figure: 4. Density (ha-1) of woody species

Therefore, allocated hillsides were denser than non-allocated communal hillsides with the reference to trees and saplings while non-allocated communal hillsides were more abundance in the availability of shrubs. Shrubs were less counted in the allocated hillsides comparing with the adjacent non-allocated communal hillsides. This might be happening because of the shading and competition effect of *Eucalyptus* trees planted there.

4.3.3.2. Basal area of species in the study sites

According to Table 11 below, the data obtained indicate that the average sum of the stand basal area of both the adjacent study sites, based on trees, saplings, and shrubs were47.5 m^2 per hectare. This implies that 30.1 m^2 and 17.4 m^2 per hectare for allocated hillsides and non-allocated communal hillsides. The total components of the calculated basal area of all woody species were higher for mature trees, followed by saplings and shrubs under-allocated hillsides, whereas shrub's basal area is higher followed by that of saplings and trees in the non-allocated communal hillsides. Generally, the average value of 12.8 m^2 ha^{-1} of tree basal area was calculated for allocated hillsides, while 0.8 m^2 per hectare was calculated for non-allocated communal hillsides. Furthermore, when the study sites compared in terms of sapling basal area the average value was 10.3 m^2 and 3 m^2 per hectare for allocated and non-allocated communal hillsides, respectively. Thus, the mean difference value obtained indicates that there was a statically significant different ($P< 0.001$) between the total average basal area of allocated and non-allocated communal hillsides. This may be happened because of the intervention of users to get benefit from a forestation activity.

The highest proportion of the basal area of the woody species was occupied by *Eucalyptus globules* in the allocated, while *Euclea schimperi* in the non-allocated communal hillsides. The basal area of planted trees were better in the allocated hillsides than the adjacent non-allocated hillsides with mean value of 9.55 ± 4.5 than non-allocated communal hillsides which had scored with mean value of 1 ± 0.28 while, naturally grown trees were more in non-allocated communal hill side. But, the difference is insignificant. Thus, the basal area of the study site was greatly influenced by the dominant tree life present in it and the human manipulation in protecting and planting woody tree species there.

Table: 13. Basal area (ha-1) of study sites based on tree life

Species life form	Tikul-Emni		Enda-Anahb		Adefa		Average	
	Ahs	NAhs	Ahs	NAhs	Ahs	NAhs	Ahs	NAhs
Tree $m^2 ha^{-1}$	5	0	15.5	0	18	0.8	12.8	0.8
Sapling m^2ha^{-1}	7.6	1.5	10.9	0	12.5	7.5	10.3	3
Shrub m^2ha^{-1}	6	11.3	7.3	14.7	7.8	15	7	13.6
Total	18.6	12.8	33.7	14.7	38.3	23.3	30.1	17.4
T-value					1.75		1.40	
P-value			**0**[a2]		0.009		0.000	

Source: field survey, 2019

[2]T-test cannot be computed because of one of the group is empty

Table:14. Basal area (ha^{-1}) ($\boldsymbol{Mean \pm sD}$) of study sites based on tree type

No	Basal area based on tree types	Land future	
		Ahs	NAhs
1.	Planted tree basal area ha^{-1}	19.0	2
	$Mean \pm sD$	9.55±4.5	1±0.28
	T-value	2.5	
	P-value	0.000	
2.	Naturally grown trees basal area ha^{-1}	10	16
	$Mean \pm sD$	5±2.8	8.2±7.6
	T-value	-0.55	
	P-value	0.63	

Source: Field survey, 2019

From the total evaluated plots in the allocated hillsides, 36 plots were with the available of saplings of *E. globulus* and *E. camadulensis*, followed by mature trees that were accompanied in 35 plots with available of *E. globulus* and *E. camadulensis* trees.However, 31 plots were with shrub vegetation cover were conducted.

In the non-allocated communal hillside 35 plots were with accessible shrubs of *Euclea schimperi* and *Rumex nervosus*and then 11 plots were found with available of saplings of *E. globulus* and *E. camadulensis*, and again one plot only valued with the existing of mature trees of *E. camadulensis* tree.

4.3.3.3. Importance value index of woody species in the study area

As the field survey result directed *Eucalyptus* woody species have got the highest IVI (Appendix: 2.4.) and this implies that these species uniformly dispersed with a large value of dominancy position in the allocated hillside which is assigned to users. The site of those species needs to set a proper managing plan how to use wisely, but *Olea europaea* and *Rhus* *vulgaris* with less number of IVI and indicates that less in abundance which needs a good management opportunity to being numerous.

The woody species in the non-allocated communal hillsides were valued from 1.9 to 86.8 IVI (Appendix: 2.5.).This indicates that Shrubs with the highest value were visible as the most dominant and abundant in number in the non-allocated communal hillside, i.e., *Eucleaschimperi*, *Becium grandiflorum*, and *Rumexnervosus* were consecutively found with the highest number and more frequent than the other species. However, *Eucalyptus globulus* and *Eucalyptus camadulensis* were had the next valued following the woody shrub species. Therefore, *Eucalyptus* trees were ranked first in the allocated hillsides, whereas shrubs in the non-allocated communal hillsides. This dissimilarity existed through human intervention over the land. Hence, allocated hillsides devoted to cover with human planted trees, while non-allocated hillsides were matched to cover with naturally grown shrubs. The index (IVI) targeted that, *Eucalyptus globulus, Eucalyptus camadulensis*, *Euclea schimperi,* and *Becium grandiflorum* were the first four most important dominant woody species under the allocated hillsides, whereas *Euclea schimperi, Becium grandiflorum, Rumex nervosus*, and *Eucalyptus globulus* were the most important dominant in the non-allocated communal hillsides. Therefore, measuring the species importance value is a good index for summarizing vegetation characteristics and ranking the species for the management plan and conservation practices. Species with lower IVI need high preservation efforts, whereas those with higher IVI require a wise utilization management plan in the study area.

3.3.4. Natural regeneration status of the study sites

Six mature trees, 102 saplings, and 211 naturally appearing seedlings were obtained from the field survey. Out of the total, 6 mature trees, 81 saplings, and 146 seedlings were naturally presented in the allocated hillsides. However, 21 saplings and 65 seedlings were counted in the non-allocated hillsides. Naturally accessible regenerating seedlings were not more seen in the study areas since the environment of the hillside was exposed to some limitation factors. But, few naturally grown seedlings were offered near the border in the non-allocated communal hillsides and beneath or mixing with some shrubs of *Euclea schimperi* and *Maytenus senegalensis* at the middle part of the allocated hillsides mostly. Based on the study result in table 12 below, naturally appearing seedlings were statistically different (P<0.05) in Tikul-Emni, and (P<0.01) in Adefa. In general, the allocated and non-allocated communal hillsides were significantly different (P<0.01).

Table: 15.The density (ha^{-1}) of tree and shrub seedlings of the study sites

Seedling type	Tikul-Emni		Enda-Anahb		Adefa		Average	
	Ahs	NAhs	Ahs	NAhs	Ahs	NAhs	Ahs	NAhs
Tree seedlings ha^{-1}	1700	590	250	0	985	550	978	800
Shrub seedlings ha^{1}	0	0	650	0	1583	250	1159	450
Total	1700	590	900	0	2,568	800	2,137	1,250
T-value	3.12		0[a3]		3.26		2.62	
P-value	0.03				0.003		0.005	

Source: field survey, 2019

The only woody species representing the seedling stage that was taken to compare the study sites were *Acacia seyal*, *Acacia etbaica*, *Juniperus procera*, *Olea europaea*, *Rhus vulgaris*, *Dodonaea angustifolia*, *Calpurnia aurea*, and *Carissa edulis*. The order of woody species according to the frequency of seedlings that were counted in the field was (Appendix: 2.6.), *Acacia seyal* (25.6%), *Olea europaea* (21.3%), *Juniperus procera* (10.9%), *Rhus vulgaris* (8.1%), and *Acacia etbaica* (9%), in the allocated hillsides, whereas *Dodonaea angustifolia* (18%), *Calpurnia aurea* (3.3%), and *Carissa edulis* (3.8%) were counted in the non-

[3] T-test cannot be computed because of one of the group is empty

allocated communal hillsides. The study result was agreed with the conclusion of Ashenafi Manaye *et al*.(2019), which revealed that better regeneration potential shown in the exclosure than open grazing lands. Therefore, allocated hillsides had a higher number of individuals of seedlings, saplings, and trees than adjacent non-allocated communal hillsides. This clearly shows that vegetation recovery is better under-allocated hillsides than non-allocated hillsides. Since allocated hillsides are protected from further human and animal disturbance. Besides this, the figure-5 below indicate that the regeneration status of the study sites. It indicates that normal regeneration status in the allocated hillsides with inverted J shape of vegetation structure.

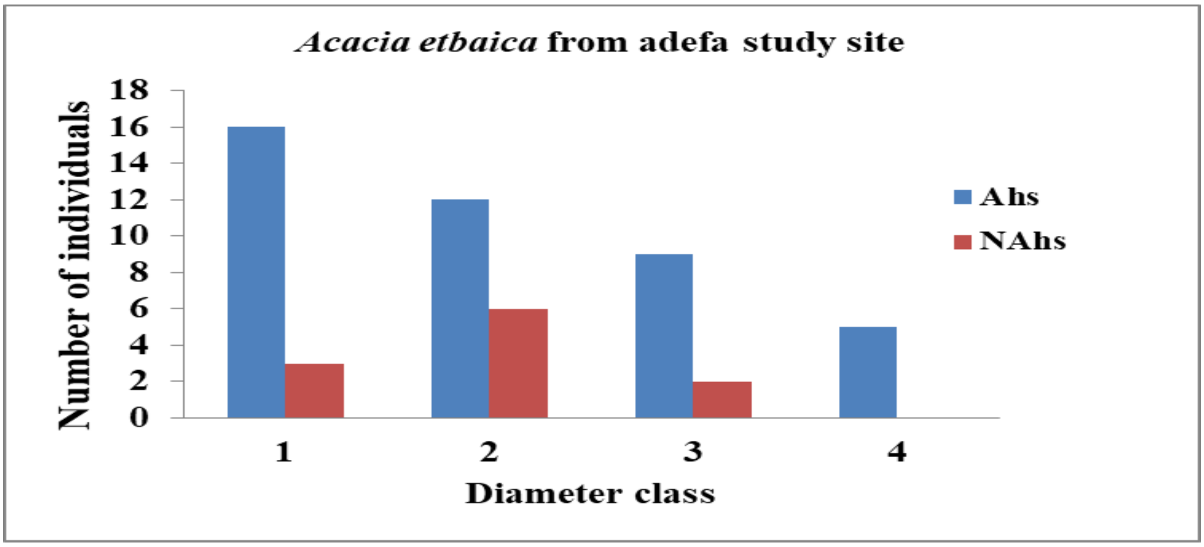

Figure: 5.Frequency distribution of diameter class naturally grown woody species

1=>2-3 cm dbh, 2=> 3 - 6 cm dbh, 3=>7 cm dbh and 4=>> 8 cm dbh class

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

This study assessed the effect of the allocation of degraded hillsides on the recovery of woody vegetation by comparing with adjacent non-allocated communal hillsides. An allocated hillside has maintained by user-groups, but non-allocated communal hillsides addressed by the local people. Thus, the study findings can be concluded as follows;

From the finding of the assessment, hillside terraces were widely practiced and implemented almost all over the hillside plots sampled in three study areas. Besides this, hillside terraces plus trench were particularly implemented under the allocated hillsides, to boost the growth of planted seedlings via minimizing the soil moisture stress.

In complementary to the study physical SWC structures were constructed as a precondition for the rehabilitation of degraded hillsides. Based on this fact, the result of the thesis indicates that there was a vast difference in quantity and coverage of soil and water conservation made in the study sites. The finding of this research revealed that there was an availability of SWC structure made on average 2,067 meters under-allocated, whereas 1,310 meters per hectare in the non-allocated communal hillsides. Allocated hillsides treated immediately through biophysical activities with the full interest of owners. Hence, erosion hazard becomes minimized from the hilltops of land futures is easily observable.

As a strategy, tree planting on the hillside of the study area has been done every year. However, the attention focused on how to maintain seedlings were not well, because every year the planting program has taken place through the mass mobilization of the community, particularly in the non-allocated communal hillsides. Due to this the thesis finding explorers that the survival rate of seedlings in general failed. Relatively 72% of seedlings survival rate was obtained from allocated hillsides, while 46% in the none-allocated communal hillsides.

Allocated hillsides were more covered with Construction and fuel wood advantageous trees. That is *Eucalyptus* species which satisfy the construction and fuel wood demand of the local people. Even though *Eucalyptus* plantation was established, the diversity of woody species conditions becomes enhanced. The Shannon diversity index was scored 2.22 and 1.48 with total abundance species of 1317 and 1204 species for allocated and non-allocated communal hillsides. Comparatively, allocated hillsides were better than from the adjacent non-allocated communal hillsides in species composition, diversity, and density. Even though the original vegetation status of the study sites at the time of the establishment was not documented, the result from the present study demonstrated that the importance of allocation of hillsides in the recovery of the degraded hillside was best. Therefore, it is simple to conclude that allocating degraded hillside is the preferable and comfortable opportunity to enhance the woody vegetation coverage of degraded hillsides.

Since allocated hillsides are preserved and protected from external disturbance, naturally regenerated seedlings have existed there. From the field measured, it is easy to understand that naturally grown seedlings were available under or mixing with some shrubs mostly at the middle part of the allocated and around the border of non-allocated communal hillsides. Hence, the average potential of natural-appearing seedlings status was 2137 seedlings per hectare in the allocated hillsides, while 1250 seedlings per hectare in the non-allocated communal hillsides. Therefore, the naturally appearing seedlings of allocated and non-allocated hillsides were significantly different.

Generally, this is to conclude that allocating degraded hillsides to youth farmers was a multi-wise opportunity to recover the green opportunity of deforested hillsides.

5.2. Recommendations

The strategy of assigning allocation of degraded hillsides for tree planting is considered as one option to solve the vegetation degradation problems of the study area. This approach can have a positive effect on the environment, social and economic situations in the future. Hence, the following recommendations are presented.

- Even if different types of physical soil and water harvesting structures have been constructed, most of the structures are faced with technical problems. Thus, it is recommended that proper layout should be designed before construction through building the capacity of farmers who participate in the layout of the hillside terraces.
- From the field observation, several seedlings are planted in the study area. Most of the time the planting program occurred through mass mobilization of the local people, as a result, the survival rate is obtained less. It is highly recommended that to have proper planning of pre and post-management activities with a manageable amount of seedlings through matching the labor with the area to be afforested.
- Even though there is an increase in the woody species composition and diversity under-allocated hillsides in the study area, it is recommended that to plant different types of seedlings which fitted multi-purpose might more increase the vegetation cover through avoiding mono planting of *Eucalyptus* species.
- From the field observation and focus group discussion, it is found that allocated hillsides entitled to private have not fully secured for the user-groups by providing a land-tenure controlling system. Users should feel a sense of ownership to invest more in their share. Thus, it is recommended that to avoid such a problem by the provision of a land certificate to ensure the use right of the allocated hillsides.

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APPENDIX: 1. Data Collection Sheet

SAMPLE UNIT CODE……………

(1) **Start date _______ / _ _________ / _ _________ E.C** (2). **End date _ _ ____ /___E.c**

a) <u>Descriptive notes on the field work</u>

A brief summary of the work carried out SU particularities, description of the difficulties encountered during data collection in the SU as well as a strategy used, solutions for problems and recommendations.

a_1) **Organization and site description**(team organization and logistics, access, site description, and particularities – recommendation for the future survey): …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………
a_2). **Field measurements**(terrains, vegetation, measurements, constraints, and particularities): …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… ……………………………………………………………………………
a_3) **Interviews and contacts with the population**(contacts with interviewees, authorities, owners, local guides): …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… ……………………………………………………………………………………………
a_4) **Sample plot present condition (managing situation)** **1) Allocated hillsides:** …………………………………………………………………………………………… …………………………………………………………………………………………… ……………………………………………………………………………… **2) Non-allocated communal hillsides:** …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… ………………………………………………………………………

1. **SWC Activities (20×20M2)**

No	Types of technique	Slope SU	Spacing	Amount	Dimension in "m"			Remark
					length	width	Height (depth)	
a)	**PHYSICALSWC**							
1	Hillside terracing							
2	Hillside + Trench							
3	Stone bund							
4	Stone bund + trench							
b)	**BIOLOGICAL SWC**							
1	Mulching							
3	Counter planting							

2. Level of plantation carried out (20×20m2)

No	Planting year	species	Planted	Count survival	remark
1					
2					
3					
4					
5					

3. Biodiversity and natural regeneration status

3.1. Trees (20m×20m), > 10 cm dbh, > 2m height

SU.Qu.N°	Artificial Tree	Natural Tree	Species name		Dbh	Collar Dbh	Diameter Height	Year(s) since cut	Total height	Bole height	Stem quality	Health		
			Common/local (language)	Scientific								Crown Condition	Overall tree Condition	Causative agents
					cm	cm	m		m	m				

3.2. Shrub and Sapling (5×5m2) 2-10cm dbh &> 2m height for saplings, and less than 1.3 m for shrub

Qu.No	Shrub	Sapling	*Species name*		Dbh	Collar Dbh	Diameter Height	Year(s) since cut	Total height	Bole height	Stem quality	*Health*		
			Common/local (language)	Scientific								Crown Condition	Overall tree Condition	Causative agents[3]
					cm	cm	m		m	m				

3.3.Naturally appearing Seedlings ($2 \times 2m^2$)

SU. Qu.N°	N. regenerated	Species name		Dbh	Collar Dbh	Diameter Height	Year(s) since cut	Total height	Bole height	Stem quality	Health		
		Common/local (language)	Scientific	cm	cm	m		m	m		Live	Dead	Causative agents

Check List for Key Informant → Forest related experts

1. Have you had any hint about privately allocating hillside?

2. What about the communal hill lands?

3. Is there any difference between private and communal hill lands?

4. Have you observed any opportunities and challenges?

What are the success points (stories) and what are the fallers?

5. What activities do you make to achieve the goals?

6. What are the initiating points to allocate hillsides to private?

7. How do we sure the legality and long term ownership of privately allocating hill lands?

8. If the hill lands are for forestry purposes from where do they have (seedling source)?

9. How do you explain the species site matching?

2. Focus Group Discussion Check lists

1. Do you remember when the hillside allocation was started?

2. What challenges do you observe?

3. How do you sure about your land ownership?

4. How many members are allocating per hillsides?

5. Have you had a management plan and who is the decision-maker?

6. What are the tangible feasibilities according to (Ecological, Economic and Sociality)?

7. How do you participate in the construction of some activities (Physical andBiological, Cost of construction and Source of labor)?

APPENDEX: 2. Statusof woodyspeciesof the study site

Appendix:2.1.Species composition

Tree life form	Species	Tikul-Emni		Enda-Anahb		Adefa		Total	
		Ahs	NAhs	Ahs	NAhs	Ahs	NAhs	Ahs	Nah
Trees	*Eucalyptus globules*	11		89				100	
	E. camadulensis					108	1	108	1
	Acacia etbaica					6		6	
	Acacia seyal								
Sub total		11		89		114	1	214	1
Saplings	*Eucalyptus globulus*	68	9	98				166	9
	E. camadulensis					99	25	99	25
	Juniperus procera	5	1			11		16	1
	Acacia seyal	21	7					21	7
	Rhus vulgaris					9	4	9	4
	Olea europaea	4				2	6	6	6
	Acacia etbaica					29	3	29	3
Sub total		98	17	98		150	38	346	55
Shrubs	*Euclea schimperi*	14	5	9	70	177	238	200	313
	Rumex nervosus	10	59	246	375		3	256	437
	Salvia officipalis		31	10	14			10	45
	Withania somnifera	10	14	17		3		30	14
	Becium grandiflorum	12	22	68	99	43	212	123	333
	Calpurnia aurea			31		17		48	
	Carissa edulis					37		37	
	Maytenus senegalensis					23	2	23	2
	Dodonea angustifolia	16				14	4	30	4
Sub total		62	131	381	558	314	459	757	1148
Total		171	148	568	558	578	498	1317	1204

Source: Field survey, 2019

Appendix: 2.2. Shannon-Wiener diversity index of species found under-allocated hillsides

No	Species	Family	Life form	n	P_i	Ln(Pi)	$-1(P_i (ln(P_i)$
1.	*Eucalyptus globulus*	Myrtaceae	Tree	266	0.20	-1.6	0.32
2.	*Rumex nervosus*	Polygonaceae	Shrub	256	0.19	-1.6	0.31
3.	*Euclea schimperi*	Ebenaceae	Shrub	200	0.15	-1.9	0.29
4.	*Eucalyptus camadulensis*	Myrtacea	Tree	207	0.15	-1.8	0.28
5.	*Becium grandiflorum*	Lamiaceae	Shrub	123	0.09	-2.3	0.22
6.	*Calpurnia aurea*	Fabaceae	Shrub	48	0.03	-3.2	0.12
7.	*Carissa edulis*	Apocynaceae	Shrub	37	0.02	-3.5	0.10
8.	*Acacia etbaica*	Fabaceae	Tree	35	0.02	-3.6	0.09
9.	*Dodonea angustifolia*	Sapindaceae	Shrub	30	0.02	-3.8	0.08
10.	*Withania somnifera*	Solanaceae	Shrub	30	0.02	-3.8	0.08
11.	*Maytenus senegalensis*	Celastraceae	Shrub	23	0.01	-4.01	0.07
12.	*Acacia seyal*	Fabaceae	Tree	21	0.02	-4.13	0.06
13.	*Juniperus procera*	Cupressaceae	Tree	16	0.01	-4.42	0.05
14.	*Salvia officipalis*	Lamiaceae	Shrub	10	0.07	-4.82	0.04
15.	*Rhus vulgaris*	Anacardiaceae	Tree	9	0.06	-4.96	0.03
16.	*Olea africana*	Oleaceae	Tree	6	0.005	-5.3	0.02
	Total			1317	1		2.22

Source: Field survey, 2019

Appendix: 2.3.Shannon-Wiener diversity index of species found in the non-allocated hillsides

No	Species	Family	Life form	n	Pi	Ln(Pi)	-1(Pi (ln(Pi)
1.	*Rumex nervosus*	Polygonaceae	Shrub	437	0.36	-1.01	0.37
2.	*Becium grandiflorum*	Lamiaceae	Shrub	333	0.28	-1.28	0.35
3.	*Euclea schimperi*	Ebenaceae	Shrub	313	0.26	-1.34	0.34
4.	*Salvia officipalis*	Lamiaceae	Shrub	45	0.04	-3.2	0.12
5.	*Eucalyptus camadulensis*	Myrtacea	Tree	26	0.02	-3.8	0.08
6.	*Withania somnifera*	Solanaceae	Shrub	14	0.01	-4.4	0.05
7.	*Eucalyptus globulus*	Myrtacea	Tree	9	0.01	-4.9	0.04
8.	*Acacia seyal*	Fabaceae	Tree	7	0.01	-5.1	0.03
9.	*Olea africana*	Oleaceae	Tree	6	0.005	-5.29	0.02
10.	*Dodonea angustifolia*	Sapindaceae	Shrub	4	0.003	-5.7	0.019
11.	*Rhus vulgaris*	Anacardiaceae	Tree	4	0.003	-5.7	0.019
12.	*Acacia etbaica*	Fabaceae	Tree	3	0.002	-5.9	0.015
13.	*Maytenus senegalensis*	Celastraceae	Shrub	2	0.002	-6.4	0.011
14.	*Juniperus procera*	Cupressaceae	Tree	1	0.001	-7.1	0.006
Total				1204	1		1.48

Source: survey result, 2019

Appendix:2.4.Importance value index (IVI) of species under-allocated hillsides

No	Species	Family	Life form	n	RD	RDo	RF	IVI
1.	*Eucalyptus globulus*	Myrtacea	Tree	266	20.2	34	22	76.2
2.	*E. camadulensis*	Myrtacea	Tree	207	15.7	26	21.6	63.3
3.	*Euclea schimperi*	Ebenaceae	Shrub	200	15.2	25	12.2	52.3
4.	*Becium grandiflorum*	Lamiaceae	Shrub	123	9.3	10	9.5	28.8
5.	*Rumex nervosus*	Polygonaceae	Shrub	256	19.4	1.04	6.8	27.2
6.	*Calpurnia aurea*	Fabaceae	Shrub	48	3.6	1.2	2.7	7.5
7.	*Acacia etbaica*	Fabaceae	Tree	35	2.7	0.15	4.1	6.9
8.	*Acacia seyal*	Fabaceae	Sapling	21	1.6	0.02	4.1	5.7
9.	*Carissa edulis*	Apocynaceae	Shrub	37	2.8	0.06	2.7	5.6
10.	*Juniperus procera*	Cupressaceae	Sapling	16	1.2	1.5	2.7	5.4
11.	*Dodonea angustifolia*	Sapindaceae	Shrub	30	2.3	0.03	2.7	5
12.	*Maytenus senegalensis*	Celastraceae	Shrub	23	1.7	0.01	2.7	4.5
13.	*Salvia officinalis*	Lamiaceae	Shrub	10	0.8	0.56	2.7	4
14.	*Withania somnifera*	Anacardiaceae	Shrub	30	2.3	0.04	1.4	3.7
15.	*Rhus vulgaris*	Lamiaceae	Sapling	9	0.7	0.28	1.4	2.3
16.	*Olea africana*	Oleaceae	Sapling	6	0.5	0.11	1.4	1.9
	Total			1317	100	100	100	300

Source: survey result, 2019

Appendix: 2.5. Importance value index (IVI)of speciesin thenon-allocated communal hillsides

No	Species	Family	**Life form**	n	RD	RDo	RF	IVI
1.	*Euclea schimperi*	Ebenaceae	Shrub	313	26	33.8	27	86.8
2.	*Becium grandiflorum*	Lamiaceae	Shrub	333	27.7	12.1	28.4	68.1
3.	*Rumex nervosus*	Polygonaceae	Shrub	437	36.3	14.3	13.5	64.1
4.	*Eucalyptus globulus*	Myrtacea	Tree	9	0.7	30.4	4.1	35.2
5.	*E. camadulensis*	Myrtacea	Tree	26	2.2	2.5	5.4	10.1
6.	*Salvia officinalis*	Lamiaceae	Shrub	45	3.7	1.1	4.1	8.9
7.	*Olea africana*	Oleaceae	Sapling	6	0.5	2.4	2.7	5.6
8.	*Withania somnifera*	Solanaceae	Shrub	14	1.2	0.4	4.1	5.6
9.	*Rhus vulgaris*	Anacardiaceae	Sapling	4	0.3	0.7	2.7	3.7
10.	*Juniperus procera*	Cupressaceae	Sapling	1	0.1	0.5	2.7	3.2
11.	*Acacia etbaica*	Fabaceae	Sapling	3	0.2	1.2	1.4	2.8
12.	*Acacia seyal*	Fabaceae	Sapling	7	0.6	0.3	1.4	2.2
13.	*Dodonea angustifolia*	Sapindaceae	Shrub	4	0.3	0.6	1.4	2.2
14.	*Maytenus senegalensis*	Celastraceae	Shrub	2	0.2	0.4	1.4	1.9
	Total			1204	100	100	100	300

Source: survey result.2019

Appendix:2.6. Naturally regenerated seedlings

Seedling types	Species	Ahs	NAhs	Total	%
Tree seedlings	*Acacia seyal*	29	25	54	25.6
	Acacia etbaica	13	6	19	9
	J.procera	21	2	23	10.9
	Olea europaea	27	18	45	21.3
	Rhus vulgaris	16	1	17	8.1
	Sub total	106	52	158	74.9
Shrub seedlings	*D. angustifolia*	25	13	38	18
	Calpurnia aurea	7	0	7	3.3
	Carissa edulis	8	0	8	3.8
	Sub total	40	13	53	25.1
Total		146	65	211	
%		69.19	30.81		

Source: survey result.2019

APPENDEX: 3. Plates about the Study area

Appendix: 3. 1. Water harvesting pond and Planted seedlingsin Tikul-emni

Appendix: 3.2. Allocated and non-allocated hillsides

Appendix: 3.3. Grass Harvesting, guards and Focus group discussion