EthioTrees

Ecosystem restoration and agroforestry by landless and smallholder farmers in Tigray (North Ethiopia)

Project Design Document

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Executive Summary

Located at the northernmost limit of the African monsoons, the North Ethiopian Highlands are a hotspot of vulnerability to land degradation and climatic changes. As a result of ongoing land degradation, reforestation projects have been widely implemented in Northern Ethiopia, and the effects of integrated catchment management have been well studied. Especially after a large-scale degradation phase around the decade of the 1980s, important efforts were made, such as the creation of *community forest patches* throughout the Highlands. These are areas where livestock and uncontrolled woodcutting are limited, and nowadays, established on a large scale in Northern Ethiopia. Communal cost-benefit evaluation shows potentially highly positive outcomes, as these forest patches store green water, carbon and nutrients, and can deliver non-timber forest products (honey, incense) to the nearby communities. In areas across Ethiopia, a variety of non-timber forest products can bring substantial amounts of cash income to farmer households.

However, the significant potential of non-timber forest production remains largely untapped. To date, in Northern Ethiopia, there is not enough attention to the participatory development of community-wide benefits such as carbon storage, flood reduction and non-timber forest production when establishing community forest patches (often called hizaétis or "exclosures").

This project partners with communities across Central Tigray by helping to restore their community forest patches for supporting socioenvironmental changes: (i) to boost community-driven woodland restoration on large and highly degraded slopes where grazing is limited; (ii) to support agroforestry practices by smallholder farmers; (iii) to store carbon in the supported woodland and agroforestry plots; and (iv) to support ecosystem services development and valorisation that includes increased groundwater availability, fruits, honey production and frankincense production for landless farmers. The community-driven projects help the local communities to implement soil and water conservation, support enrichment planting, apply agroforestry and improved management techniques, bee hives for honey production, and frankincense tapping and sorting materials. EthioTrees works with communities, smallholder farmers and local associations of landless farmers and strives towards 50% female participation in all activities. The initial associations were established in 2016, which forms the baseline year of the project.

EthioTrees has established an extensive monitoring program to quantitatively measure restoration performances in the community forest patches and agroforestry plots. In every forest patch, systematic vegetation surveys in fixed plots are conducted for above-ground biomass estimation. Above-ground biomass in 2016 was mainly derived from bushes or shrubs with diameter < 10 cm but height > 1.3 m.

Soil samples are systematically taken along transects and analysed for soil organic carbon through dichromate oxidation. Average soil thickness in the project forest patches ranged between 12-16 cm and average soil organic carbon content ranged initially between 2.9 and 3.1%.

In parallel, an agroforestry monitoring program has been established to quantify agroforestry tree planting performance. The agroforestry technical specification calculates both baseline and intervention carbon stocks and emissions over time. The estimated net carbon benefits range from 232.5 tCO_2e/ha for boundary planting to 805.8 tCO_2e/ha for high-density homegarden planting.

The project aims to boost soil organic carbon, biomass, biodiversity status, groundwater recharge, and cash income for (landless) farmers.

- Direct estimation of change by re-measurement of identical sample plots (resampling of vegetation and soil data of the same plot locations to the baseline survey) was done from November 2022 to February 2023. Based on the re-measurements and aligning the EthioTrees project with Plan Vivo Module PU001, we estimate the sequestration rates of future expansion sites for the next 5 years using 8.2 tCO2e/ha/yr (including buffer and leakage correction). Note that this rate remains close to (but is more conservative than) the original sequestration rate predicted in the PDD of 2017 (which was 9.2 tCO2 per hectare per year, including buffer and leakage correction).
- Following the vegetation surveys, we use Shannon's diversity index as a robust indicator for biodiversity status in the project areas. Initially, the average diversity index of 1.4 in our project areas testified to the degraded status of the forest patches under baseline conditions. At the first verification round, the improvement of the Shannon index was significant ($p<0.05$).
- Systematic socio-economic surveys are performed to assess the livelihood impact of the project, including the effect on the potential of non-timber forest products as cash income. The landless participants derive significantly less income from sales of agricultural products and sales of livestock as compared to farmers with land. Yet, the cash income derived from non-timber forest products is comparable to the income derived from food aid and sales of crops, and is even higher as compared to the income derived from the sales of livestock and employment wages. This exemplifies the large potential of NTFPs to increase cash income of vulnerable young people without access to land. Overall, the vast majority of the farmers identify the lack of access to drinking water as the main problem for their livelihood. Therefore, many communities use there socioecological reinvestments to work on water accessibility.

<u>Overview</u>

Project Title:	EthioTrees: Ecosystem restoration and agroforestry by landless and smallholder farmers in Tigray, North Ethiopia
Location:	Ethiopia, Tigray
Version:	2.0
Project Coordinator:	Climate Lab
Validator:	Wolde Mekuria (Ph.D.); Researcher in Land Resources Management; P. O. Box 5689, Addis Ababa, Ethiopia
Validation Date:	15 September 2017
Verification:	MUTU International
Verification Date:	October 2023
Project Intervention(s):	Ecosystem Restoration and Agroforestry
Project Participants:	The project started with 950 participating households in 2016 and grew by including a total of 41 600 households by 2025. The project aims for continuous and organic growth, by including more and more interested communities and smallholder farmers in central Tigray.
Project Area:	The project started with 541 hectare undergoing restoration activities in 2016 and grew to include a total of 21 837 hectare by 2025. The project aims for continuous and organic growth, by including more and more community lands and agroforestry plots in central Tigray.
Project Period:	1 February 2016 to 31 January 2066 (possibly to be extended)
Expected Ecosystem Benefit:	The project community forest patches often connect with remnant Orthodox "church forests" to increase biodiversity of woody vegetation. Soil and water conservation measures are implemented and groundwater is replenished. Special attention is given to the unique *Boswellia papyrifera* or Tigrinya incense tree. The agroforestry plots are connected to smallholder farmer plots and help to increase farm productivity and climate resilience.
Expected Livelihood Benefit:	The project supports the production of non-timber forest products such as fruits, honey and frankincense by smallholder farmers and associations of (landless) farmers. Besides, carbon benefits have been used to build water wells, water reservoirs and schools, while delivering food aid during the great famine.

A. Aims and objectives

The overall aim of this project is to improve rural household income for smallholder and landless farmers in different villages in the North Ethiopian Highlands, by supporting woodland restoration, agroforestry and woodland ecosystem services development. The North Ethiopian Highlands have high cattle densities, steep slopes and are located near the northernmost limit of the African Monsoons. Steep erodible slopes are often designated as communal lands where cattle grazing can take place. The Highlands are thus a hotspot for land degradation and are very vulnerable to climatic changes.

Therefore, the main aims of this project are (i) to boost community-driven woodland restoration on large and highly degraded slopes where grazing is limited (or impeded?); (ii) to support agroforestry practices by smallholder farmers; (iii) to store carbon in the supported woodland and agroforestry plots; (iv) to support ecosystem services development that includes increased green water and groundwater availability, non-timber forest products, honey production and frankincense production for (landless) farmers. The project follows the Plan Vivo Standard to guarantee the overall sustainability of the project and to ensure that both project planning and implementation/governance are driven by the local population.

Further, our project interventions should lead to the following specific (quantifiable) project objectives:

(i) Improved local landless and smallholder farmers household income through the sales of non-timber forest products such as fruits, honey and frankincense.
(ii) Expected improved productivity downslope of the forest patches in croplands and agroforestry plots, through increased blue and green water availability, soil moisture and activity of springs.
(iii) A social shift towards stall-feeding, as fodder can be derived from fodder trees and grass taken from the forest patches (cut-and-carry).
(iv) Sequestration of carbon, through increases in above and belowground biomass and soil carbon.
(v) Increased biodiversity and tree cover with decreased sheet erosion rates, less land degradation (desertification) activity and water runoff – which will create resilience against the effects of recurrent droughts.

B. Site Information

The project is located in the Region of Tigray (North Ethiopia), centred around the *woreda* (district) of Dogua and Kola Tembien (Figure B1). Detailed maps of the project sites are presented in annex 8. The current project landscape surface area anno 2025 includes 21 526 ha community forest patches and 311 ha smallholder farmer agroforestry plots. The planimetric area of the initial project zones include: in Adi Lehtsi 412 ha; in Gidmi Gestet 46 ha and in Meam Atali 83 ha. For the surface area calculation report and the methodology applied, we refer to Annex 11.

Table B1: Overview of project sites and sizes anno 2025

Area ID	Real Landscape Surface Area (ha)*	Area ID	Real Landscape Surface Area (ha)*	Area ID	Real Landscape Surface Area (ha)*
Adi Lehtsi	472	*Fereqdre*	111	*Menji Giratmango*	90
Gidme Gestet	51	*Gedmi tsitsewhiey*	55	*Hohole (Gra Atami)*	123
Meam Atali	87	*Gogon-Kojejar*	138	*Lehama (Gorgue)*	90
May Getnet	54	*Gra emba araya*	107	*Mekno*	71
May Hibo	58	*Hzaeti B'eray (HzBr)*	314	*Menji Moro*	137
Afedena	84	*Jira*	130	*laelay kurkura*	185
Adilal	153	*Kbret*	190	*Kalay Sfra*	124
Gemgema	105	*Maekeldur*	165	*Tsehay Zerei*	92
Zban Dake	333	*May agualat-Enderta*	238	*Humer*	68
May Baeti	51	*Mhdar Abuer*	129	*Guma Amaru*	119
Lafa	48	*Mierafchege*	366	*Adishm Tnsae*	419
Daero Hidag	118	*Miska*	95	*Adi Agobay*	198
Togul	37	*Quaya*	294	*Adikurtuman*	57
Sesemat	48	*Sequrti*	391	*Adichomo*	530
Adi Meles	70	*Shegalu*	129	*Koyetsa*	71
Chele Quot	55	*Shegere*	55	*adi shihak*	313

Katna Ruba	47	*Sito*	234	*Gra jumut*	93
Gojam Sefra	293	*Wetlaqo*	69	*Mftah korecha*	123
Debremed hanit	755	*Wukro and gdmi awuhi*	196	*Endamedhanialem*	55
Hawahiwa	214	*Zaka*	281	*Moranfo*	109
Dawsira	1414	*Kurara*	49	*Gonou*	198
Adienkrti (AdEn)	486	*Werasige*	284	*Beherawi*	101
Adikilte (AdKl)	188	*Busha*	85	*Jerquawe*	484
Akeb hidmo (AkHd)	45	*Tsiwtsiwa*	91	*Gorgoro*	206
Ba'ati Haile (BtHl)	176	*Farqua*	98	*Embay kome*	129
Barajira (Brjr)	178	*Wedigets*	81	*Beati geretsahmo*	332
Chemate	96	*Endahibye*	209	*Mewlad agam*	97
Chike	455	*Alogen*	244	*Tsgaba*	253
Daengule	146	*Betmarya*	299	*Adi mereta*	118
Daerotimqet	103	*Endabanow*	49	*mayta muz*	139
Da'kakwey	69	*Sekela Koyetsa*	333	*Beati nebri*	59
Dakuakuat	140	*Seqere*	106	*Flika*	54
Dastenay	97	*Tata*	118	*Tsariya*	95
Da'tsehagat	231	*Abaqo*	196	*Tiemti wushita*	68
Deguagush	180	*Adi Degol*	206	*Gulcheda*	102
Emba	57	*Rubalemin*	642	*filfle*	105
Emba newi	156	*Debre Ango*	99	*Dramba/endagebeta*	292
Emure	328	*Endemariam*	68	*may korabit*	229
Endahibey	158	*Endatahses*	75	*May Bhri*	205
Endalibanos	75	*Mshig*	77	*Agroforestry*	311
Endanebrey	61	*Gdmi Segenet*	119	***TOTAL***	**21837**

*Since the project areas are located on steep slopes in the Tembien Highlands, it is more accurate to use the landscape surface area for calculating the area "Extent of the project area" (PU001), see annex 11 for details.

Short description of the tree initial project sites:

On a large limestone plateau in the dryland area between the rivers Geba and May Zegzeg, the village of

Adi Lehtsi is located. The local association of landless farmers is active in the tapping and sorting of frankincense. Frankincense trees are present in a poorly vegetated shrubland that covers nearly the entire escarpment towards Geba river. In this dry region with shallow soils, the incense variety *Boswellia papyrifera* can be found. The community forest patch was established in the shrubland in 2016.

Another example is the degraded community forest patch of Gidmi Gestet, located between an upslope part of the village and a hamlet more downslope. The area has quite steep and rocky limestone slopes, and the bushland vegetation is poor in biomass and biodiversity. At the project initiation, olive trees are still very scarce in this area. Cattle have been excluded in the area 11 years ago, but the association for community forest management was only established in 2016. Field observations before the start of the project indicated that cattle were still regularly entering the area.

The degraded community forest patch of Meam Atali is located on a gentle slope just down of the village named Togoga. Here, cattle have been excluded 8 years ago, but the association for community forest management was only established in 2016. The climatic conditions are very suitable to produce the Tigray 'white honey' for the local market.

Figure B1: General map of Ethiopia and Region of Tigray and indication of the woredas of Dogua and Kola Tembien (source: IP, 2016; Ethiopian Demography and Health, 2016).

Topographic and geological features

The tabular geomorphology of the project area is strongly influenced by the subhorizontal morphostructure of the layers. The project area basically consists of Mesozoic sedimentary Antalo limestone, where alternating hard and softer layers lead to a stepped topography. On top of the sedimentary rocks, subhorizontal Cenozoic basalt lavas are present further upslope. Soils can be classified as Vertisols, Vertic Cambisols, Cumulic Regosols, Calcaric Regosols and Phaeozems (Vanmaercke et al., 2010). In the low-lying limestone areas of Tembien (i.e. where *Boswellia papyrifera* is occurring), most soils are Leptosols and Regosols, even though the spatial soil pattern is very complex.

Biodiversity

Common indigenous tree species with high abundance in the project area are *Acacia, Olea, Celtis* and *Cordia*. *Juniperus procera* is rather rare. *Boswellia papyrifera* can be found in the community forests at low altitude (on the flanks of the deeply-incised river valley of the Geba) where all livestock grazing is banned. *Dodonea* and *Asteraceae* are common in recently established community forest patches (Reubens et al., 2009). Community forests attract a great variety of (large) wild mammals including hyenas (Mastewal Yami et al., 2010), and a high number of colourful bird species (Aerts et al., 2009).

Figure B2: *Boswellia papyrifera* at the Adi Lehtsi site.

Climate information

Monsoonal precipitation occurs from June until September in the form of intense rainstorms. Annual precipitation increases from north to south in the Tigray Highlands, ranging between 500 and 900 mm yr−1 (Jacob et al., 2013). Inter-annual rainfall variability is equally important, as Nyssen et al. (2005) showed yearly rainfall depths in the study area range between 546 mm in 2002 to 879 mm in 1998 in the nearby town of Hagere Selam.

Recent changes in land use and environment conditions

Forest cover in the Northern Ethiopian Highlands is very limited, with remote sensing studies estimating current forest cover at 0.88 – 1.9 % in Tigray (excluding Eucalyptus plantations) (Kassa Teka Belay et al., 2014; de Mûelenaere et al., 2014). Pollen analysis shows that deforestation in the Northen Ethiopian Highlands is a 'cyclic' process over time, activated by long-term climatic dry spells and during periods of social and political instability. For instance, there have been periods of significant deforestation around 3500 years ago, 1500 years ago, 300 years ago and 30 years ago during phases of drought and social conflict (Lanckriet, 2016). Yet, paleo-environmental analysis also shows that deforestation is not irreversible. Localized land resilience happened before – for instance during the Axumite era, during the 17th century or even more recently. This suggests that the dryland mountains of Northern Ethiopia can be robust and elastic for fast recovery, under conditions of appropriate management (Lanckriet, 2016). Their recent but strong growth is a very encouraging and promising development.

Croplands are commonly cultivated with wheat (*Triticum spp.*), barley (*Hordeum vulgare*), *hanfez*, which is wheat and barley sown together, and the endemic *Eragrostis tef*, and are ploughed with the local ard plough or mahresha. Since the 1990s, important conservation efforts (check dams, stone bunds, community forest patches, reforestation) were made and agricultural intensification was enhanced (e.g. improved crop varieties, chemical fertilizers). Still, overgrazing of rangeland is a specific problem in the Highlands, as current stocking rates are well in excess of estimated optimum stocking rates and cattle is often allowed to graze on the croplands during the dry season and on steeper slopes during the wet season (Nyssen et al., 2004a).

Drivers of degradation and loss of habitats

In the North Ethiopian Highlands, the interplays between climatic vulnerability and forest cover changes caused declining water availability (Nyssen et al., 2004a), as woody vegetation cover changes can induce vulnerability to droughts (Frankl et al., 2011). Consequently, water and land productivity in Northern Ethiopia is partly linked to land cover changes and droughts, while crop production is under considerable strain from water deficiencies. Indeed, green water availability is the key-element of agricultural productivity in this region because agriculture is characterized by a low marginal product of labour and limited productivity impact of inputs such as fertilizers (Pender & Gebremedhin, 2008). Considering the situation of the late 20th century, Nyssen et al. (2004b) wrote in this perspective: 'Soil erosion not only affects soil depth but leads in addition to rapid siltation of reservoirs. Nutrients are lost due to use of cattle dung as fuel, lack of manuring, and soil erosion. Gullying leads to rapid lowering of ground water tables.' According to these authors, land degradation in the Eritrean and Ethiopian Highlands is strong and clearly connected to the geomorphic processes that are impacted by land cover changes: sheet and rill erosion, and gullying. Furthermore, multi-model ensembles project increased (year-to-year) hydroclimatic variability in Ethiopia by the end of this century (McSweeney et al., 2010).

For a description of the ecological baseline scenario as impacted by the Tigray War, we refer the reader to the Techspec Agroforestry.

C. Community and Livelihoods Information

Participating communities and socio-economic context

According to the 2007 census, the woreda of Dogua Tembien counted 113,595 people (56,955 men; 56,640 women; including 25,290 households and 7,270 people living in urban areas). Population density was 61.31 persons per km^2. Around 15% of the households had access to safe drinking water. More than 90% of the population lives from (subsistence) agriculture, and farmers' crop yields range from 500 to 1500 kg ha^{-1} (Naudts, 2002). The very vast majority of all inhabitants (over 98%) is Tigrayan, follows Ethiopian Orthodox Christianity and speaks Tigrinya as first language.

The project works closely with rural households near young community forest patches in different villages in Tembien (initially: Togoga, Gidmi Gestet, Adi Lehtsi). During the first phase of the project activities, awareness, acceptance and participation of these rural communities in the project were assessed and ensured by the local coordinator.

At several community forest patches, the project also engages landless farmers of different gender and age. A landless farmer represents a household without valid land certificate. These landless farmers are often relatively young (20-40 years old) and organized in associations. The associations elect a representative through a democratic election. The members of the association are 'under rotation' responsible to manage a part of the community forest (including the patrolling process and the daily management) and are able to benefit from ecosystem services from the forest patches. Ecosystem services include honey production, frankincense production, and grasses for stall-feeding. EthioTrees provides free training on the optimal and sustainable use of these ecosystem services. When there is no association present (yet), the project engages directly with the community (*bayto*).

Participating smallholder households in these communities are also encouraged to implement agroforestry practices, as of 2023. Local nurseries of the EthioTrees project provide native and naturalized tree seedlings and technical support for implementing agroforestry activities in homegardens, boundary planting or woodlots (see Part G2). Supporting smallholder agroforestry is important to strengthen food security, vitamin intake, microclimate amelioration, income generation and environmental protection. The project initially engaged with 118 smallholder households and 1 association to engage in agroforestry. After the first year, the project will expand the agroforestry activities in the region.

A more detailed socio-economic baseline profile of the participating communities is presented below through the results of the socio-economic survey.

Based on the interviews in 2016 (see Part K), we can explore the socio-economic baseline conditions. An average household counts 4.8 people, and the head of the family is on average 37.6 years old. All of the interviewees are Orthodox and 96% of the households own livestock, mainly including oxen, cows, calves, goats, donkeys and chicken. At current market prices, the livestock assets per household represent on average 17,230 ETB (21,340 ETB in Meam Atali; 13,437 ETB in Adi Lehtsi). The main sources of livelihood for all the households are crop farming, honey production, frankincense production and livestock production.

The interviewees mention a number of capital assets, including radios, beds, barrels, mobile phones, watches, jerikans, motors, farm tools (i.e. mareshas, hoes, spades, sickles, medoshas, axes, saws), traditional beehives, and modern beehives. Based on current market prices, the value of these capital assets represents on average 5,993 ETB (10,386 ETB in Meam Ali; 1,938 ETB in Adi Lehtsi). The bulk of the capital assets in Meam Ali are composed of modern beehives.

Household yearly income is derived from the sales of agricultural products, employment wages, revenues from the sales of livestock, revenues from sales of honey and gum, and revenue from aid. Sales of agricultural products include the spice *gesho*, bananas (in Adi Lehtsi), pepper, wheat, barley and teff.

Sales from agricultural products deliver an average yearly household income of 829 ETB per household. This is 2,733 ETB for the farmers with land and only 228 ETB for landless farmers.
Revenues from wages deliver an average yearly household income of 1,256 ETB per household with land and 1,653 ETB for the landless farmers, who may occasionally have off-season jobs in town.

Revenues from the sales of livestock deliver an average yearly household income of 970 ETB per household. This is 1,100 ETB for the farmers with land and 929 ETB for the landless farmers. Revenues from the sales of non-timber forest products deliver an average yearly household income of 1,909 ETB per household. This is 400 ETB for the farmers with land and 2386 ETB for landless farmers. Yearly revenues from aid are on average 2774 ETB. Surprisingly, farmers with land receive significantly more aid as compared to farmers without land (4038 ETB versus 2374 ETB).

As the association in Meam Atali was only established in 2016, only 3.6 kg of honey were produced per household per year (average of the 2016 data). In Adi Lehtsi, on average 200 kg of frankincense were produced per tapping household per year (2016 data). Sales prices in 2016 were on average 210 ETB per kg of honey, and 28 ETB per kg of frankincense.

Most of the farmers mention lack of training and drought as the biggest problems of honey and frankincense production. Free grazing, erosion and lack of time to tap are also mentioned several times. Nearly all the interviewees mention a shortage of (drinking) water as the biggest problem for their village, followed by access to a road, electricity, a clinic and a market.

Overall, the landless participants derive significantly less income ($p < 0.05$) from aid and sales of agricultural products as compared to the control group. The landless farmers derive more income from employment wages and from the sales of non-timber forest products.
The cash income derived from non-timber forest products is comparable to the income derived from sales of crops and aid, and is even higher as compared to the income derived from the sales of livestock and employment wages. Overall, this exemplifies the large potential of NTFPs to increase cash income of vulnerable young people without access to land.

For a description of the socioeconomic baseline scenario as impacted by the Tigray War, we refer the reader to Part G2.

Land tenure & ownership of carbon rights

The Northern Ethiopian Highland is home to an old agrarian society (sensu Roberts, 1997). In Northern Ethiopia, before the late 19th century, the agro-system was organised in an unequal feudal way (locally named gult-system, or later rist-system) (Ståhl, 1974). Local noblemen, such as *dedjazmach*, owned most of the lands (Bruce, 1976), and these lands were often leased in a sharecropping system, locally named mwufar (Segers et al., 2010). After the end of the feudal era in 1974, the military regime or DERG (1974 - 1991) tried to implement a land reform (an overall nationalization of farmlands with strong state control of the farms) which succeeded only partially in the project area (Naudts, 2002). After the end of the military regime in 1991, the Tigray People's Liberation Front (TPLF) initiated another land redistribution, where all households received about three farm plots (in total about 1 ha per household). However, croplands are still often lent out in the mwufar sharecropping system, consisting of a temporary transfer (normally for the duration of one agricultural season) of the use rights of a plot of land in exchange for a share of the grain harvest (Segers et al., 2010). Yet, to date, the feudal land system is in practice abolished and the post-1991 system leaves a dominant fingerprint on the landscape. Under the new constitution, ownership of all land and all natural resources in Ethiopia became 'monopolized' by the Federal State, while farmers received usufruct rights of the croplands, formalized by a land certificate (Crewett et al., 2008).

Most farmers and associations have access to (communal) land certificates to substantiate these usufruct rights. Nevertheless, farmers or associations can lose their land usufruct rights if they move out, or if they strongly neglect the land. Meanwhile, there are a lot of youngsters without access to lands. To date, the responsibility of land reform is decentralized to the Regional Government of Tigray even though no large reforms are planned over the foreseeable future. Common access rights are granted for grazing lands, wastelands, forests and community forest patches (typically lands on sloping terrains of more than 100 hectares) to the communities. In practice, these lands are directly controlled by the tabia (sub-district) administration and are managed on a daily basis by community members or associations of landless farmers. In our project, we agreed on a Memorandum of Understanding between (i) the organisation and project structure; (ii) the councils of the 'woreda', the 'tabia' (sub-district) and the 'kushet' (municipality); and (iii) all members of the associations.

Unlike the land, sequestered carbon rights are not property of the state, but can as "fruits of the land" be considered as private property under usufruct right (see Humbo Assisted Natural Regeneration Project; UNFCCC, 2016).

Table C1: Land and Carbon Rights

Project Area	Ownership and user rights status	Carbon rights	Evidence
Community forest patches	Under the constitution, all land and all natural resources in Ethiopia are owned by the State, while people can receive usufruct/access rights. Common usufruct/access rights are granted for grazing lands, wastelands, forests and hizaétis (typically lands on sloping terrains) to the communities. In practice, these lands are controlled by the tabia administration and often managed on a daily basis by associations of landless farmers. We refer to the Tigray Land Proclamation of 2006.	Unlike the land itself, sequestered carbon rights are not property of the State, but can as "fruits of the land" be considered as property under usufruct right.	Tabia bylaws and Tigray Land Procla-mation 2006
Agroforestry on smallholder plots	Land tenured by individual smallholder farmers	As the land is tenured by individual smallholders, so are the carbon rights derived from this land.	Property rights (farmer land title deeds)
Agroforestry on association plots	Land tenured by associations of farmers		Property rights (association

			land title deeds)

D. Project Interventions & Activities

Project interventions

The project developed a holistic landscape approach for socioenvironmental regeneration in Tigray. The approach integrates ecosystem restoration of steep upslope community lands (hizaéti) with downslope agroforestry plots in smallholder homegardens, plot boundaries or woodlots. The approach implements the following specific interventions and activities over the duration of the total project period:

- Assisting the communities and associations of landless farmers in the project area to establish and manage hizaéti on highly degraded wastelands. Hizaéti are naturally regenerated areas from which livestock and uncontrolled woodcutting are limited. During the first phase of this activity, awareness, acceptance, and participation of target communities in the project is assessed and ensured by the local coordinator through qualitative interviews; and free training on improved hizaéti management is provided.

- Supporting agroforestry practices by smallholder farmers through distribution of tree seedlings and dissemination of agroforestry management techniques. Establishing local nurseries with fruit, fodder and other useful tree species for agroforestry practices.

- Coordinating and supporting the communities and associations of (landless) farmers in maintaining the hizaéti, including implementing soil and water conservation activities and planting additional trees to further support the natural regeneration. The project assists the natural regeneration of the indigenous vegetation, partly through improved management and partly through enrichment planting activities. Enrichment planting to further support the forestation activity and to support biodiversity improvements focusses on indigenous vegetation (*Olea, Juniperus, Dodonea, Cordia, Celtis, Acacia*); Eucalyptus will not be planted in the project area. The project implements soil and water conservation activities, including stone bunds, soil bunds, percolation ponds and 'half moons' to trap runoff water. The project continuously monitors biodiversity, including both plants and trees as well as animals (mammals and birds) (see further).

- Complying with the Plan Vivo Standard to guarantee the overall sustainability of the project. The project analyses baseline conditions in soil carbon and biomass carbon, and monitors soil and biomass carbon content in the project zones, along with monitoring of socio-economic conditions and biodiversity.

Project activities for each intervention

Table D2 – Description of activities				
Intervention type	**Project Activity**	**Description**	**Target group**	**Eligible for PV accreditation**
Ecosystem restoration	Implement soil and water conservation	Install 'soft' soil and water conservation structures, such as percolation ponds, soil bunds and 'half moons', to trap water and sediment	Community group and hizaéti associations	Yes
	Enrichment planting	Plant additional seedlings derived from local nurseries to further boost ecosystem restoration		Yes
	Support improved management techniques	Provide support through free training on hizaéti management, soil and water conservation, and sustainable and honey frankincense production		Yes
Agroforestry	Establish agroforestry nurseries	Nurturing and planting of fruit trees, cash trees, trees for selective harvesting, etc.	Individual smallholders or groups smallholder famers	Yes
	Planting in woodlots, plot boundaries and homegardens			
● Note that for each intervention eligible for PV certification, a technical specification is included in Part G. Several project activities may contribute to a single project intervention.				

Effects of activities on biodiversity and the environment

Biodiversity in the project zones (flora and fauna) will be increased, in both a direct as an indirect way. Floral biodiversity will be directly improved through the (enrichment) planting of native tree seedlings. Although tree planting is only part of a broader strategy to improve environmental resilience (i.e. also including soil and water conservation and improved hizaéti and agroforestry management). Seedlings will be planted in the agroforestry plots and in the hizaéti to strengthen and assist the natural regeneration. In collaboration with the participating communities, a seedling mix of *Acacia, Olea, Celtis, Cordia,* and *Dodonea* is applied in the Hizaéti. Whereas, permanent multi-purpose trees are planted in homegardens, boundary planting and woodlots (e.g. *Faidherbia albida, Balanites aegyptiaca, Dovyalis abyssinica, Acacia species, etc.*)

Further, because of the effects on the soil performance (i.e. increased soil water, soil carbon and soil nutrient availability and decreased erosion rates), natural regeneration further boosts floral diversity. Downslope of the project activities, we expect an increase of the groundwater table and spring activity. Besides, because of the incentives provided to the local communities in terms of payments for ecosystem services and non-timber forest production, further dissemination of similar activities to surrounding communities is expected.

As a result, a small but significant increase of faunal biodiversity is expected. As will be explained further, we use Shannon's diversity index as a robust indicator for biodiversity status in the project areas.

E. Community participation

Participatory project design

Participation and acceptance by the local population and (landless) farmer groups are key to the successful management of the project. During the very first phase of the project activity, tabia meetings and several community meetings are organised. These *baytos*, or people's councils, are based on communal collective participation and consensus building through a group discussion. During the first community meetings, the basic project logic is explained and potential interest of the community is discussed, as well as the initial feedback.

If an association is present in the project area, the association representatives are invited as well and/or a separate meeting is organised with the association. As stated above, associations consist of landless farmers who will benefit from non-timber forest production. These elect a representative, a vice-representative and a financial controller through a democratic election. The members of the association manage parts of the hizaéti and the non-timber forest production. They are all landless (often younger) farmers and are thus socially very vulnerable. In Ethiopia, an association is an independent legal entity. Thus, any profit that may be derived from non-timber forest production is equally shared among all members, regardless of the position within the association, age, gender, or the work that was performed.

Participation of women in the associations is actively encouraged, by striving towards 50% female participation. For instance, in the frankincense association of Adi Lehtsi, the female participants are responsible for frankincense sorting and grading while the male participants are involved in tapping and hizaéti management. Overall, gender participation is evidenced by a female participation grade in the participating associations of well over 40%.

Nevertheless, no fixed quotas or legal obligations are given. Women participation is further stimulated by inviting women to all meetings. If desired, separate meetings can be organized. Agroforestry practices are generally organised at household level (mixed male and female). Note, however, that non-timber forest products are often sold by women on the farmer market, strengthening the cash position.

Table E.1: Stakeholder Analysis

Stakeholder Group	Stakeholder Type	Impact	Influence	Engagement
Participating communities	Local stakeholder	Highly positively impacted by the project	High positive influence on the project	Involvement through project agreements, community meetings, trainings, benefit sharing
Smallholder farmers	Local stakeholder	Highly positively impacted by the project	High positive influence on the project	Involvement through project agreements, association meetings, trainings, benefit sharing
Frankincense associations of landless farmers (e.g. 4 associations by 2023)	Local stakeholder	Highly positively impacted by the project	High positive influence on the project	Involvement through project agreements, association meetings, trainings, benefit sharing
Low-level government levels (kushet, tabia, woreda)	Secondary stakeholder	Moderately positively impacted by the project	Moderate positive influence on the project	Involvement through cooperation agreements
High-level government levels	Secondary stakeholder	Negligible impact by the project	Limited impact on the project	Involvement through legal framework

Community-led implementation

All participating members of the communities, associations or smallholder farmers are trained in the Plan Vivo methodology by EthioTrees members, and are thereafter invited to establish 'plan vivos' of their area. The sessions include training on the participatory mapping procedure, but also ensure that the farmers or the communities have a good understanding of the PES agreement, the basic concepts of climate and carbon benefits and offsetting, and climate benefit estimation. If applicable, monitoring responsibilities are discussed, and it is explained that PES may depend on the success of project interventions/sales of the project.

During the establishment of 'plan vivos', members of EthioTrees are present and provide logistical support (paper, pens) but they do not steer the 'plan vivo' development. The community group or smallholder farmer should have full freedom to add any element they prefer on the ‘plan vivos’. The participants develop a map of the present situation, and a map of the desired situation. Maps are developed in the local language and in the local alphabet. After mapping, the local coordinator assesses the cartographic quality of the plan vivos (correct area delimitation, legend) and possibly invites the participating members to make cartographic corrections.

For every site, plan vivo maps were designed during such meetings. Thus, these plan vivos are handwritten spatial land management plans, voluntarily produced and owned by the community or community sub-group or smallholder farmer, which form the basis of a project agreement. This voluntary and participatory mapping/planning process addressed the following local socio-ecological needs and priorities:

- Local livelihood needs and opportunities to improve or diversify livelihoods and incomes
- Reduce pressure on the ecosystem by introducing zonal planning (plan vivo mapping)
- Land availability and land tenure
- Food security
- Practical and resource implications for participation of women
- Application of honey or frankincense production
- Opportunities to enhance biodiversity through planting native species

The plan vivos are stored in the office of EthioTrees, and scans are stored on a separate EthioTrees drive. Examples are presented in Annex 5.

Community-level project governance

After ‘plan vivos’ are established, EthioTrees organizes trainings on agroforestry management and on optimal hizaéti management (guarding process, enrichment planting of trees, soil and water conservation, honey production, frankincense cultivation, limited timber production, grasses for livestock feeding in stable). Regular discussion sessions, training session and workshops are organized together with the local supervisor, the local authorities and EthioTrees Ethiopia. During all activities and meetings, additional measures can be taken into account to ensure a democratic project design. For instance, the project interventions should be agreed on by the *tabia* and *kushet* council, all members of the hizaéti association and all neighbours. Moreover, the hizaéti can only be located on previously degraded rangelands or wastelands and not on previous croplands or important grazing lands. Livestock feeding can be partly derived from biomass (grasses) from the hizaéti. Eventually, the different associations are practically committed to the on-ground governance of implementation activities: EthioTrees provides a supporting role.

The basis for the long-term engagement is the bayto (community council). During these baytos, the activities are discussed and evaluated. The use of the shared plan vivo benefits is also discussed and decided, and the needs of farmers within the wider community are also considered (e.g. neighbours, teachers).

Figure E1: Meeting and training session at the site Meam Atali (village of Togoga).

Complaints and suggestions that are raised during community meetings or walks around the project areas are recorded by the project coordinator in a “complaints and suggestions logbook”. The logbook is regularly updated and scans are sent to Climate Lab Belgium. Where possible, remediating actions – following complaints and suggestions – are taken. The project coordinator is responsible to organise consultation rounds (if required with the bayto - village council) and remediation actions. We refer to the PES agreement for actions in case of dispute.

F. Ecosystem Services & Other Project Benefits

Carbon benefits

Table F1 summarises the carbon benefits per ha for each intervention over the project crediting period. For a detailed description of the methodology and estimation procedure, we refer the reader to Part G.

	Table F1 – Carbon benefits (Note 1)					
	0	1	2	3	4	0.9 x [2-(0+1+3)]
Intervention type (technical specification)	**Current carbon stock (t CO2e / ha)**	**Baseline carbon uptake / emissions i.e. without project (t CO_2e/ha)**	**Carbon uptake/emissions reductions with project (t CO_2e/ha)**	**Expected losses from leakage (t CO_2e/ha)**	**Deduction of risk buffer (t CO_2e/ha)**	**Net carbon benefit (t CO_2e/ha)**
Hizaéti restoration (2017 calculation)	172.8 (Note 1)	0.0 (Note 2)	-376.2 (Note 3)	2%	10%	182.8
Restoration (2023 calculation)	172.8	0	-359	2%	10%	164.2
Agroforestry: boundary planting	1.9	43.4	-214.9	0	-25.8 (10%)	**232.5**
Agroforestry: Low-density homegarden	1.9	38.2	-472.4	0	-51.1 (10%)	**459.5**
Agroforestry: High-density homegarden	1.9	38.2	-857.1	0	-89.5 (10%)	**805.8**
Agroforestry: woodlot	1.9	38.2	-812.2	0	-85.0 (10%)	**765.4**
Agroforestry: Homestead intercropping	See footnote below Table G2.7			0	10%	**134.6**
	<u>Notes</u> Note that the underlying calculations in this table come from the technical specifications described in Part G1 (Restoration) and G2 (Agroforestry). Also note that the "Hizaéti restoration (2017 calculation)" is no longer operational, having been replaced by the "Restoration (2023 calculation)"					

Livelihoods benefits

Table F2 describes how the project will positively affect different livelihoods aspects of the participating groups. The project will positively affect food and agricultural production, financial assets and incomes, environmental services (water, soil, etc.), (limited) timber products and non-timber forest products, land and tenure security, use-rights to natural resources and social and cultural assets. The effect on energy production is most probably negligible (Table F2).

Table F2 – Livelihoods benefits				
Food and agricultural production	Improved green water availability	Improved fruit tree production	Improved honey production	Improved cash crop production
Financial assets and incomes	Improved income from incense sales	Improved income from honey production	Improved income from fruit and vegetable production	Improved agricultural production through increased green water
Environ-mental services (water, soil, etc.)	Improved ground-water recharge	Prevent soil loss and erosion	Carbon storage	Improved biodiversity and biomass
Energy	Improved availability of firewood	-	-	-
Timber & non-timber forest products (incl. forest food)	Fruit trees	Incense and honey production	Cut-and-carry of grasses	Fodder and wood availability
Land & tenure security	Working with smallholder (landless) farmers	Bylaws are voted by the village council	Monitoring by community guards or association members	Protection of community land from encroachment by individuals
Use-rights to natural resources	Associations receive use rights (incense and honey)	Communities can use grasses through cut-and-carry	Free use of improved springs	Individual rights for fruits and branches
Social and cultural assets	Empowering (landless, often young) farmers	Providing local jobs	Stimulating gender equity	Bottom-up approach to spatial land planning

Nevertheless, some livelihoods aspects may be negatively affected. Therefore, the project will implement mitigation measures to address these issues:

- Following the reforestation, there may be a *reduction of the area of grazing lands*. Therefore, fodder trees could be planted in the agroforestry system. Moreover, a *cut-and-carry system* should allow fodder to be derived from the hizaéti. Since hizaéti have a higher biomass production as compared to grasslands, it is possible that there will be a net positive effect on fodder availability.

- There may be a *geographic division of project benefits*, as croplands downslope will benefit from the improved green water availability, but upslope croplands will not. Therefore, as shown by the plan vivos (Annex 5), the communities are planning to install *percolation ponds* upslope of the hizaéti. This will locally benefit water availability for the upslope communities. Overall, we expect a net gain in (ground)water availability, also for the upslope communities. For instance, in the village of Adi Lehtsi, the walking distance to drinking water during the driest months of the year (i.e. downslope to the Geba river) is at least 4 hours. Establishing ponds will thus greatly benefit this upslope community.

Ecosystem & biodiversity benefits

We completed Table F3 to describe the ecosystem impacts of each project intervention. EthioTrees is confident that the trainings, the soil and water conservation investments (including percolation ponds) and the enrichment planting will positively affect biodiversity, water availability, soil productivity, survival rates of seedlings, availability of P and N and carbon storage (Table F3). There are no potential negative impacts from the project activities on ecosystems and biodiversity.

Table F3 – Ecosystem impacts				
Intervention type (technical specification)	**Biodiversity impacts**	**Water/ watershed impacts**	**Soil productivity/ conservation impacts**	**Other impacts**
Organized trainings	Showing the importance of a biodiverse (agro)forest for honey productivity, shade, soils and grass	Technical help on establishing percolation ponds and reservoirs	Technical help on soil and water conservation	Increased survival rate of seedlings
Agroforestry	Direct impact of planting endemic and naturalized fruit and fodder tree species, to be monitored via Shannon index	More soil moisture through more rainfall interception	Increased availability of P and N nutrients	Carbon storage (see part G)
Soil and water conservation, including percolation ponds	Increase of species diversity (e.g. *Olea*) through improved green water and soil organic carbon	Direct increase of the groundwater table	More soil moisture and soil organic carbon, also in the surrounding croplands, increased availability of P and N nutrients	Carbon storage
Enrichment	Direct impact of	Decreased runoff	Accumulation of	Carbon storage

planting of seedlings	planting endemic species	and long-term groundwater recharge through more rainfall interception	organic matter derived from falling leaves	(see Part G)

G1: Technical Specifications Restoration

The methodology used to estimate baseline carbon stocks in Part G are explained in Part §K.

Project intervention and activities

In line with the applicability conditions of Plan Vivo for ecosystem restoration projects, the project interventions and activities include:

- Implementation of soil and water conservation, including percolation ponds
- Enrichment planting
- Training and support for improved management restoration techniques
- Support for frankincense harvesting and trading and for bee hives.

All the project activities and inputs for the interventions are designed to be applicable to local biophysical conditions.

In the following, the restoration calculations are listed for the initial project areas. For the calculations of the areas included between 2017 and 2023, and for the resampling results, we refer to Appendix 11.

Table G1.1 – Link with local biophysical conditions

Project activities	**Inputs for the interventions**	**Link with local biophysical conditions**
Organized trainings	EthioTrees afforestation, agroforestry and ecosystem experts provide trainings	The EthioTrees project has - years of experience in natural resource activities and trainings in Tigray .
Soil and water conservation (SWC), including percolation ponds	Providing material and technical expertise, organizing labour	Stone bunds are traditionally used since Axumite times. Together with Mekelle University, a significant amount of SWC optimization techniques have been established adjusted to local conditions.
Enrichment planting of seedlings	Providing seedlings and technical expertise, organizing labour	Endemic species and optimal planting techniques are adjusted to local conditions.

Below we present a summary of the project interventions and activities that need to be carried out to achieve the expected impact indicators with details of magnitude of the activities necessary to achieve those impacts. This is presented in a “logframe” to make it clear that project activities, if executed as planned, are sufficient to achieve the expected impacts. After verification in year 5, the impact indicators can be assessed or revised accordingly.

Additionality and Environmental Integrity

EthioTrees project interventions should exceed current laws and regulations for forest and land management. For instance, current bylaws in most of the villages in Tigray prohibit the access of cattle in hizaéti. Commonly, this is implemented by positioning guards near hizaéti. Natural regeneration is thus dependent on the skills and awareness of the different guards. In the EthioTrees projects, we will move beyond this system by assisting natural regeneration and training of the guards and other association members.

This project is not the product of a legislative decree, or a commercial land-use initiative likely to have been economically viable in its own right. Rather, EthioTrees provides the practical training, technical support, and incentives to develop ecosystem restoration and agroforestry activities. We refer to the economic valuation of Tigrayan exclosures by Mekuria et al. (Annex 9), clearly demonstrating the significant investment barriers for exclosure development without access to carbon credits: only if all benefits are taken into account and financially rewarded [by including carbon revenue], exclosures are competitive to alternatives land uses.
Below we add a table with the most important barriers to project development, including the additionality under the combined EthioTrees – Plan Vivo effort (Table G1.3).

Table G1.3: Additionality of the combined EthioTrees – Plan Vivo effort.

Barrier	Baseline scenario	Additionality of the combined EthioTrees – Plan Vivo effort
Financial	- Limited funds - Other priorities - Limited private credit availabilities	Start-up capital secured by EthioTrees; payment for ecosystems scheme supported by Plan Vivo See Investment barrier analysis Mekuria et al (Annex 9).
Technical	Although natural resources conservation is quite well established in Tigray (especially as compared to other	Academic input of environmental scientists; skilled local coordinator; training for local farmers; focus on

	regions in Africa), to date technical knowledge on assisted natural regeneration and socio-economic ecosystem service valuation is still limited. Thus, to strengthen the existing efforts, there is ample opportunity for projects focussing on valuation of (socio-economic) ecosystem services.	(socio-economic) ecosystem service valuation
Institutional, social	- "Top-down approach", although room is given for local initiatives - Rewarding for implementation activities	- Bottom-up approach with first consultation round, continued workshops and benefits for landless farmers - Rewarding for implementation results

Further additionality and spill-over effects of the project may include increased blue/green water availability for crops close or downstream to the hizaéti, erosion control, limited timber production and non-timber forest production (honey and incenses).

The project area has not been negatively altered prior to the start of the project for the purposes of claiming payments from ecosystem services (see photographs in Annex).

Up to date, there are no other relevant projects or initiatives in the project area, nor are there any agreements that are in place, that could lead to double counting.

Project Period

The project start date was February 2016. The crediting period of time over which the climate benefits will be quantified will be 20 years. This is an estimation of the period during which a stable state of ecosystem carbon can be reached under a certain type of management. In our case, we can compare the stable state of the ecosystem carbon in a well-managed hizaéti based on the carbon content of remnant (church) forests in Tigray (Mekuria et al., 2011). Indeed, there will be a slowdown in carbon storage after climax vegetation will be reached, reasonably comparable to the state of a church forest. The crediting period is somewhat shorter than the duration stated by the United Nations Framework Convention on Climate Change (30 years) (UNFCCC, 2003). Nevertheless, twenty years is the period over which we can make reliable estimations of carbon sequestration rates in the Dogua Tembien region (see further). After 20 years, the crediting period can be prolonged if the climax is not reached. In any case, the project will monitor and safeguard project implementations over 50 years. The project period (50 years) is thus 30 years longer than the initial crediting period. Note that the physical durability of the project carbon removals will be much higher than 50 years, exemplified by Abrham Abiyu et al. (2018) who show that well managed Ethiopian community forests have been stable for up to 250 years. Note that the full Permanence and Post-Crediting Stabilization Plan is available on the EthioTrees public dataroom: https://drive.google.com/drive/u/4/folders/1mdCAvwTZZ1ixZKfx4KktqTwSAm5Ihjxq

Although the time since hizaéti establishment is different for each site, the start of application of proper forest management is the year 2016 for the initial project sites. For the baseline scenario, we can assume stable bushland conditions (see further). A crediting period of 20 years corresponds with the period 2016-2036, during which a stable forest ecosystem can be reached under proper forest management. A project period of 50 years corresponds with the period 2016-2066, during which the project will monitor and safeguard project implementations.

Baseline scenario, and initial carbon stocks of the initial three sites

Currently, the areas that are included in the project are all 'exclosed' and basically consist of degraded bushlands. Without improved management techniques, soil and water conservation and enrichment planting, we can expect a relatively stable bushland system where future carbon sequestration will be very limited.

The carbon pools and emissions sources that will be accounted for and others that have been excluded are listed in Table G1.4 below.

Table G1.4: Carbon pools and emissions sources that are included or excluded.		
Pools or emission sources	**Type of pool or emission source**	**Included?**
Carbon pools	Soil organic carbon	Yes: soil organic carbon is the dominant pool for carbon sequestration in the Tigray Highlands (Mekuria et al., 2011), given this dry, degraded and erosive environment
	Above-ground biomass	Yes: above-ground biomass (trees, shrubs) is a major pool for carbon sequestration in the Tigray Highlands (Mekuria et al., 2011)
	Underground biomass	Yes: Mokany et al. (2006) provides reliable and conservative estimations of root-shoot ratio for subtropical dry woodland
Emission sources	Grass-cutting	No: estimations of grass-cutting are unreliable. However, grasses are also not included as carbon pools in the above-ground biomass estimations. Moreover, as hizaéti have a higher biomass production as compared to grasslands, it is possible that there will be a net positive effect on grass availability.
	Project gasoline use	No: the effect is negligible, as the project participants dominantly use public transport and a motorbike.

The reader is referred to Part K for the detailed description of the measurement (methodology), calculation and calibration procedures for soil organic carbon and above-ground biomass.

Initial average soil organic carbon ranges between 2.9 and 3.1 %, while average topsoil depth ranges between 12 and 16 cm (baseline data of 2016) (Table G1.5). As a result, the average soil organic carbon content (in ton C/ha) ranged between 51.2 and 63.0 ton C / ha in 2016.

Table G1.5: Results of the soil organic carbon					
	Average soil depth (m)	Average soil organic carbon content (%)	Standard deviation soil organic carbon content (%)	Average soil organic carbon SOC (ton C/ha)	Standard deviation soil organic carbon SOC (ton C/ha)
Gidmi Gestet	0.161	2.93	0.73	63.0	15.7

Meam Atali	0.126	3.06	0.54	51.2	9.1

Above-ground biomass in 2016 was mainly derived from bushes or shrubs with diameter < 10 cm but height > 1.3 m (measured in the compartments of 10x10 m). On average, the total biomass of bushes and shrubs account for 2.0-3.7 ton C / ha. Larger trees with diameter (at breast height) > 10 cm account for less of the total biomass, because of their smaller abundance (Table G1.6).

	Table G1.6: Summarized results of the vegetation survey								
Area	Compart-ment	Average circum-ference (cm)	Average diameter (cm)	St. dev. of diameter (cm)	Average crown diameter (cm)	Aver. height (cm)	Aver. number of trees per plot	Carbon content per compar-tment (ton C / ha)	Remark
Gidmi Gestet	A (20x20 m)	37.3	11.9	3.3	332.3	387.8	4.2	2.7	The larger trees are dominated by *Acacia*
	B (10x10 m)	9.2	2.9	2.0	107.2	214.4	22.9	3.7	
	C (5x5 m)	4.0	1.2	0.6	44.0	109.5	3.7	0.3	
Meam Atali	A (20x20 m)	38.9	9.9	5.4	320.0	392.5	0.9	0.6	The larger trees are dominated by *Olea*
	B (10x10 m)	11.4	3.6	1.6	132.8	204.9	11.2	2.2	
	C (5x5 m)	6.3	1.9	0.7	63.2	97.9	3.4	0.6	
Adi Lehtsi	A (20x20 m)	39.9	12.7	3.8	335.7	385.1	2.5	1.9	The larger trees are dominated by *Boswellia*
	B (10x10 m)	10.2	3.2	2.0	153.4	230.6	10.8	2.0	
	C (5x5 m)	6.4	2.0	1.0	58.7	94.6	3.6	0.8	

In Table G1.7, we summarize the results of the initial soil carbon determination and the biomass survey to quantify the initial carbon stock for each carbon pool.

Table G1.7: Quantification of the initial carbon stock for each carbon pool			
Carbon pool	**Project area**	**Initial carbon stock ICS (ton C/ha)**	**Brief description of methodology (see Part K)**
Initial Soil organic carbon ISOC	Adi Lehtsi	*	Calculation using mixed soil samples, Walkley-Black method and soil thickness measurements
	Gidmi Gestet	63.0	
	Meam Atali	51.2	
Initial Above-ground biomass IAGBM	Adi Lehtsi	*	Calculation using transect sampling of biomass parameters as input for a calibrated allometric equation
	Gidmi Gestet	6.7	
	Meam Atali	3.4	
Total Initial Carbon Stock TICS	Adi Lehtsi	43.0*	TICS = ISOC + TICS
	Gidmi Gestet	69.7	
	Meam Atali	54.6	

** Estimation of Total Initial Carbon Stock = 43.0 ton C/ha based on carbon-age calibration, see further. In Adi Lehtsi, the hizaéti is large, steep and the area is extremely hot. It was practically impossible for the project employees to perform labour-intensive soil sampling activities there. Therefore, the carbon-age calibration was used as a reliable alternative to provide a region-wide conservative estimation of the TICS in Adi Lehtsi. The area is very degraded (both in terms of soil and vegetation) so a TICS value of 43.0 ton C/ha may even be an overestimation.*

We further estimated the changes in carbon stocks for each carbon pool under baseline conditions, i.e. without the project.

In Adi Lehtsi, the hizaéti was established in mid-2016, i.e. after the start of the project. Thus, in the baseline scenario for Adi Lehtsi, cattle would continue to degrade the grassland/bushland vegetation. We can reasonably expect the change in carbon stock in Adi Lehtsi to be stable or even declining in the baseline scenario under continued pressure from livestock. The average Shannon diversity index = 1.4, which testifies the degraded status of this hizaéti in 2016. Overall, we can reasonably assume that there is no change in carbon stock in Adi Lehtsi as compared to the initial carbon stock for the baseline scenario: $\Delta C_{baseline} = 0$.

In Gidmi Gestet, bylaws to exclude cattle have been voted 11 years ago, but the association for hizaéti management was only established in 2016. Field observations before the start of the project indicated that cattle were still regularly entering the area (due to a lack of intensive guarding). The average Shannon diversity index = 1.3 in this project area, which testifies the degraded status of this hizaéti in 2016. The low values for diversity and total initial carbon stock illustrate the limitations for carbon sequestration and ecosystem restoration if management is not properly and intensively applied.
TICS of Gidmi Gestet is estimated at 69.7 tC/ha, which is higher than the total carbon stock in communal grazing lands in Dogua Tembien of 35.4 tC/ha (Mekuria et al., 2011). Aerial photographs from 1994

suggest that prior to the area being declared as an hizaéti in 2005, vegetation cover was shrubland with a similar vegetation structure to the area in 2016. This suggests that although the initial carbon stock in Gidmi Gestet is higher than in the communal grazing lands in Dogua Tembien, this is not the result of regeneration since the time of hizaéti, but rather an indication that the declaration as hizaéti has made little impact on the vegetation structure over the last 11 years. The baseline scenario is therefore that without effective protection carbon stocks will remain at 69.7 tC/ha, so $\Delta C_{baseline} = 0$.

In Meam Atali, bylaws to exclude cattle have been voted 8 years ago, while the association for hizaéti management was only established in 2016. The average Shannon diversity index = 1.4 in this project area, which testifies the degraded status of the hizaéti in 2016. Low values for diversity and total initial carbon stock illustrate the limitations for carbon sequestration and ecosystem restoration if management is not properly and intensively applied.

TICS of Meam Atali was initially estimated at 54.6 ton C/ha, which is higher than the total carbon stock in communal grazing lands in Dogua Tembien of 35.4 tC/ha (Mekuria et al., 2011). Aerial photographs from 1994 and thereafter suggest that prior to the area being declared as an hizaéti in 2008, vegetation cover was shrubland with a similar vegetation structure to the area in 2016. This suggests that although the initial carbon stock in Meam Atali is higher than in the communal grazing lands in Dogua Tembien, this is not the result of regeneration since the time of hizaéti, but rather an indication that the declaration as hizaéti has made little impact on the vegetation structure over the last 8 years. The baseline scenario is therefore that without effective protection carbon stocks will remain at 54.6 tC/ha, so $\Delta C_{baseline} = 0$.

The interviewees further point to the presence of hyenas, apes, snakes, rabbits and foxes in the hizaéti, as well as numerous bird species. One interviewee suggests that the 'small tiger' would be new to the area. All interviewees in Gidmi Gestet and Meam Atali suggest that over the past 10 years, the number and diversity of mammals has increased instead of decreased, in part because of the establishment of free-grazing areas.

Baseline scenario for all sites

In more generalised terms, we can assume no change in woody biomass carbon stocks if the conditions in AR-TOOL14 v4.2 section 5 are met. AR-TOOL14 vs 4.2 states in section 5: "Changes in carbon stocks in trees and shrubs in the baseline may be accounted as zero for those lands for which the project participants can demonstrate, through documentary evidence or through participatory rural appraisal (PRA), that one or more of the following indicators apply:

i. Observed reduction in topsoil depth (e.g. as shown by root exposure, presence of pedestals, exposed sub-soil horizons)

ii. Presence of gully, sheet or rill erosion; or landslides, or other forms of mass movement erosion;

iii. Presence of plant species locally known to be indicators of infertile land;

iv. Land comprises of bare sand dunes, or other bare lands;

v. Land contains contaminated soils, mine spoils, or highly alkaline or saline soils;

vi. Land is subjected to periodic cycles (e.g. slash-and-burn, or clearing regrowing cycles [or grazing]) so that the biomass oscillates between a minimum and a maximum value in the baseline;





Figure G1.1: Exemplary photographs of baseline conditions at sites Abaqo, Betmaria, Enda Medhanialem and Humer, evidencing widespread erosion and grazing before hizaéti establishment

Besides, “removals in soil organic carbon under the baseline scenario are zero for afforestation, reforestation and agroforestry activities that meet the applicability criteria in AR-ACM0003 v2.0 and/or if it can be demonstrated that soil organic carbon stocks are expected to decline under the baseline scenario. The applicability criteria in AR-ACM0003 v2.0 apply:

(i) The land subject to the project activity does not fall in wetland category;

(ii) Soil disturbance attributable to the project activity does not cover more than 10 per cent of area in each of the following types of land, when these lands are included within the project boundary: Land containing organic soils; Land which, in the baseline, is subjected to land-use and management practices and receives inputs listed in appendices 1 and 2 to this methodology: Grassland in which soil disturbance is restricted. For example, digging pits of size 0.50 m × 0.50 m (length × width) at a spacing of 3 m × 3 m on 1 hectare is equal to a coverage of 2.78 per cent (see Figure G1.2 for typical examples).

Figure G1.2: Typical examples for project percolation/infiltration pits, assuredly covering well below 10 per cent of the project areas.

In conclusion, the changes in carbon stocks in trees, shrubs and soils in the baseline scenario may be accounted as zero.

Ecosystem service benefits: initial 2016 estimations

EthioTrees followed a data-driven approach based on a confrontation of the baseline data with existing high-quality studies in the region. For the updated calculations of the plot resampling, we refer to the Appendix 11.

Dessie Assefa et al. (2017) estimated carbon storage under different land use classes in North Ethiopia. Their study concludes that average soil organic carbon content in North Ethiopia is 239 ton C/ha under forest cover. Mekuria et al. (2011) have also measured soil carbon and above-ground carbon in 14 well-managed exclosures of varying age in Dogua Tembien. The paper has been published in a highly-estimated SCI-ranked international journal (Land Degradation and Development) and is attached in Annex 9. The research setting and study region was similar to the carbon estimation methodology used in this Project Design Document, and the carbon estimation is clearly more conservative than that of Dessie Assefa et al. (2017). The authors conclude that well-managed old (> 20 years) exclosures in Dogua Tembien obtain climax vegetation with equivalent ecosystem carbon stocks compared to church forests.

According to the authors, the average total carbon in a well-managed hizaéti in Dogua Tembien (TC_{climax}) is not significantly different from a church forest (TC_{climax} = 102.5 ton C/ha). Because of the high quality of the study, the conservative estimations, and because the study region is the same and on the same limestone lithology, we will take into account this conservative estimate of TC_{climax} = 102.5 ton C/ha instead of 239 ton C/ha for our estimations.

Nevertheless, EthioTrees follows a strict checklist listing the 10 conditions under which we can use the estimates of Mekuria et al. (2011). All sites described in the PDD meet these requirements, while the checklist can also be used when identifying candidate sites for expanding the project:

1. The project site is located on either limestone or basalt lithology, but not on sandstone lithology;
2. Soils of the project sites should be dominated by Leptosols, Luvisols, Regosols, Cambisols or Calcisols but not by Vertisols;
3. Sites should be located between 12–15° N latitude and 36° 30'–40° 30' E longitude,
4. All sites should have tropical semi-arid climate;
5. Grass harvesting (using a cut and carry system) can be permitted in accordance with the PES agreement;
6. The hizaéti can only be located on former degraded rangelands or wastelands but not on former croplands or important grazing lands;
7. There is a set of clear rules (village by-laws) to ensure that the local population can receive ecosystem services of non-forest timber products (honey from bee hives and possible frankincense or incense);
8. There is willingness to establish a formal association of landless farmers;
9. To avoid increased grazing pressure elsewhere in the village, there should be some basic interest by the local community to encourage livestock feeding in the stable (e.g. through feed boxes).

Based on the data of Mekuria et al. (2011) (see Annex 9), there is a very strong relation between Total Carbon Content (ton C /ha) and the age of a well-managed hizaéti (AWME, yrs) (Figure G1):

TCC = 3.0137 AWME + 39.959 (R^2 = 0.87; $p < 0.05$)

Based on this relation, we could estimate the Total Initial Carbon Storage TICS in the Adi Lehtsi site (AWME = 1) through interpolation at 43.0.

We could calculate the standard error of the estimate, where σ_{est} is the standard error of the estimate, Y is an actual score, Y' is a predicted score, and N is the number of pairs of scores:

$$\sigma_{est} = \sqrt{\frac{\sum (Y - Y')^2}{N}}$$

The standard error of the estimate σ_{est} = 8.4 ton C/ha. We will take this error value into account while discussing the uncertainty (see below).

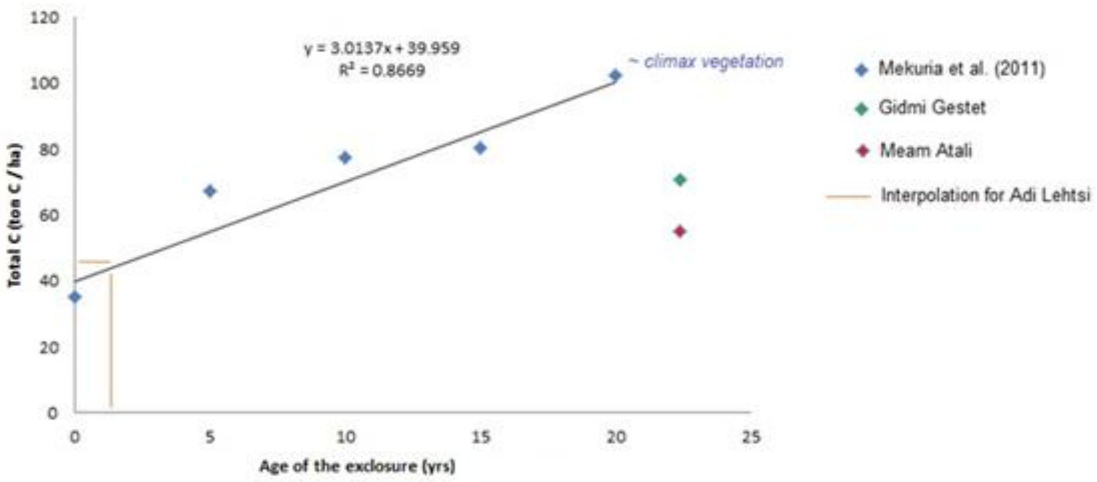


Figure G1: Total Carbon Content (ton C /ha) explained by the age of the well-managed hizaéti (AWME, yrs); data of Mekuria et al. (2011). Gidmi Gestet and Meam Atali are also indicated and aged after 1994. Note that the data points derived from Mekuria et al. (2011) are based on the average values of 14 exclosures. Standard error of the estimate = 8.4 ton C/ha.

We used this robust regional relation to provide conservative accumulation rates (see below) and climax carbon stock (TCclimax = 102.5 ton C/ha). As explained above, since none of the project areas would be effectively protected without the project intervention, they are expected to be degraded or remain unchanged in the baseline scenario, so it is assumed in all cases that ΔCbaseline = 0. Aerial photographs after 1994 corroborate the stability of this business-as-usual scenario under bushland cover.

Following this approach, the carbon benefit for all project areas could be estimated by assuming a carbon accumulation rate until they reach the climax carbon stock. Thus, we calculate the Total Carbon Benefits (TCB) as conservative accumulation rates of each project area:

TCB = (TC_{climax} – TICS) / 20

This yielded:

TCB (Adi Lehtsi) = (TC_{climax} – TICS) / 20 = (102.5 – 43.0) / 20 = 3.0 tC/ha/yr

TCB (Gidmi Gestet) = (TC_{climax} – TICS) / 20 = (102.5 – 69.7) / 20 = 1.6 tC/ha

TCB (Meam Atali) = (TC_{climax} – TICS) / 20 = (102.5 – 54.6) / 20 = 2.4 tC/ha.

Summary

By taking into account the area of each hizaéti (Adi Lehtsi = 412 ha; Gidmi Gestet = 46 ha; Meam Atali = 83 ha) and the project period (20 years), as well as the molar conversion factor of 3.67 (Mekuria et al., 2011), we calculated the total benefits for all project areas combined. tCO_2 per year.

TCB (Adi Lehtsi) = 3.0 x 412 ha x 3.67 = 4536 tCO_2 per year

TCB (Gidmi Gestet) = 1.6 x 46 x 3.67 = 270 tCO_2 per year

TCB (Meam Atali) = 2.4 x 83 x 3.67 = 731 tCO_2 per year

Total Carbon Benefits of the Project = 5,537 tCO_2 per year

Ecosystem service benefits: first monitoring recalibration

From 2016 to 2018, the EthioTrees project established baseline monitoring plots across 18 exclosures in Dogue Temben district, Tigray, Ethiopia, in order to monitor change in tree/shrub biomass, belowground and soil carbon stock in the project exclosures over time. The exclosures were chosen based on the interest and consent of the communities. The exclosures were protected well by the communities from the entrance of livestock and cutting of trees – even during the two-year war (November 2020 to November 2022) in the region. Local communities living around the exclosure include landless farmers and youth who sometimes formed associations based on their willingness to manage and benefit from the exclosures. Baseline biophysical (vegetation and soil) and socio-economic data were collected from 2017 – 2018. For direct estimation of change by re-measurement identical sample plots, resampling of vegetation and soil data of the same exclosure and the same plot locations was done from November 2022 to February 2023.

In each project exclosure, baseline vegetation and soil data were collected along transect lines in permanent nested quadrat plots. For the baseline survey, 6 - 23 plots per exclosure were used depending on the size of the exclosures. Only the same plots (pairs over time) were used for analysis of carbon stock between the baseline and resampling period. In total, 159 plots were used for analysis of changes in biomass. Based on the developed vegetation dataset, aboveground biomass of trees during baseline was estimated using the allometric equation recommended by Brown et al. (1989). To date, an improved locally developed equation is currently available (Ebuy et al., 2018); for the sake of consistency, both equations were used for the baseline and for resampling biomass estimation. Biomass was calculated for each tree and at each nested plot level, then scaled up to the main plot (20 x 20 m) to avoid underestimation of biomass at each site. Biomass at plots as well as at site level are expressed in *ton per hectare*.

Biodiversity was determined using the total number of species in the community (richness S), as well as the proportion of species i relative to the total number of species (pi). Shannon's diversity index was calculated by using the natural logarithm of this proportion (ln(pi)).
$H' = -\Sigma n = 1n(pi * \ln pi)$

The resampling results show that the number of trees species recorded at the baseline survey was 70 whereas 99 tree species were recorded during the resampling survey. T-test show there is significant variation between the two point of time. In addition to the number of species the total number of individuals recorded in the baseline was only 16914 trees as compared to 43080 trees in the resampling survey. Measurement of diversity using Shannon indices show 2.202 at the start of the project whereas the indices increased to 2.645 after five years of restoration period. T-test show that Shannon indices is significantly greater in the resampling as compared to the baseline survey. In conclusion, the results indicate that restoration of degraded woodland lead to increased biodiversity which suggest the need of more interventions to restore the degraded areas of Tigray through establishment of exclosure.

Biomass carbon stock

Following FAO, 2017 and Winrock, 1997, above-ground carbon (ton/ha) was calculated based on the relationship between above ground biomass (AGB) and above ground carbon using the following equation: $C = 0.55 \times AGB$. In addition, belowground biomass was determined using the equation used by Mokany et al. (2006). According to this equation belowground biomass in trees/shrubs in subtropical dry woodland is conservatively estimated to be 32.2% of the aboveground biomass. Aboveground and belowground biomass carbon were added to obtain the total carbon stock of biomass TBC.

Total biomass carbon = AGB + BGB

Soil carbon analysis

Soil organic carbon test was done using dichromate oxidation method by Mekelle university, soil chemistry laboratory and Mekelle soil laboratory, Ilala, Mekelle. Walkley-Black method (Walkley and Black, 1934) was used for soil organic carbon determination (in %C) of the composite soil samples. Soil organic carbon content (SOC, in ton C/ha) was calculated using the method used by Mekuria et al. (2011) and Wendt & Hauser (2013).

$$SOC(tonC / ha) = (\%C.\%100).Bd.D.\ \alpha$$

Where:

Bd is the bulk density (ton/m^3),

D is the thickness of the black topsoil (in m), and

α is 10000 m^2/ha.

A bulk density of 1.33 g cm-3 and 20 cm soil depth were used for all plots and sites.

Total carbon stock for change determination

Total carbon at each plot was calculated by summing up the carbon sequestered by plants and the carbon stock in soils.

$$\text{Total carbon} = AGC + BGC + SOC$$

Where:

AGC is the above ground carbon,

BGC is belowground biomass and

SOC is soil organic carbon, all in tonC/ha.

Statistical analysis

The change in biomass carbon, soil carbon and total carbon stock over an average period of five years was analyzed using the Wilcoxon signed-rank test at 95% confidence interval. The Wilcoxon signed-rank test is a non-parametric test used to compare changes over time in matched samples (e.g. fixed plots), often used when the basic assumptions of a paired t-test (normality etc.) are not met. Yearly rate of carbon stock change at each plot was calculated as the difference between the resampling and baseline divided by the total period and multiplied by 3.667 (molar conversion towards ton of atmospheric carbon dioxide equivalent).

Result and interpretation

Based on the analysis of total carbon stock of 159 plots, carbon stock has increased in most plots between the baseline and resampling period. Wilcoxon signed rank test showed that biomass carbon accumulation has significantly increased over an average five years. The results also show a greater number of small trees in the resampling as compared to the baseline in most plots. With 159 paired plots and using robust non-parametric testing at $p<0.05$, one can be confident that the Wilcoxon test shows significant increases in above- and belowground biomass across the population sample.

Soil carbon comparison between the baseline and resampling show that soil carbon stock has increased significantly. Some sites, however, showed a decrease in soil carbon. This phenomenon can be the result of different factors. Topsoil is sensitive to soil erosion if exposed to runoff. Severe runoff that removes topsoil might occur at these sites. Shifting of plot locations during resampling from the baseline could also result in variation of soil carbon as it might include some small rocky areas or poor soil. However, with 159 paired plots and using robust non-parametric testing at $p<0.05$, one can be confident that the Wilcoxon test shows significant increases in SOC across the population sample.

The overall analysis of biomass carbon sequestration shows that carbon stock in trees has significantly increased in resampled plots (22.70t/ha ±20.66) as compared to the baseline biomass carbon stock (14.36t/ha ± 11.24) over the average period of five years ($p<0.05$, n = 159). Similarly, soil organic carbon has increased significantly in resampled plots (88.04t/ha ± 33.04) as compared to the baseline (81.24t/ha ±24.34) ($p< 0.05$, n=149). Analysis of total carbon stock (i.e. biomass plus soil stock) show a significant increase of carbon stock in resampling (110.74t/ha ±38.44) as compared to the baseline total carbon stock (95.6t/ha ± 27.82) ($p<0.05$, n = 159).

Hence, the calculation of the rate of annual change of total carbon stock at the overall project scale resulted in a final sequestration rate of **11.47 tCO_2e ha^{-1} yr^{-1}**. This positive result is slightly higher than the initial prediction at validation (i.e. 10.3 tCO_2 per hectare per year) and illustrates that despite many challenges due to the severe war in Tigray, carbon sequestration in biomass as well as in soil has significantly increased across the project zone.

Future carbon benefit calculations

Aligning EthioTrees promptly with Plan Vivo Module PU001, we estimate the sequestration rates of future expansion sites as follows:

- Biomass carbon sequestration is quantified using AR-TOOL14: Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities, Version 4.2. Section §6.2 prescribes the direct estimation of change by re-measurement of sample plots. It is therefore more reliable to use the EthioTrees biomass carbon sequestration rate verified in 2023 for the expansion sites (rather than the past ex-ante model of Mekuria et al., 2011). The analysis of biomass carbon sequestration, verified by Mutu Certification in 2023, shows that carbon stock in trees has significantly increased in resampled plots (average = 22.70 tC/ha) as compared to the baseline biomass carbon stock (average = 14.36 tC/ha) over the average period of 4.8 years ($p<0.05$, n = 159 plots). The EthioTrees biomass sequestration rate is thus verified at 1.74 tC/ha/yr.

- SOC changes can be calculated using AR-TOOL16: Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities, Version 1.1. Based on §11 of the tool, considering uncertainties and inherent limitation of the precision of a factor-based estimation, the value of the rate of change of SOC stock must be accounted as 0.8 tC/ha/yr.

- Applying a molar conversion of 3.67, the applicable carbon sequestration rate for the next 5 years is thus 8.2 tCO_2e/ha/yr (including buffer and leakage correction). Note that this rate remains close to (but is more conservative than) the original sequestration rate predicted in the PDD of 2017 (which was 9.2 tCO_2 per hectare per year including buffer and leakage correction).

Leakage & Uncertainty

We identified three potentially significant reductions in climate benefits due to leakage, and developed appropriate mitigation measures:

- *Diseases* may affect vegetation growth. This will be mitigated by establishing a *biodiverse mixture* of different species.
- *Illegal tree cutting and grazing* will be mitigated by maximizing community participation and by sufficient training of the guards and other association members. Community participation and awareness will be further stimulated by creating value from non-timber forest products.
- There is potential for leakage from reduction of above-ground biomass from *displaced grazing and increased cut-and-carry*. As indicated in the PES agreement, both the associations, other customary NTFP users and the village councils pledge to monitor and counter potential displaced grazing and organise an annual meeting. Livestock feeding in the stable (e.g. through feed boxes) will thus be stimulated through trainings and observations of displaced grazing will be reported. EthioTrees will monitor potential displaced grazing over time by incorporating the issue in regular interviews with participants and locals.

  Moreover, the cut-and-carry system will counter the need for displaced grazing and will benefit children schooling (more time to go to school) and off-farm income possibilities. As exclosures have a 30% higher grass production (!) as compared to grasslands (see Mekuria et al., 2010), there will be a net positive effect on grass availability and thus on fodder availability.

  Assuming yearly grass consumption of one Tropical Livestock Unit (TLU) being 2.3 ton (FAO, 2017) and average livestock density in the Ethiopian Highlands being 0.36 TLU/ha (Yohannes, 1989), grass consumption through (displaced) grazing in the Tembien Highlands would amount to approximately 0.8 ton/ha/yr. As grass production in an average hizaéti amounts to 4.6 ton/ha and grass production in grassland amounts to 3.5 ton/ha (Mekuria et al., 2010), the ecosystem restoration project will counter the need for displaced grazing as there will be even more grass available for cut-and-carry than can be destroyed though potential displaced grazing.

Additionally, as indicated in Table G1.3, grasses are not included as carbon pools in the above-ground biomass estimations, so cut-and-carry or displaced grazing cannot impact the carbon benefit estimations

As indicated in the section on the annual monitoring, if the number of observations of displaced grazing mentioned during the yearly meeting of association, other NTFP users and the village council, is more than 2 then the annual monitoring target will be missed. Nevertheless, since 2.0% of the total carbon content of a mature exclosure consists of the grass volume (7.6tCO2e grass over 376.2 tCO2e TC_{climax}) (Mekuria et al., 2011), and assuming no cut-and-carry system in place (*quod non*), a 2% leakage deduction would be the volume (hypothetically) displaced by a full displacement of the grazing pressure. This 2% leakage deduction is applied in Table F1 and represents the worst-case (conservative) estimation of the leakage risk.

Overall, initially we took a quite conservative estimate of TC_{climax} = 102.5 ton C/ha (based on Mekuria et al., 2011) instead of 239 ton C/ha (Dessie Assefa et al., 2017). Following Mekuria et al. (2011), expected carbon sequestration rates of well-managed and old exclosures in Dogua Tembien are 246 tCO2 per hectare over 20 years, or 12.3 tCO2 per hectare per year. Mekuria et al. (2011) also mention that all changes in total carbon are significant at the 0.01 level (paired t-test). Nevertheless, we used an even more conservative approach taking into account a risk buffer and a baseline scenario with an existing Total Initial Carbon Storage TICS, so the initial estimated project sequestration rate in our project was (**only) 9.2 tCO2 per hectare per year, based on the resampling analysis and aligning the project with the Plan Vivo Carbon Standard (PV Climate) version 5, future expansions will be modelled using 9.31 tCO2 per hectare per year.** This is on the lower side of other values estimated by Plan Vivo projects in nearby African countries (Kenya, Uganda). For instance, Trees for Global Benefits in Uganda estimated a sequestration rate of 10.0 tCO2 per hectare per year (woodlot projects).

Besides, our techniques are based on sound scientific methods that were published in SCI-ranked journals and calibrated in the project area. Because of the robust and conservative approach, uncertainty has been minimized as much as possible. Probably, remaining uncertainty can be related with the initial soil organic carbon determination method. Ferrous iron in soils, if present, leads for instance to high results for the dichromate-ferrous sulphate titration. However, soil samples that have been air-dried for 1 or 2 days contain insignificant amounts of soluble iron compounds, even though ferrous iron had been high in the fresh sample. Where the chloride content of the soil is high, some interference can also occur. Yet, in most cases, chloride effect can be ignored as a chloride content of 1%, for example which is a very high figure, would result in an error of only about 0.1% in the organic carbon content (Department of Sustainable Natural Resources, 2017).

Even so, every 5 years, soil carbon and above-ground biomass will be re-assessed according to the same methodology as was used for the baselining. This will allow a continuous evaluation of the carbon estimations over the course of the project.

G2: Technical Specifications Agroforestry

Project intervention and activities

Agroforestry aims

Agroforestry aims to purposefully integrate trees into crop and/or livestock systems, to enhance ecologic, economic and/or social benefits. Agroforestry is a key land management strategy that has significant potential for reducing deforestation and forest degradation while improving rural livelihoods directly or indirectly. It provides habitats for perennial woody species outside the forests and for alleviating resource-use pressure on nearby conservation areas. There is increasing evidence that enhancing biodiversity does not depend on “natural” ecosystems alone, given that many farmers have historically increased the planting and management of trees on their smallholder lands outside the forest land – to provide the needed outputs and improve biodiversity while doing so.

Various agroforestry systems have been widely used across different parts of the world for different purposes, and their occurrence is often site-specific. For example, silvopastoral systems, windbreaks and shelterbelts, and multipurpose trees on farmlands, are among the major agroforestry practices in arid and semi-arid lands. Indeed, agroforestry is a management system practiced by many populations in the Horn of Africa, and is very important for food security, microclimate amelioration, income generation and environmental protection.

Agroforestry can reduce resource use conflicts between arable farming, livestock rearing and forestry interests, especially in human-dominated landscapes. Agroforestry trees are used to satisfy the needs and demands of rural households by providing wood and non-wood products and services. Some of the major products and services can include: heating, cooking, household utensils, cultural values, provision of pollen and nectar for honey production, construction of houses and handles of farm implements, traditional medicines, economic benefits, fodder values, livestock browsing as well as shade/shelter for humans and livestock, and employment opportunities, particularly for smallholder farmers. Tree planting can be profitable, can augment a household’s income through sales of wood and non-wood products and can contribute to risk management by diversifying outputs and spreading risks of agricultural production failure. For example, in the Horn of Africa, trees on farms constitute up to 17% of total gross income among tree crop growing households. Planting trees is currently being seen as an alternative livelihood strategy, particularly in drier areas. In areas where drought is frequent, soils on steep slopes are nutrient-poor, and use of fertilizers and improved seeds might be risky and less profitable, tree planting can be among the main livelihood strategies.

Integrating tree species into farmlands also provides a protective function. Combining trees and crops in spatial/temporal arrangements helps to mitigate environmental degradation and to adapt farming systems to climate change, while absorbing atmospheric CO_2.The beneficial effects of several tree species on soil fertility, crop productivity and carbon sequestration have been reported by several researchers. Among other things, trees on farms contribute to improving soil humus, soil fertility or soil structure and provide shade essential for crop growth.

Traditional agroforestry practices in Tigray

In Tigray region, Ethiopia, agroforestry is an ancient practice whereby farmers manage trees on their land for multi-purpose uses. The region knows four main forms of agroforestry, including parklands, home gardens, boundary planting and woodlands. The promotion of agroforestry practices is a key strategy to reverse natural resource degradation in both the Tigray Highlands and Lowlands, and to increase productivity. In Tigray, despite an overall reduction in biodiversity in the natural forests, traditional planting or retaining trees at farmlands in the form of agroforestry have given refuge to a considerable number of native woody species. Farmers are eager to plant trees on their agricultural lands and at their backyards owing to its convenience for management, so that acute environmental degradation and wood product shortages can be reversed. The Tigray agricultural landscapes play a major role in the conservation of native woody species, as high diversities of woody species can be recorded in different agro-ecosystems, indicating the significance of agroforestry to improve species richness. Agroforestry clearly is an additional strategy for biodiversity conservation in Tigray, aligning well with nearby exclosure activities.

Different agroforestry types are practiced in different landscapes such as intercropping, home garden/backyard planting, farm boundary planting, homestead intercropping, gully bank/channel planting, and parkland planting. Valuable woody species that have no clear negative effect on food productivity can be introduced on crop fields considering the preferences of the smallholders with appropriate management. Table G2.1 presents some common species applied under different agroforestry systems across Tigray.

Table G2.1. General characteristics of common agroforestry species in Tigray (based on the Kew Plant Database, 2023)

Species	Other names	General	Native or naturalized to Ethiopia	Other
Faidherbia albida	*Acacia albida*	Shrub or tree, growing primarily in the seasonally dry tropical biome	Native	Perennial, Not climbing, Shrub/ Tree up to 30 m high, with ± rounded crown; bark rough, dark brown or greyish; branchlets straw-coloured or whitish
Acacia polyacantha	*Senegalia polyacantha*	The native range of this species is Tropical & S. Africa, Indian Subcontinent. It is a tree that grows primarily in the seasonally dry tropical biome.	Native	Tree up to 21 m high; trunk with fissured bark and knobby persistent prickles; Young branchlets pubescent or puberulous, rarely subglabrous, grey to brown branches
Ziziphus spina-christi	Christ's Thorn	The native range of this species is Mauritania to Pakistan. It is a shrub or tree and grows primarily in the desert or dry shrubland biome.	Native	IUCN Red List of Threatened Species: LC - least concern Shrub or tree to 15 m tall, usually spiny but sometimes unarmed; bark grey to brown, fissured; branchlets whitish to straw-coloured
Grevillea robusta	Silky oak	The native range of this species is Australia. It is a tree and grows primarily in the subtropical biome. It is used as animal	Naturalized	Tree up to 30 m high; leaves up to 35 cm long, pinnate with up to 22 alternate or subopposite pinnae, the pinnae with 1–several linear or

		food, a poison, a medicine and invertebrate food, has environmental uses and for fuel and food		linear-oblong acute lobes to deeply pinnatifid or pinnate with up to 16 lobes or pinnules, glabrous above, closely appressed pubescent beneath.
Cordia africana	Sudan teak	The native range of this species is Tropical & S. Africa, SW. Arabian Peninsula, Comoros, Central Madagascar. It is a shrub or tree and grows primarily in the seasonally dry tropical biome.	Native	Small to medium sized deciduous tree, up to 24 m high; trunk usually forking a few meters from the base; bark grey to dark brown, shallow fissured; crown spreading, dome-shaped; branchlets glabrous, powdery or pubescent, sometimes hairy.
Mangifera indica	Mango	The native range of this species is Assam to China (S. Yunnan). It is a tree and grows primarily in the seasonally dry tropical biome.	Naturalized	Cultivated for its edible fruit. It is used to treat unspecified medicinal disorders, as animal food, a poison and a medicine, has environmental uses and social uses and for fuel and food.
Persea americana	Avocado	The native range of this species is Central Mexico to Costa Rica. It is a tree and grows primarily in the seasonally dry tropical biome. It is used as animal food, a poison, a medicine and invertebrate food, has environmental uses and social uses and for fuel and food.	Naturalized	A rapidly-growing tree or shrub that normally grows up to 20 m tall (but can reach 40 m) and lives for about 50 years. The crown (cluster of branches and leaves at the top of the trunk) is rounded.

Moringa oleifera	Drumstick tree	The moringa plant is native to northern India, where it was first described around 2000 BC as a plant with many medicinal values.	Naturalized	M. oleifera is a small, fast-growing and short-lived tropical tree, well-known for its multi-purpose attributes, wide site adaptability and ease of establishment. Its principal value lies in its nutritional value and the use of the leaves, pods and flowers for human consumption as well as for livestock feed.

Parkland agroforestry and dispersed interplanting

Parkland agroforestry as a scattered on-farm tree system is one of the most ancient traditional practices of the semi-arid and sub-humid zones of Ethiopia. The system is characterized by well-known scattered trees on cultivated and recently fallowed lands. Some parklands investigated so far are composed of high species diversity, up to 40-50 woody species. Parkland agroforestry based on indigenous tree species is a highly preferred type of agroforestry because of its relatively high biomass production per tree, high survival capacity and high land use efficiency. Parklands represent the dominant agroforestry practice in the semi-arid and sub-humid zones of the Tigray region too.

In many parts of the region, dispersed interplanting of trees on farmlands has become a common parkland practice with Acacia parklands representing one of the most widespread options. Such woodlands have an enormous ecological and economic importance in arid and semi-arid areas. *Acacia albida* (*Faidherbia albida*), *Acacia polyacantha*, *Acacia abyssinica*, *Acacia tortilis*, *Acacia senegal*, *Acacia seyal*, *Acacia mellifera*, *Acacia asak* and *Acacia lahai* are common tree species widely used in agroforestry practices in Ethiopia. There is also a practice of parkland agroforestry with Cordia Africana Lam. and Croton macrostachyus Del. trees on crop fields. Given the challenges of dry season open grazing, parkland agroforestry is not considered for the purpose of this technical specification.

Home garden agroforestry

The home garden agroforestry system is a land-use practice involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial crops and livestock, within the compounds of individual houses. Here, the integral crop-tree-animal unit is being managed by the family. Home gardens are known for their structural complexity and diversity of plant species which have evolved over time to match socioeconomic, cultural, and ecological needs. The high species richness in Tigrayan home gardens might be associated with the ease of planting and managing the trees. In home garden agroforestry, not only vegetables and medicinal plants can be grown, but also permanent multi-purpose trees (Faidherbia, Grevillea, Moringa) as well as native (wild) and naturalized fruit trees (mango, avocado, guava etc).

Acacia albida Del. (*Syn. Faiderbhia albida Del. A Chev*.) for instance is commonly found across the Tigray region. Farmers take care of *Faiderbhia albida* (Del.) trees around their homestead and farmland in order to improve soil fertility and increase yields. This tree species has a special phenology as it sheds its leaves during the rainy season and keeps them during the dry season, i.e. from October to June. Thus *F. albida* sheds its leaves when ploughing begins and hardly competes for light and water during the growing season of the crop. The foliage shedding characteristics of F. albida are thus very attractive for farmers. Furthermore, *F. albida* trees fix nitrogen and provide nitrogenous (and other) nutrients to the nearby vegetables or crops when their leaves fall and are incorporated into the soil. In addition, the trees provide fencing, fodder and shade to the livestock and their wood can serve as fence and fuel. Several studies have shown the positive effect of F. albida trees on the yields of different crops (e.g., maize, sorghum, barely, teff, etc) cultivated by the traditional smallholder farming systems in Tigray.

Boundary planting

For boundary planting, trees and shrubs are planted along farm boundaries for soil conservation and as live fence. Live fences are lines of trees or shrubs planted in close spacing on farm boundaries or on the borders of agricultural fields. Well-known tree species planted on farm boundaries or as live fences in Tigray include *Faidherbia albida, Acacia polycantha, Balanites* *aegyptiaca, Ziziphus spina-christi, Eucalyptus camaldulensis, Eucalyptus globulus, Cordia africana, Moringa, Grevillea robusta, Dovyalis abyssinica, Opuntia ficus-indica*, and other Acacia species.

In La'ilay Adiyabo, *Acacia polyacantha* trees have been dispersed on farm boundaries to cover a large part of the agricultural landscape. *Acacia polyacantha* belongs to the family of Fabaceae and is an important agroforestry tree commonly found in wooded grassland, deciduous woodland and bushland, and riverine forests in the dry and moist "Kolla" agroclimatic zones of Ethiopia. *Acacia polyacantha* is a large, deciduous tree that grows towards an average height of 3.5–20 m. Incorporating *Acacia polyacantha* into or around the farming system can improve and maintain the fertility of the soil, increase the annual income of households and contribute to carbon sequestration.

Woodlot planting

Woodlots are commonly established on underutilized or degraded lands and inside gullies, for the purpose of supplying timber, fuelwood or fodder. Well-known trees include *Eucalyptus camaldulensis, Eucalyptus globulus, Grevillea robusta* and *Acacia* species such as *Acacia polycantha*. It should be noted that Eucalyptus is not part of the EthioTrees planting mix. Eucalyptus has allelopathic effects on the surroundings and a negative impact on the water table. Nonetheless, land use intensification in Ethiopia has resulted in the planting of large amounts of Eucalyptus species on non-agricultural lands for fuel wood and construction. This has motivated farmers to plant Eucalyptus in woodlots, as Eucalyptus grows quickly and is used for different constructions, as firewood and can be easily sold (especially by farmers close to towns, markets and roads).

Ziziphus spina-christi for instance, is also well-known in Tigray. *Ziziphus spina-christi* is a multi-purpose tree that can deliver fodder to the livestock and is often grown in combination with different annual crops such as teff, maize and sorghum. Woodlots are often fenced against grazing livestock and/or planted with trees that are less attractive for livestock.

Homestead intercropping

In this system, farmers are generally interested in planting 50 up to 100 trees, in combination with their millet, sorghum, wheat and maize cultivation. Seedlings are usually planted close to the homesteads (to be able to easily monitor animal grazing and regularly apply water). The planting density is preferably low (around 300 trees per ha), because the farmers want to reconcile tree planting with crop production – and therefore need to avoid excessive shading. The trees are planted in lines, often along existing stone bunds. Popular trees are Faidherbia albida, Acacia polyacantha, Ziziphus spina-christi, Grevillea robusta, Mangifera indica, Persea americana, Cordia Africana and Moringa oleifera. Thinning or harvesting is not applied in this system.

Management of agroforestry trees

The optimal distance required between trees is dependent on purpose and location. The average spacing between individual trees on parklands may be between 8 m to 12 m. For woodlot plantations, the spacing between trees is much denser and depends on the purpose as pole or as firewood. The spacing of trees in homegardens and along boundary plantations is variable from very narrow to wider spacings, depending on their purpose and on the availability of land. Farmers plant at a wider distance when the objective is to boost soil fertility, while the spacing can be as narrow as <1m when the main purpose is to generate firewood. Seedlings are planted from nurseries, but can at the request of the participating farmer also be nurtured in-the-field.

Weeding, topping, lopping, and pruning are the common management interventions performed after planting, often to reduce competition with crops or to use the branches for different purposes. For instance, some farmers prune Faidherbia every year for fodder and every 2-3 years for fencing and fuelwood, and/or perform pollarding when a tree grows at least to three meters after which pollarding can be done at intervals of about 4 years. When pruning is performed, only a portion of the crown height should be pruned, branches should be clipped near to the stem, and if necessary wounds should be treated with a sharp instrument to speed up healing. In any case, pruning will not be performed in this Plan Vivo agroforestry project. When the trees are young 3 – 5 layers of green branches shall be retained. Deadwood is generally removed. Weeding is a common preparation technique during seedling stage, while replenishing may be performed the next rainy season (after survival rate estimation), in order to replace underperforming seedlings. Watering is done sometimes under critical shortage of rain especially for seedlings planted in homegarden. If planting is done in close spacing, thinning activities decrease the quantity of trees in an area to improve the advancement of the rest. Thinning can be important for agroforestry quality, as it positively impacts the development and strength of remaining trees. All thinned (and pruned) wood is removed and can be used by the farmers (for cooking, construction etc.).

Importantly, protection from livestock and watering of seedlings are necessary for the survival and growth of the trees. Indeed, free grazing may be the main challenge for scaling up agroforestry practices. Grazing and water deficiencies can have severe impacts on the survival and growth of seedlings.

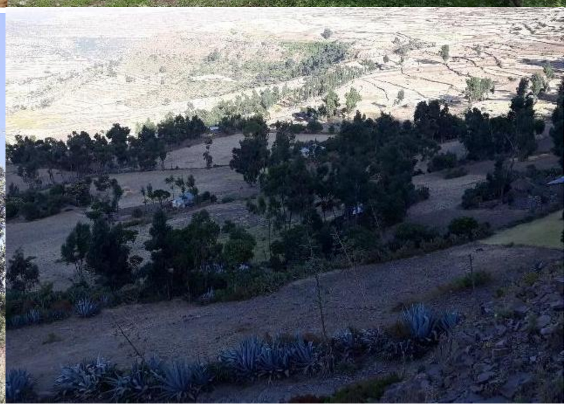


Figure G2.1: (above, left) Faidherbia albida parkland agroforestry (farmland), Abrha Watshbha (Tigray, Ethiopia), Jan 2003 (Etefa); (above, right) Acacia spp parkland agroforestry (grazing land), Mehoni (Tigray, Ethiopia), Aug 2018 (Etefa); (middle, left) *Ziziphus Spina Christi* woodlot agroforestry, Mehoni (Tigray, Ethiopia), Sep 2018 (Etefa); (middle, right) Boundary planting Dogu'a Temben, Tigray (Ethiopia), Nov 2017 (Etefa); (down) Homegarden agroforesty, Abrha Ae Atsbeha (Tigray), July 2012 (Etefa).

Additionality and Integrity

Tree growing is a long-term investment and without substantial support from the government, other non-governmental organizations (NGOs), or carbon funds, subsistence farmers may not be able to afford it. Furthermore, researchers have suggested that more attention should be given to the expansion (technical support and trainings) and management of trees/shrubs to increase their number per household, to satisfy the increasing needs. For instance, researchers suggested that future expansion of agroforestry in Tigray should target to introduce more diversified trees/shrubs to resource endowed, educated and aged households, and more abundance/density of high economic value trees/shrubs to poorer households based on selected local tree management practices. It is in any case highly unlikely that Tigrayan subsistence households would be independently able to invest in significant agroforestry expansions in the region, especially after the massive devastation and impoverishment following the Tigray War (2020-2022).

EthioTrees agroforestry interventions exceed current laws and regulations for forestry and land management. To date, there are no laws and regulations directly applicable to agroforestry interventions in Tigray. Besides, this project is not the product of a legislative decree, or a commercial land-use initiative likely to have been economically viable in its own right. Rather, EthioTrees provides high-quality nurseries, free seedling distribution, practical training, technical support and incentives to develop agroforestry activities. Below we add a table with the most important barriers to project development, including the additionality under the combined EthioTrees – Plan Vivo effort (Table G2.2).

Table G2.2: Additionality of the combined EthioTrees – Plan Vivo effort.

Ecosystem Restoration	Main Barriers	Activities to Overcome Barriers
Financial	- Limited funds - Other priorities - Limited private credit availabilities - Nurseries are closed during the great famine - Massive devastation and impoverishment following the Tigray War (2020-2022).	Start-up capital secured by EthioTrees; benefit sharing scheme supported by Plan Vivo; free distribution of seedlings; wages of nursery technicians
Technical	Although natural resources conservation is quite well established in Tigray, there is ample opportunity to support valorization of agroforestry products, while the Tigray War resulted in large-scale environmental degradation	Skilled local coordinator; academic input of Mekelle and Ghent University; training for farmers; attention to the valorization of the agroforestry products value chains
Institutional /Social	- “Top-down approach”, although room is given for local initiatives - Fallout of the Tigray War	- Bottom-up approach with first consultation rounds, continued workshops and benefit sharing for subsistence farmers; - Carbon benefits: bridging the gap in

		times of crisis (see: https://www.planvivo.org/blog/carbon-credits-bridging-the-gap-in-times-of-crisis)

The project area has not been negatively altered prior to the start of the project for the purposes of claiming payments from ecosystem services (see §Baseline Scenario). Up to date, there are no other relevant projects or initiatives in the project area, nor are there any agreements that are in place, that could lead to double counting.

Regarding environmental and livelihood integrity, agroforesty could potentially slightly reduce agricultural productivity for crops growing near the plot boundary. To avoid such possible effects, the project will provide agroforestry trainings to create awareness on boundary effects of agroforestry for non-shade tolerant crops (e.g. Eragrostis tef). For example, shade-tolerant crops such as maize or nitrogen-fixing leguminoses could get priority along boundaries. Besides, the project will not plant exotic invasive tree species, such as Eucalyptus or Pinus trees, which have allelopathic effects on the surroundings and have a negative impact on the water table.

Project period

This is an intervention that generates ex-ante carbon credits for the homestead intercropping and high-density home garden planting activities, and ex-post carbon credits for boundary planting, low-density home garden planting, and woodlot planting, which are calculated over a 35-year crediting period. Ex ante carbon revenue payments will be made to the participants during the first 10 years of the project period, in line with the achievement of the milestone targets. Ex-ante payments allow to cover the early costs of planting the seedlings and taking care of these during the first years. Meanwhile, the payments also support the participating subsistence farmers with cash to meet their direct livelihood needs in the difficult years after the Tigray War.

After 10 years, farmers will benefit from the fruit production, the fodder production (livestock feeding) and the thinning (timber). Start and end date of the project are 1 August 2023 till 31 July 2058.

Baseline scenario

Current conditions and trends in the project region

In a joint endeavour, researchers pertaining to the Departments of Geography of Mekelle and Ghent Universities have collected an important set of field data concerning the impacts of the war in Tigray. This preliminary study involved 35 focus group interviews and 50 repeat photographs. As the full analysis and paper publication may take quite some time, we have chosen to publish here a handout with a representative subset of observations (interview quotes, photographs, and processed satellite imagery) – see Appendix A. In summary, post-war observations are consistent with wartime analysis on failing crop yields, famine, and massive death toll in the Tigray war. Many major findings hold true across the ten studied settlements and their surroundings: there is a clear increase of gullying, charcoaling, wood cutting, crop failure and starvation. This is corroborated by the remote sensing study of the Conflict and Environment Observatory (2022), showing that there is evidence for trees and other woody vegetation being lost across Tigray since the start of the Tigray War, most likely linked to conflict-driven collapse in the availability of fuel for heating and cooking.

According to African Union representatives, the conflict may have been the deadliest of the 21st century, with around 600,000 civilians killed (about one tenth of the Tigrayan population). Most are starvation deaths, but there are also 50,000 to 100,000 victims of direct killings, and more than 100,000 additional deaths due to lack of health care (Ghent University, 2022). According to the United Nations (UN), around 2.3 million children had been cut off from desperately needed food aid and humanitarian assistance. In 2022, the livelihood conditions in Central Tigray have been summarised as follows (Plaut, 2022):

- *No schooling. Most of the school materials are destroyed. Every child thinks about the drone and airstrike. They never feel safe.*
- *More than 90% of health care facilities are destroyed.*

- Families are in disarray. No salary for the last 20 months. Everybody is looking for aid but can't get it. They are losing their children due to hunger and starvation. They are unable to save their families.

- No medicine. Due to lack of medicine thousands of people are dying. The death rate is extremely high.

- No communication. Instead of calling and messaging through phone, we go back to the old way of communication. We write a letter and ask someone to take it. Most of the time it gets lost somewhere and sometimes it arrives very late.

- No bank. Even if people have money in their account, they are not able to withdraw because there is lack of cash in the bank – any bank communication is blocked and the cash has been looted by troops, when withdrawing from Mekelle, back in June 2021.

- No electricity. The main power line was from Addis Ababa and they cut it off. After they cut it, the Tigray electric power was connected to Tekeze Hydropower. The substation was then hit by drone strike. Again it was repaired. Then the main station in Mekelle was hit. Again they repaired it and so on.

- No fuel. Transportation costs have increased tremendously.

- Farmers did not harvest as usual. Because the farmlands were not properly ploughed on time and lacked fertilizer.

- Even if you have cash at hand things are quite expensive to buy. Every week there is high inflation. For example, early February 2022, the EthioTrees project bought food for the communities. We paid 2800 birr for one quintal (100 kg) of wheat and 4300 birr for 1 quintal of flour but early March 2022 it was3700 birr and 5200 birr for the same amount.

In summary, it is clear many trees are being lost across Tigray since the start of the Tigray War, linked to conflict-driven collapse in the availability of fuel for heating and cooking, and the lack of investment during and after the war. In general, it may take many years for Tigrayan society to recover and for smallholders to restart investment in their livelihood diversification.

The conflict exacerbates an existing long-term trend towards decline in woody biomass. We refer to Appendix A for the full land use/cover change mapping study by EthioTrees team members (Etefa et al., 2018) in the project region (1930s till 2014). The land use mapping study concludes: In the 1930s, shrubland (48%) was dominant, followed by cropland (39%). The fraction of cropland in 2014 (42%) remained approximately the same as in the 1930s, while shrubland significantly dropped to 37%. Forests shrank further from a meagre 6.3% in the 1930s to 2.3% in 2014.

Carbon pools and emission sources

These technical specifications are developed using the Plan Vivo approved SHAMBA methodology. We include the following carbon pools in the baseline scenario, in line with the SHAMBA method (Table G2.3):

Table G2.3. Carbon pools included in the (SHAMBA) carbon quantification.

Carbon pool	Included?	Justification/Explanation
Above-ground woody biomass	Yes	This is a potentially significant pool and is considered for tree planting and agroforestry activities
Below-ground woody biomass	Yes	This is a potentially significant pool and is considered for tree planting and agroforestry activities
Non-tree biomass	No	Although not explicitly included in the accounting, crop residues are modelled and included as an input to the soil organic carbon pool where appropriate
Dead wood	No	Although not explicitly included in the accounting, dead wood is modelled and included as an input to the soil organic carbon pool where appropriate
Litter	No	Although not explicitly included in the accounting, tree litter inputs are modelled and included as an input to the soil organic carbon pool where appropriate
Soil organic carbon	Yes	This is a major pool affected by tree planting, agroforestry and agricultural activities
Wood products	No	Wood products are not accounted for, and are conservatively excluded

This intervention is targeting private lands that are currently almost devoid of trees. It is assumed that the current woody biomass on the plots would remain static under both the baseline scenario and under the project intervention scenario. Indeed, given the fallout of the Tigray War, it is highly unlikely that farmers would independently plant more trees on their farms without extra project support. For instance, most nurseries in Tigray are closed and nursery technicians are unemployed.

Initial carbon stock for each carbon pool

Despite many studies on land degradation in the Highlands of Northern Ethiopia, quantitative information regarding long-term changes in land use/cover (LUC) is rare. We refer to the study of Guyassa et al. (2018), who quantified LUC changes in Central Tigray over 80 years (1935–2014). Aerial photographs (APs) of the 1930s and Google Earth (GE) images (2014) were used. The point-count technique was utilized by overlaying a grid on APs and GE images. The occurrence of cropland, forest, grassland, shrubland, bare land, built-up areas and water body was counted to compute their fractions. A multivariate adaptive regression spline was applied to identify the explanatory factors of LUC and to create fractional maps of LUC. The results indicate significant changes of most types, except for forest and cropland. In the 1930s, shrubland (48%) was dominant, followed by cropland (39%). The fraction of cropland in 2014 (42%) remained approximately the same as in the 1930s, while shrubland significantly dropped to 37%. Forests shrank further from a meagre 6.3% in the 1930s to 2.3% in 2014. High overall accuracies (93% and 83%) and strong Kappa coefficients (89% and 72%) for point counts and fractional maps respectively indicate the validity of the techniques used for LUC mapping.

Mekuria et al. (2011) conducted a detailed regional carbon assessment in four districts of Tigray (128–158 N latitude and 368 30’–408 30’ E longitude), all having tropical semi-arid climate. Major land uses include cultivated lands (between 9 and 33 percent of the area), forest lands and exclosures (3–58 percent), grazing lands (6–39 percent) and others/shrublands (20–41 percent). The authors used standard methods to conduct vegetation inventory and to determine aboveground carbon stocks. They sampled sites from shrublands, mature exclosures/forested slopes, as well as adjacent communal grazing lands. They used the methods of Hoff et al. (2002) and Snowdon et al. (2002) to make a detailed assessment of aboveground woody biomass. A similar approach was followed by Aweke Gelaw et al. (2014) when quantifying carbon stocks at rainfed croplands.

Table G2.4. Major land cover changes and related carbon stocks in central Tigray.

Land cover category	**Land cover (%), as mapped by Guyassa et al. (2018)**		**Carbon stock estimation for land cover categories**	
	1935	**2014**	**Average AGC (tC/ha)**	**Regional reference study for AGC**
Grazing lands	6.7	18.7	*0.52*	Mekuria et al. (2011)
Mature exclosure/forest	6.3	2.3	*8.9*	Mekuria et al. (2011)
Shrubland	48	37	*3.7*	Mekuria et al. (2011)
Croplands	39	42	*<0.5*	Aweke Gelaw et al. (2014)

This intervention is targeting tree planting on plots that are currently almost devoid of trees, while smallholders will draw any existing vegetation on the plan vivo maps. Areas that are already tree covered will be left out of the project. Still, based on the results of Table G2.4, the project applies an overall carbon stock of grazing lands (~0.52tC/ha) as the initial carbon stock of the baseline scenario.

Changes in carbon stocks under baseline conditions (i.e. without project)

The baseline scenario for all project areas consists of a stable system where the plots remain almost devoid of vegetation and the fallout of the Tigray War further reduces tree density. We can reasonably expect the change in carbon stock under the baseline scenario to be stable (while even under further pressure since the Tigray War). Without active nurseries, distribution of seedlings, investment funding, planting, and training on management techniques, we can expect a stable baseline where future carbon stocks will not increase (and may even decline). Indeed, it is highly unlikely that farmers would independently plant more trees on their farms without nurseries or without extra project support.

In more standardized terms, Plan Vivo Module PU001 (applicable for Agroforestry) requires *"no change in woody biomass carbon stocks if the conditions in AR-TOOL14 v4.2 section 5 are met"*

(§5.1.2). The AR-TOOL14 vs 4.2 states in section 5: *"Changes in carbon stocks in trees and shrubs in the baseline may be accounted as zero for those lands for which the project participants can demonstrate, through documentary evidence or through participatory rural appraisal (PRA), that one or more of the following indicators apply:*

i. Observed reduction in topsoil depth (e.g. as shown by root exposure, presence of pedestals, exposed sub-soil horizons);

ii. Presence of gully, sheet or rill erosion; or landslides, or other forms of mass movement erosion;

iii. Presence of plant species locally known to be indicators of infertile land;

iv. Land comprises of bare sand dunes, or other bare lands;

v. Land contains contaminated soils, mine spoils, or highly alkaline or saline soils;

vi. Land is subjected to periodic cycles (e.g. slash-and-burn, or clearing regrowing cycles [or dry season open grazing]) so that the biomass oscillates between a minimum and a maximum value in the baseline."

We note that the above underlined conditions are valid and safeguarded as project applicability conditions.

Carbon benefits

Agroforestry provides various ecosystem services and environmental benefits while promoting eco-intensification based on more efficient use of the resources. Agroforestry systems can sequester a significant amount of carbon in above ground biomass (including trees and crops or grasses), roots and soil. Researchers showed that agroforestry systems play an effective role in global carbon sequestration, in carbon capture and in the long-term storage of atmospheric carbon dioxide. Agroforestry can often enrich soil organic carbon (SOC) better than monocropping systems, thereby reducing greenhouse gas emissions. The high diversity of woody plants and relatively better management (fencing, watering of seedlings) by farmers can be the main reasons for successful carbon sequestration by agroforestry trees.

This technical specification uses the SHAMBA model to calculate baseline and intervention carbon stocks and emissions over time. All SHAMBA input and output files are available upon request. Intervention activities per agroforestry type are detailed in Table G2.5 while all DBH growth curves are reported in Table G2.6.

Table G2.5. Intervention activities per agroforestry subtype (excluding parkland agroforestry).

Intervention	Main species planted	Initial planting density (total)	Pruning?	Thinning/ harvesting?
Boundary planting	*Faidherbia albida, Acacia polyacantha, Ziziphus spina-christi, Grevillea robusta, Moringa oleifera*	400	No	Thinning of 33% at 10 years.
Low-density homegarden planting	*Mangifera indica, Persea americana, Cordia africana, Faidherbia albida, Moringa oleifera*	625	No	Thinning of 33% at 10 years.
High-density homegarden planting	*Persea americana, Cordia africana, Grevillea robusta, Faidherbia albida, Moringa oleifera*	1250	No	Thinning of 33% at 10 years.
Woodlot planting	*Faidherbia albida, Acacia polyacantha, Ziziphus spina-christi, Grevillea robusta*	2500	No	Harvest of 20% after 5, 7, 9 and 11 years
Homestead intercropping	*Faidherbia albida, Acacia polyacantha, Ziziphus spina-christi, Grevillea robusta, Mangifera indica, Persea americana, Cordia Africana and Moringa oleífera*	300	No	No

Table G2.6. DBH growth curves (cm) of the main tree species involved (based on field

measurements of 467 trees across Tigray, see Appendix A).

Age (yr)	Gravellea	Acacia	Ziziphus	Moringa	Mango	Avocado	Cordia
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	8.1	6.5	8.9	3.0	10.0	9.9	6.4
10	15.0	13.0	15.7	16.0	17.1	18.0	19.0
15	19.0	21.9	19.7	23.6	21.3	22.3	26.6
20	21.8	28.2	22.5	29.0	24.3	25.6	31.9
25	24.1	33.1	24.7	33.2	26.6	28.1	36.0
30	25.9	37.1	26.5	36.6	28.5	30.1	39.4
35	27.4	40.5	28.0	39.5	30.1	31.9	42.2

Table G2.7. Carbon benefits (SHAMBA results) (see Appendix A for SHAMBA curves)

0	1	2	3	4	2-(1+3+4)
Intervention type (technical specification)	Baseline carbon uptake / emissions i.e. without project (t CO_2e/ha)	Carbon uptake/emissions reductions with project (t CO_2e/ha)	Expected losses from leakage (t CO_2e/ha)	Deduction of risk buffer (t CO_2e/ha)	Net carbon benefit (t CO_2e/ha)
Boundary planting	43.4	-214.9	0	-25.8 (10%)	**232.5**
Low-density home garden planting	38.2	-472.4	0	-51.1 (10%)	**459.5**
High-density home garden planting	38.2	-857.1	0	-89.5 (10%)	**805.8**
Woodlot planting	38.2	-812.2	0	-85.0 (10%)	**765.4**
Homestead intercropping	*		0	-10%	**134.6**

**The homestead intercropping model has been added to the agroforestry scheme in 2024, after the formal approval of PU001, which is why PU001 was used to calculate carbon benefits for homestead intercropping (instead of SHAMBA). For the full calculation, we refer to Annex G.*

Uncertainty and leakage

Leakage

Leakage is defined as a reduction in carbon stocks or increase in greenhouse gas emissions outside the project area, as a result of project activities. The main potential source of agroforestry leakage would come from displaced grazing, i.e. grazing pressure displaced towards other nearby areas because grazing is no longer possible inside the project areas.

This technical specification uses AR-TOOL15 version 2.0 to estimate leakage significance: A/R Methodological tool – Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity. The tool states under §10: "Leakage emission attributable to the displacement of grazing activities under the following conditions is considered insignificant and hence accounted as zero:
(a) Animals are displaced to existing grazing land and the total number of animals in the receiving grazing land (displaced and existing) does not exceed the carrying capacity of the grazing land;
(b) Animals are displaced to existing non-grazing grassland and the total number of animals displaced does not exceed the carrying capacity of the receiving grassland;
(c) Animals are displaced to cropland that has been abandoned within the last five years;
(d) Animals are displaced to forested lands, and no clearance of trees, or decrease in crown cover of trees and shrubs, occurs due to the displaced animals;
(e) Animals are displaced to zero-grazing system [e.g. feeding boxes fed by the fodder-producing trees such as Ziziphus].

Livestock densities in the pasture zones of the North Ethiopian highlands (0.67 TLU/ha) approach optimum densities (0.69 TLU/ha) (Nyssen et al., 2004). Note that a Tropical Livestock Unit is equivalent to a standard zebu ox of 250kg; for each other type of domestic animal (goats, sheep etc.) there is a conversion equivalent.

Additionally, fodder-producing trees are part of the planting mix while livestock feeding in the stable (e.g. through feed boxes) will be stimulated through trainings. Moreover, the cut-and-carry systems in nearby exclosures will counter the need for displaced grazing and will benefit children schooling (more time to go to school) and off-farm income possibilities. In general, the extent of grazing areas or the grazing intensity will not increase as a result of project activities, because an equivalent amount of fodder will be provided through fodder-producing trees and the cut-and-carry systems from nearby exclosures.

To further reduce possible leakage, extra applicability conditions are included, and milestone-based monitoring is proposed, based on independent information collected from the individual farms. Payments are thus delivered upon achievement of each of the milestones. Whenever milestones are missed, corrective actions must be implemented before the payments can be issued.

Uncertainty

Regarding the uncertainty assessment, we follow Plan Vivo Module PU005 and Tool PT001 on the Smallholder Agriculture Monitoring and Baseline Assessment. Input parameters for modelling expected baseline and project emissions must be conservative, so uncertainty of expected baseline and project emissions under application of SHAMBA is assumed to be zero, and the value Ux in PU005 is set to zero. Since actual project emissions are modelled, using model inputs from monitoring data collected from the project area, model error is assumed to be zero, and the value Ux in PU005 is set to zero.

Applicability conditions

EthioTrees follows a strict checklist listing the project applicability conditions. All project areas must meet these requirements, while the checklist can also be used when identifying candidate plots for expanding the project:

1. Project areas should be located between 12–15° N latitude and 36° 30’–40° 30’ E longitude;
2. All sites should have tropical semi-arid climate;
3. A project area can only be located on smallholder plots largely devoid of trees;
4. Project areas cannot be located on important grazing lands;
5. Woodlot plantations must be fencible, and fenced by the smallholder when relevant;
6. Boundary and homegarden plantations must be within field of view from the homestead to timely observe any potential seedling grazing – or protected against grazing otherwise;
7. Fodder-producing trees must be part of the planting mix.

Monitoring scheme

The project will rigorously keep track of the performance of each project area over time. Each project area has a PES agreement with a plan vivo map (Appendix A), along with a monitoring scheme specifying the performance-based milestones that are based on the growth rates in the SHAMBA model (Table G2.8).

Table G2.8. Milestone-based monitoring scheme

Time of measurement (yr)	**Performance-based milestone**	**Method of measurement**	**% of payment per ha to smallholder (ex ante):** homestead intercropping and high-density home garden planting	**Payment per ha (ex post):** boundary planting, low-density home garden planting, woodlot planting
0 (within one year of planting)	At least 50% of the planned number of trees is raised and protected against grazing	Physical counting of *all* new trees raised by smallholder	20%	Unlocking of annual smallholder payments during 35 years if the targets continue to be met (see*)
1	100% of the planned number of trees raised, protected against grazing and micro-irrigation happened	Physical counting of *all* new trees raised by smallholder	20%	
3	At least 65% of the raised trees surviving	Physical counting of *all* the surviving trees	20%	
5	An average DBH of at least 4cm	DBH measurements, based on a represent	10%	

		ative sample of at least 10% of the trees concerned		
7	Average DBH of at least 6cm	DBH measurements, based on a representative sample of at least 10% of the trees concerned	10%	
10	An average DBH of at least 9cm	DBH measurements, based on a representative sample of at least 10% of the trees concerned	20%	
11 to 35	Permanence of the existing tree	Annual counting, based on a	Continued free trainings upon request	

		representative sample of at least 10% of the trees concerned, or remote-sensing equivalent		

*Successful evaluation of the performance milestone is determined by a combination of on the ground technician judgement and in-office data analysis. If both the technicians and the data suggest that the producer has met the target, full payment is received every year, over 35 years. If the target has not been met but the threshold is achieved, partial payment is made and corrective actions are implemented. If the threshold is not met, payments are withheld until targets are reached the following year. In that case the project will explore jointly with the smallholder how tree growth in his field can be supported. In accordance with the technical specification, the majority of the producers will reach 100% of the planned number of trees after one year. If they miss the target, they will supplement towards 100% capacity by the following year.

It is important to note that *all* project areas are visited by project staff or by a community liaison officer in the years specified in Table G2.8.

At the first three milestone checks, all raised trees are observed (to count the number and the survival rate). At all milestone checks, diameter at breast height is measured for *every* project area at a representative subpopulation of that area (subpopulation equal to 10% of the total trees present in the project area). The subpopulation of 10% of the trees standing is sampled during linear transect walks crossing the project area and starting with a standard size (5m x 5m for seedlings, 20m x 20m for larger trees) recording every tree encountered within the areas along the transects (until the 10% target is obtained). . Alongside DBH measurements, species, number of trees and health status are recorded as well.

Thus, the project will monitor average DBH at species level. Note that it is merely the payment scheme that is based on an average DBH for mixed species. This is for matters of clarity towards participants, while project will indeed plant mixed agroforestry areas to avoid monoculture plantations and increase woody biodiversity.

Next, the project will also monitor SOC over time in at least 10 fixed survey plots per agroforestry subsystem. At every fixed survey plot, a composite soil sample is created by mixing 5 soil samples taken in the corners and in the middle of a 5x5m compartment. Samples are taken by augering in the 0-0.2 m depth. The method of Walkley-Black (Walkley and Black, 1934) is used for soil organic carbon determination (in %C) of the composite soil samples. Soil organic carbon content (SOC, in ton C/ha) can then be calculated following Mekuria et al. (2011) (see PDD, section §K), and resampled every 5 years.

In the same fixed plots, the project will also monitor the Shannon biodiversity index every 5 years.

Note that it is possible for a cohort of smallholders to collaborate, for instance to create impact at catchment scale. In that case, a *gudjle Im'at* must be in place and all participating farmers need sign individual agroforestry PES agreements (see Annex 3). Onboarding, dropouts, and fair representation are then organized by the local *gudjle Im'at* or "farmer development group". Development groups exist to improve the transfer of knowledge on modern agricultural techniques and technologies to and among farmers through a number of trained contact farmers. They have formalized bylaws prescribing their organization and decision making. Grouped together, a number of *gudjle Im'at* working together may form a larger "watershed committee". In any case, farmers must sign individual PES agreements, while the role of the gudjle Im'at is to support the environmental management.

The tech spec and sequestration rates will be updated using the field monitoring data at each verification cycle, i.e. at least every 5 years. In case there is a significant difference between the modelled and the monitored data, the tech spec and sequestration rates will be updated and resubmitted to the TRP. The project customized a Q Field application to oversee and manage the large amount of data that are generated.

H. Risk Management

Risk matrix, risk areas and risk buffer

EthioTrees uses the following risk framework (Table H2):

Table H2: EthioTrees risk framework

Managing intervention risks:
Risk appetite

Probability	1-Negligible	2-Minor	3-Moderate	4-Major	5-Severe
4-Almost certain	4-Low	8-Medium	12-High	16-Extreme	20-Extreme
3-Probable	3-Low	6-Medium	9-Medium	12-High	15-Extreme
2-Possible	2-Low	4-Low	6-Medium	8-Medium	10-High
1-Unlikely	1- Low	2-Low	3-Low	4-Low	5-Medium

Potential impact

Building on this risk framework, the following risk matrix was established (Table H3)

Table H3: Risks and mitigation measures

<table>
<tr><th>Identification</th><th colspan="3">Assessment
after mitigation measures have been taken</th></tr>
<tr><th>Risks</th><th>Probability</th><th>Potential impact</th><th>Total risk level</th></tr>
<tr><td>Social and political
• The selection of target groups creates social bias.
• Political or social instability in Tigray; political opposition to the project</td><td>1</td><td>4</td><td>4</td></tr>
<tr><td colspan="4">Justification. The selection of target groups does not lead to significant risks, partly because of ethnic homogeneity.
Despite and during the Tigray War, the project continued to operate and expand its operations. By November 2022, when the war ended after the Pretoria Peace Agreement, the forest continues to be sustainably managed by the communities. This has been corroborated by both independent field surveys and satellite studies. To avoid political opposition to the project, the project design is fully in line with the Ethiopian Federal Government's Climate-Resilient Green Economy Strategy. Their general aim is to invest around 150 billion US dollar in climate and land resilience, 80 % of which could be raised from carbon credit schemes (FDRE, 2011).
In line with the Government's Climate-Resilient Green Economy Strategy, reforestation is key to adapting to hydroclimatic changes in the Ethiopian Highlands. Overall, the fight against land degradation and climate change has become a central element of Ethiopia's government policies.</td></tr>
<tr><td colspan="4">Mitigation measures. There are additional mitigation measures to counter the risk of gender imbalance (see further).</td></tr>
</table>

To minimize the risk from instability and disinterest in Ethiopia, we consider it important to work closely with the Belgian Embassy in Addis Abeba, as well as with Mekelle University and local agencies (Bureaus of Agriculture and Relief Society of Tigray).			
Economic • Insufficient incentive to support project activities • Alternative land uses become more attractive to the local community; Community support for the project is not maintained • External parties carry out activities that reverse climate benefits; rights to benefits are disputed	2	2	4
Justification. With regard to restoration, the hizaéti have been established before the start of the project, the risk of a lack of incentive is minimized. The incentive-based approach enhances permanence of the activities. For instance, one farmer in Togoga told us: "I like this approach. It is very different from previous projects. Normally, the government comes with a budget for wages to build stone bunds. So, we make sure that the stone bunds have low quality, to make sure that we get wages again next year." Because of the focus on non-timber forest products and because the hizaéti are established by bylaw, switching to alternative land uses will be unattractive for the local community, and forbidden by bylaw. With regard to agroforestry, smallholder farmers are the direct beneficiaries and therefore highly incentivised to properly manage their agroforestry plots on their household property land. Besides, the second agroforestry milestone (see techspec) demands the protection against grazing and use of micro-irrigation. Also, applicability condition 5 (woodlot plantations must be fencible, and fenced by the smallholder when relevant) and 6 (boundary and homegarden plantations must be within field of view from the homestead to timely observe any potential seedling grazing – or protected against grazing otherwise) further cushion possible grazing risk. Finally, given the challenges of dry season open grazing, parkland agroforestry is not considered for the purpose of the agroforestry technical specification. The legal protection of the bylaw, as well as the PES agreement, prohibits external parties to carry out activities that reverse climate benefits, while the PES agreement discusses the procedure to handle disputes.			
Mitigation measures. The project will focus on non-timber forest products to create incentives for smallholder farmers and communities to support ecosystem restoration. All hizaéti should be established by bylaw. The project clearly informs smallholder farmers and communities of their responsibilities of selling carbon credits through trainings. The project provides regular trainings on (i) technical (agro)forestry issues; (ii) commercial (NTFP sales) issues; and (iii) methodological issues (Plan Vivo methodology, responsibilities).			
Environmental • Fire • Open grazing • Pest and disease attacks • Extreme weather or geological events	1	4	4
Justification. These issues are not common in the project area, and we have no observations of fire, pest and extreme weather or geological events significantly impacting ecosystem restoration in Dogua Tembien on the long term.			
Mitigation measures. To reduce risks of pests and disease attacks, seedling planting should involve a biodiverse mix of different species. Biodiversity will be monitored (see monitoring section).			
Leakage of carbon benefits • Project leads to displaced grazing • Project activities fail to deliver expected benefits	2	2	4

Justification. The risk that the establishment of new hizaéti could lead to higher cattle pressure on rangelands elsewhere in the village or in neighbouring villages is low (for details, see leakage section).			
Mitigation measures. To avoid these issues, the following measures will be taken: (i) New hizaéti that can be incorporated in the project can only be located on contemporary degraded rangelands or wastelands and not on croplands or important grazing lands. (ii) The establishment of new hizaéti must follow intensive interviews and discussions in the village, and can only be implemented if the neighbours and village council agree on the design of a set of clear rules. These rules should include the establishment of bylaws, compensation for reduced grazing areas (such as distribution of feed boxes) and guarding of the hizaéti. (iii) To avoid increased grazing pressure elsewhere in the village when working with a newly established hizaéti, EthioTrees will encourage livestock feeding in the stable (e.g. by stimulating feed boxes). Such interventions have been implemented before for farmland hizaéti and zero-grazing, with positive outcomes (Baudron et al., 2015). Moreover, to date, several social factors (children schooling, increased off-farm income possibilities) are already leading to decreased grazing pressure that goes in line with hizaéti establishment.			
Administrative • Capacity of the project coordinator to support the project is not maintained • Technical capacity to implement project activities is not maintained	2	2	4
Justification. The local coordinator, Mr. Seifu Gebreselassie is an experienced forester with an extensive social network in the Dogua Tembien area. He works closely with the members of EthioTrees as well as with the members of the hizaéti associations, and with the 'woreda'.			
Mitigation measures. The project aims to expand its workforce during the course of the project. A scientific advisory board supports the project coordinator and provides technical advice, while Mekelle University provides additional technical capacity.			

As the overall level of risk is low in all of the analysed risk areas, the risk buffer that will be foreseen is 10%.

I. Project Coordination & Management

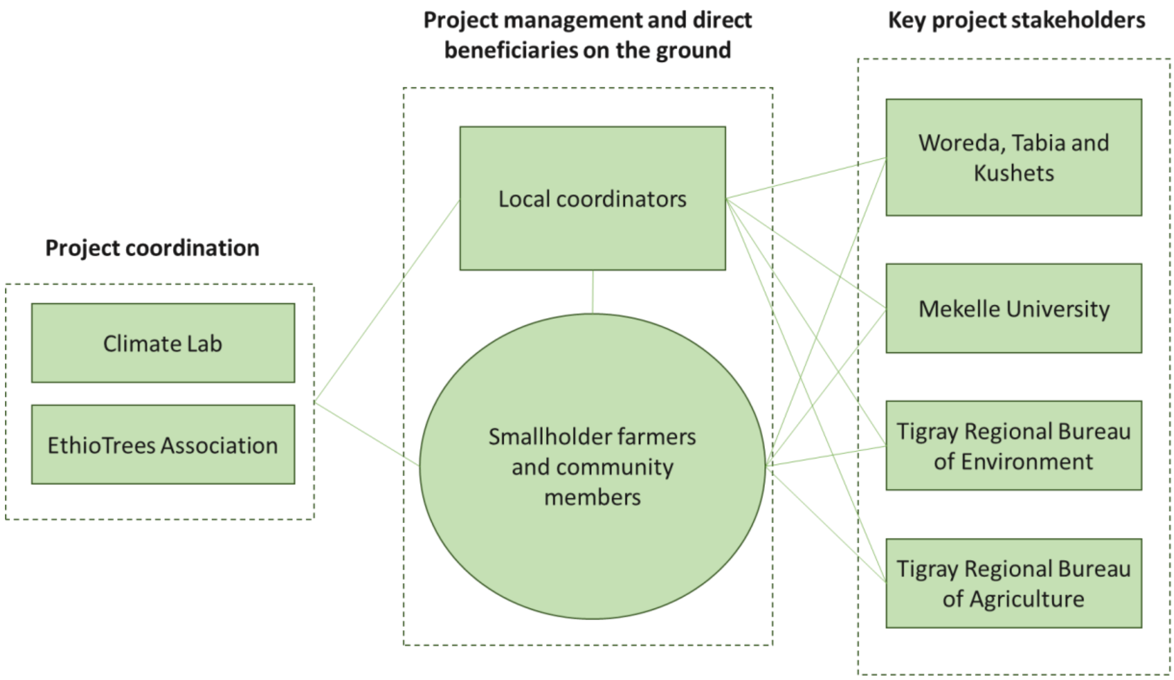
Project Organisational Structure

The project is coordinated by EthioTrees Association Ethiopia and Climate Lab Belgium. In short, Climate Lab takes care of the higher-level monitoring activities, such as developing project management guidelines, carbon calculations, and integrated assessment of the project activities. EthioTrees Association is responsible for managing the project activities on the ground, including administrative reporting (see table I.1 for more details).

EthioTrees association is the partner in Ethiopia (i.e. a legal Ethiopian association with 10 members). EthioTrees is thus a combined Belgian-Ethiopian organisation aiming to promote ecosystem restoration and non-timber forest production in the Ethiopian Highlands, by supporting woodland natural regeneration and frankincense production development. The members of EthioTrees in Ethiopia include the coordinator, Mr. Seifu Gebreselassie, and 9 farmers from across Dogua Tembien.

A scientific advisory board was established with people that are linked with different relevant research departments at Mekelle University and is led by Dr. Tesfaalem Gebreyohannes.

A summary of the stakeholders of the project is schematized in Figure I.3. The project "Ecosystem restoration and agroforestry by smallholder farmers in Tigray (North Ethiopia)" is fostered by Climate Lab and EthioTrees association, along with interested smallholder farmers and 'hizaéti associations' of landless farmers. Cooperation with all local authorities (woreda, tabia, kushet) will remain close.



Schematized summary of the stakeholders of the project Note: *woreda* = district; *tabia* = sub-district; *kushet* = municipality.

Relationships to national organisations

The project works very closely with the local "woreda" (district) council and the Bureau of Agriculture of Dogua Tembien. Simultaneously, EthioTrees had meetings and agreed with all leaders of the sub-districts (*tabias*) within the project zones. Close contact with the responsible authorities ensured that necessary permissions and by-laws were agreed on, and that project benefits are shared with the community and village entity. Further, the Regional Bureau of Agriculture and Environment agreed to support EthioTrees with any logistical and administrative help if required.

EthioTrees is in contact with the Federal Ministry of Environment, Forest and Climate Change (i.e. the Responsible Designated National Authority of Ethiopia) (see PIN) and has strong contacts with Mekelle and the Belgian Embassy in Ethiopia (see Technical Support).

Legal compliance

The legal coordination of the project (including administration) is handled by the EthioTrees local coordinator (Mr. Seifu Gebreselassie). After an open announcement of the vacancy, he was officially employed by the EthioTrees (Ethiopia) legal association in 2016. EthioTrees Ethiopia is a legal association and all contracts are in accordance with federal or regional (labour) laws.

Mr. Seifu Gebreselassie is an experienced forester with an extensive social network in the Dogua Tembien area. He works closely with the members of EthioTrees as well as with the members of the hizaéti associations, and with the 'woreda'. As stated above, the governance structure has been formalized in a Memorandum of Understanding between all relevant actors.

Concerning ecosystem restoration activities, the local coordinator is responsible to:

- provide training and consultancy to all interested individuals or entities linked with the activities of EthioTrees and requesting these services;
- actively search for areas that are suitable for improved hizaéti management, and make sure that the authorities, the farmers and the farming associations agree with these activities;
- work using a community-driven approach, by fully taking into account the demands of the local farmers and population;
- purchase a variety of tree seedlings, and coordinate the improvement activities of an estimated 300 hectares of hizaéti per year in the designated project zones;
- regularly monitor socio-economic conditions within the project zones, following the guidelines that have been provided (i.e. qualitative interviews and socio-economic survey).
- regularly monitor biodiversity, biomass and soil organic carbon content within the project zones, following the guidelines that have been provided (i.e. sampling along transect lines, biomass measurements, mixed soil sampling and organic carbon analysis at the Laboratory for Soil Chemistry at Mekele University).

Concerning non-timber forest activities, the local coordinator is responsible to:

- provide training and consultancy on honey and oil production to all interested individuals or entities linked with the activities of EthioTrees and requesting these services;
- actively involve in setting up the bee hives by the associations of landless farmers, and check on the quality of the honey.

Project management

An approximate timeline for project establishment, piloting, scaling up and monitoring is given below:

- February 2016: Project establishment
- March 2016 and after: Piloting, baselining and start in Adi Lehtsi, Meam Atali and Gidmi Gestet
- July-August 2016: Approval of PIN by Plan Vivo
- April 2017: Submission of PDD
- December 2017 and after: Scaling up towards 4000 hectares in Dogua Tembien over 5 years

- Monitoring rounds will be organized in 2022, 2026, 2031, 2036 etc

This restoration project will issue ex-post on an annual basis, based on the annual activity-based monitoring framework and verified every 5 years. Agroforestry activities will issue ex-ante and ex-post credits.

All project data are stored on a shared drive with limited access (Google Drive). The project data (technical data, financial data, monitoring data) are updated on the drive at least once per month. All daily activities, and daily expenses in Ethiopia, are monitored in a separate database. Regularly, scans of invoices and receipts are made and stored on the drive.

EthioTrees uses a 'balanced scoreboard' as a longer-term strategic management tool and is thus continuously setting and monitoring internal (quantitative) targets for the coming years. Climate Lab will be in charge of business development, sales and managing transactions on the Markit environmental registry (Markit). The responsibilities for Project coordination and Management are outlined in table I.1.

Table I1 Responsibility for Project Coordination and Management Functions

Project Coordination and Management Function	Responsible Party/Parties
Stakeholder engagement during project development and implementation	ETA
Ensuring conformance with the Plan Vivo Standard and compliance with applicable policies, laws and regulations	CL
Developing technical specifications, land management plans and project agreements with project participants	CL
Ensuring that the PDD is updated with any changes to the project	CL
Registration and recording of management plans, project agreements, monitoring results, and sales agreements	CL
Managing project finances and dispersal of income to project participants as described by the benefit sharing mechanism	CL
Managing Plan Vivo Certificates in the Plan Vivo Registry	CL
Preparing annual reports and coordinating validation and verification events	CL
Securing certificate sales and other means of funding the project	CL
Assisting Project Participants to secure any legal or regulatory permissions required to carry out the project	ETA
Providing technical assistance and capacity building required for project participants to implement project interventions	ETA
Monitoring progress indicators, livelihood indicators and ecosystem indicators and providing ongoing support to project participants	ETA
Measurement, reporting and Verification of Carbon Benefits	CL

Project financial management

All income from the sales of Plan Vivo Certificates will be spent following a community consultation per association, meaning 60% of the income from the sales of the certificates will be allocated for investment (see PES agreement). It has been agreed that all income will be used fully for investments in social or environmental projects that should benefit the local community, preferably in line with the future plan of the area as developed by the communities themselves.

Once an association agrees upon a certain investment and a fitting investment budget is estimated, payments will be made directly to the contractor that wins the bid of the investment. Investments will be subject to standard contracting practice, allowing fair competition for regional contractors. All contracts will be overseen by EthioTrees Ethiopia and EthioTrees will guarantee that at least 60% of the income from the sales of the certificates will be covered by a social or environmental investment.

The project budget and financial plan is available upon request; more details are given in Annex. The project has obtained co-financing from Belgian partner organisations and subsidies for the operational phase of the project, but will use income from the sales of Plan Vivo Certificates to cover additional costs.

Marketing

A multi-phase marketing plan is under development. An attractive website is implemented, together with social media (LinkedIn). Specific segments in the Belgian private sector are targeted during every phase. Attention is given to the following market segments: “carbon retailers” in Belgium, France and the Netherlands, or the wider EU, aromatic oil and perfume companies in Belgium and France, and Flemish Universities (Belgium).

Technical Support

The local coordinator will continue to follow trainings on sustainable forest management and sustainable frankincense production, to be able to continue to deliver useful trainings to the communities.

Technical support is also derived from the network of EthioTrees with different universities. EthioTrees has strong links with the Physical Geography research group of Ghent University, which has conducted extensive research on soil and vegetation cover dynamics in Northern Ethiopia. Reseach focusses on physical geography, soil science, forest cover changes, land and water dynamics and remote sensing.

Further, EthioTrees has excellent contacts in Ethiopia (Mekelle and Bahir Dar University, the Belgian Embassy in Ethiopia, regional government officials, woreda authorities) and established links with the broader environmental research community. Technical and logistical support (cars, laboratories, soil sampling equipment etc.) can be delivered (rented) through Mekelle University. EthioTrees members are linked with several Flemish university development cooperation (VLIR and BOF) projects in North Ethiopia. The project benefits from the experiences learned by the “Sustainable access to safe drinking water and improved sanitation in the semi-arid North Ethiopia, with focus on the interaction between urban and rural areas” (SELAM-WATSANI) project in Dogua Tembien. The project works closely with colleagues from the NGOs “Ma’ar” and "Trees For Farmers", given their experiences in upscaling honey production in hizaéti, and in reforesting small-scale areas in the Northern Ethiopian Highlands respectively.

J. Benefit sharing

PES agreements

PES agreements are made with the community for the restoration areas (A) and directly with the smallholder farmers for the agroforestry practices (B).

(A) Associations or communities wanting to enter into payments for environmental services (PES) agreements for hizaéti restoration with EthioTrees, will request for a meeting, followed by signing a PES agreement. Thereafter, the process of establishing plan vivos can start. The coordinator of EthioTrees Ethiopia visits the hizaéti and communities on a regular basis to ensure that obligations are met. The program is community-driven (as it all starts with establishing plan vivos), and incentive-based (as it is based on Plan Vivo crediting after efforts have been made). EthioTrees has established an extensive monitoring program (for soil carbon, biomass, socioeconomic surveying, biodiversity) (see Part K). This allows a strict follow-up of the results and obligations over the course of the project. The most significant risk regarding PES agreements remains an inefficient management of the hizaéti. This risk can be minimized by providing extensive trainings to the communities or associations involved.

(B) Smallholder farmers or associations wanting to enter into an agroforestry PES agreement with the project have to create an individual Plan Vivo map. These smallholder farmers are provided with tree seedlings from the local nursery and technical trainings for optimal management of the plots. The only criterion for smallholder farmers to enter into a PES agreement with the project is that they have sufficient free land to plant at minimum 50 tree seedlings. Once farmers are registered with the project, they can then enter into PES agreements that specify the amount of carbon that they will sell together with the terms and conditions of the monitoring activities. Payments are based on the amount of carbon each household has generated from the implementation of the project's activities. The agroforestry PES agreement templated is included in Appendix A.

Payments & Benefit Sharing

(A) As stated before, all income from the sales of Plan Vivo Certificates from ecosystem restoration will be spent following a community consultation per association or community (i.e. per hizaéti during bayto). Payments are indirectly linked to hizaéti management performance, as the income from the sales of the certificates from any particular hizaéti depends on the performance (see PES agreement) and will be allocated for investment in or near that hizaéti. It has been agreed that all income will be used fully for investments in social or environmental projects that should benefit the local community, preferably in line with the future plan of the area as developed by the communities themselves. Payments will be withheld if there is clear evidence for fraud, or a clear violation of the PES (see PES for details).

(B) The agroforestry monitoring indicators form the basis of the results-based system and disbursement mechanism. Payments are made to smallholder producers according to predetermined milestones. The producers who do not meet their targets have their payments deferred until a set of required corrective actions are implemented. Table J1 describes the monitoring milestones in the first 10 years of the project.

Table J1: Payment breakdown

Time (yr)	Performance-based milestone	Direct payment/ha to farmer (ex ante)
0 (within 1 year of planting)	At least 50% of the planned number of trees is planted and protected against grazing	20%
1	100% of the planned number of trees planted, protected against grazing and micro-irrigation happened	20%
3	At least 65% of the planted trees surviving	20%
5	An average DBH of at least 4cm	10%
7	Average DBH of at least 6cm	10%
10	An average DBH of at least 9cm	20%

Financial structure

EthioTrees guarantees that there is equitable and transparent benefit sharing by the project.

(A) For community reinvestments, as stated above, once a bayto or an association agrees upon a certain investment and a fitting investment budget is estimated, payments will be made directly to the contractor that wins the bid of the investment. This direct transfer is required in order to minimize transaction cost and risk, or possibly corruption, and to maximize transparency. Investments will be subject to standard contracting practice, allowing fair competition for regional contractors. All contracts will be overseen by EthioTrees Ethiopia and Climate Lab will guarantee that at least 60% of the income from the sales of the certificates will be covered by a social or environmental investment, in accordance with the PES agreement. (B) The use of funds acquired from the sale of Plan Vivo Certificates from agroforestry plots will be divided into two broad categories. 40% will go to program operations and development whereas the remaining 60% will go into a separate Plan Vivo Trust Fund. This fund is effectively a distinct Belgian account administrated by Climate Lab and earmarked for payments to smallholder producers. These funds will be distributed periodically over a ten-year period based on milestones according to the technical specifications. Prior to disbursement, the money will be kept in a special fund and the interest will be used to cover the financial transaction fees of paying the producers.

From the 60% partim smallholder farmers receive, one tenth of each payment is shared with the community to support community and nursery reinvestments. This one tenth is redistributed in line with the system in place for restoration driven community reinvestments (see (A) in the paragraph above).

Once producers reach technical specifications' density targets, an internal monitoring of each Plan Vivo is done annually. Over the project lifetime, payments are issued to the producer according to a predetermined schedule based on project targets. Successful evaluation is determined by a combination of on the ground technician judgement and in-office data analysis. If both the technicians and the data suggest that the producer has met the target, full payment is received. If the target has not been met but the threshold is achieved, partial payment is made and corrective actions are implemented. If the threshold is not met, payments are withheld until targets are reached the following year. In accordance with the carbon accounting model, the majority of the producers will reach 100% planting after one year. If they miss the target, they will replant towards 100% capacity by the following year. Farmers are suspended from the project if they leave before the end of their monitoring period or miss two yearly targets in a row. It is then assumed that all trees have been cut.

K. Monitoring

As mentioned, two different technical specifications are developed: we refer to G2 for the Agroforestry Specifications (and related monitoring protocol). Below the restoration monitoring specifications are listed.

Ecosystem services benefits

EthioTrees has established an extensive monitoring program to measure and follow-up results (in terms of soil carbon, biomass, socioeconomic surveying, biodiversity), as summarized in Figure K1. Certificates will be issued based on the expected change in carbon stocks, and monitoring data will be used to validate and revise the estimates when the PDD is updated (every 4-5 years). In every PDD update (in year x), the evolution of all monitoring indicators presented below will be evaluated (soil carbon, biomass, socio-economic status, biodiversity and water) per hizaéti, to determine the number of certificates the project is eligible to receive. In particular, we will calculate the “observed total carbon increase” (i.e. total carbon in year x minus total carbon in 2017; including both soil carbon and biomass) to adjust the total carbon benefit estimates presented above (tCO2 per hectare per year).

Adjusted total carbon benefit estimates will be used to calculate the number of certificates the project will be eligible to receive during the next monitoring period.

Annual progress reports will present the annual monitoring results of the project (see below) but will also be used to add new hizaéti in the project and to estimate the number of certificates these new hizaéti will be eligible to receive.

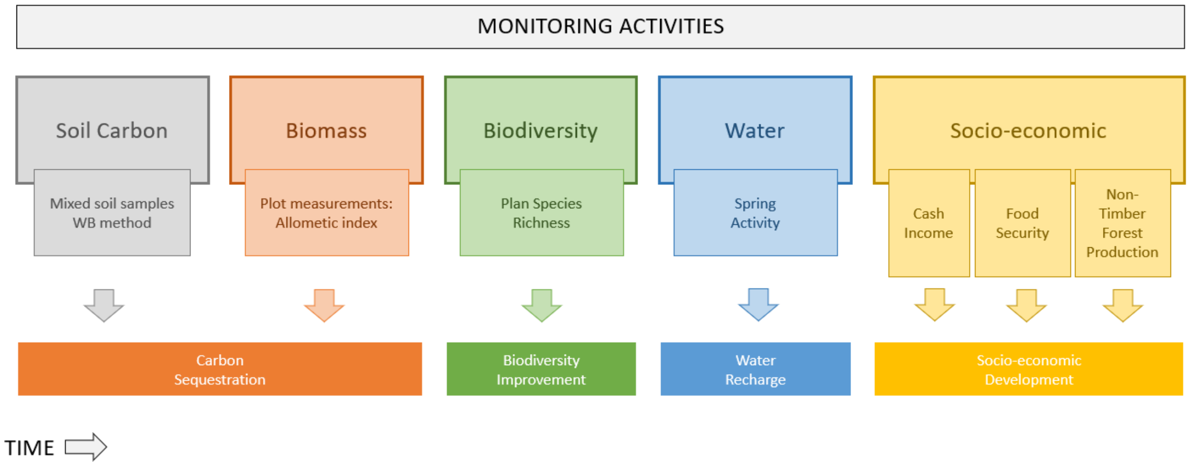


Figure K1. Monitoring activities in the hizaéti of EthioTrees, including soil carbon, above-ground biomass, biodiversity, and socio-economic development.

EthioTrees involves the communities as much as possible in the monitoring activities. Local people are trained for soil and water conservation activities. They also participate in the interviews on fauna, as well as in the socioeconomic surveys.
After every monitoring round and data analysis, a meeting with the participating communities is organized to communicate the results.

Biomass monitoring

In every hizaéti, a systematic vegetation survey was conducted. In each exclosure, survey compartments were taken on parallel survey transects. The project survey plot density must always be in accordance with CDM A/R Methodological Tool "Calculation of the number of sample plots for measurements within A/R CDM project activities". GPS coordinates (in WGS-84) of all locations are taken and every plot is resampled every 5 years. At every survey compartment location, nested compartments are surveyed:

In all strata or in the whole hizaeti, permanent sample plots (PSPs) are established on randomly generated locations as squares of 20 m x 20 m. Within the PSPs a nested plot of 5 m x 5 m is delineated in the northern corner. Plots are established by pinpointing the centre with a (precision) GPS and marking the corners along the North-South and East-West axes with fixed stones painted in white. The centre is marked with a big stone, metal bar or plastic tube.

All woody species in the PSP (20 m x 20 m) with a diameter at stamp height (DSH) of at least 2 cm and a height (H) > 1.5 m are identified and heights as well as diameters are recorded. DSH is defined at 0.3 m. The diameters of large trees are measured and recorded at breast height (DBH), if DBH is equal to or greater than 10 cm. DBH is defined at 1.3 m.

In the nested compartment of 5 m x 5 m all seedlings (H< 0.5 m) and saplings (0.5 m≤ H ≤1.5 m) of woody species with a DSH < 2 cm are determined and measured as well. All woody species are tagged. The total tree height is measured with a measuring pole if trees or shrubs are smaller than or equal to 7 m and with a hypsometer if higher than 7 m (only if a hypsometer is available for use).

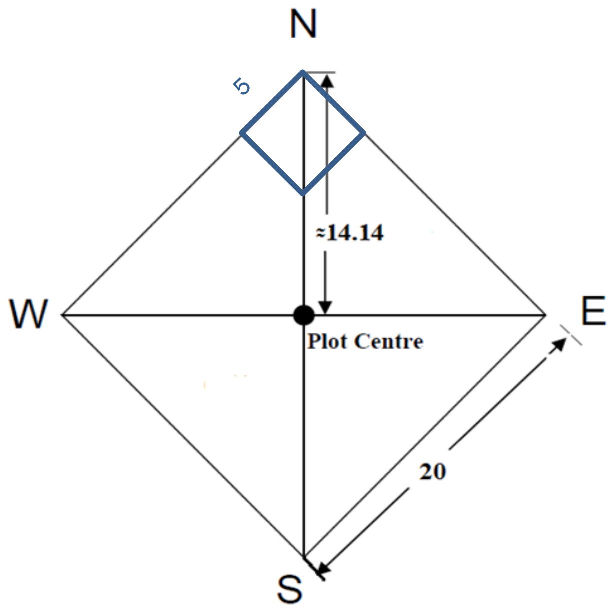


Figure Permanent sample plot design (distances in m)

Because it is not possible to plant *Boswellia* seedlings, *Boswellia* species were excluded for the baselining as they will be excluded for further monitoring and for project benefits. Recording and measuring of every plant included the name of the species, frequency, the circumference, the diameter at breast height DBH (in cm), the crown diameters L and W (in cm) and the average height H (in cm).

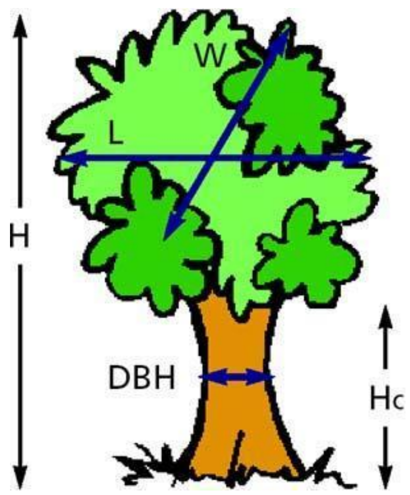


Figure K2. Parameters for the biomass estimations.

Note: Large tree (DBH ≥ 10 cm) diameter measurement details

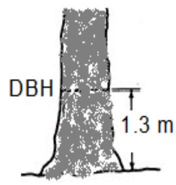
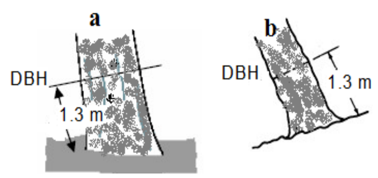
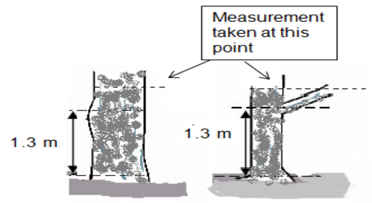
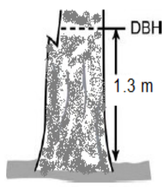
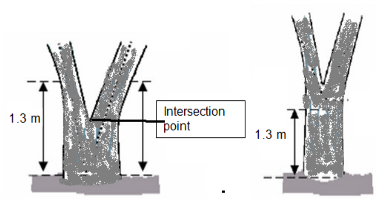
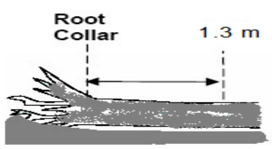
Trunk form	Where to measure
Diameter on flat ground: Measure DBH at 1.3 m above the ground.	
Leaning tree: Measure diameter at 1.3 m from the ground along the bole.	
Tree with irregularities at DBH: On trees with swellings, bumps, depressions, and branches at DBH, diameter will be measured immediately above the irregularity at the place it ceases to affect normal stem form.	
Missing wood or bark: Do not reconstruct the DBH of a tree that is missing wood or bark or at the point of measurement. Record the Diameter of the wood and bark that is still attached to the tree.	
Forked tree: **Trees forked below 1.3 m.** Trees forked below 1.3 m are treated as separate trees. DBH is measured for each stem at 1.3 m above the ground. **Trees forked at or above 1.3 m.** Trees In this case the tree count as one single tree. If a fork occurs at or immediately above 1.3 m, measure diameter below the fork just	
Live but lying tree: Measurement must be taken from the the root collar along the length to 1.3 m	

Figure K3. Sampling height and crown diameter on the field.

We used a linear regression equation approach that requires the selection of a regression equation that is best adapted to the conditions in the project area. Linear regression models have been fitted to data in various situations of variable site and ecological conditions globally. The work done by Brown et al. (1989) and FAO (1997) on estimation of biomass of tropical forests using regression equations of biomass as a function of DBH is central to the use of this approach. Some of the equations reported by Brown, Gillespie and Lugo (1989) have become standard practice because of their wide applicability. Based on the local climatic conditions, above-ground biomass AGBM (kg) of every tree or shrub was calculated using the most fitting allometric equation (FAO, 2017):

$$AGBM = \exp\{-1.996 + 2.32 \times \ln(DBH)\} \quad (R^2 = 0.89)$$

This equation can be applied in dry transition to moist tropical climates if: $5 < DBH < 40$ cm.
To date, an improved locally developed equation is available (Ebuy et al., 2018), so we report using both equations.

Above-ground biomass was summed for all trees and shrubs of compartment types, and values were rescaled to ton/ha. Above-ground carbon (ton/ha) was then calculated for all hizaéti:

$$C = 0.55 \times AGBM \text{ (FAO, 2017; Winrock, 1997)}$$

Soil organic carbon monitoring

In every hizaéti, soil samples were systematically taken for analysis of soil organic carbon. In each hizaéti, soil samples were taken on the same biomass survey transects. GPS coordinates (in WGS-84) of all sampling locations were taken. At every sampling location, a composite soil sample was created by mixing 5 soil samples taken in the corners and in the middle of a 5x5m compartment. Samples were taken by augering in the 0-0.2 m depth, and where possible, also samples of the 0.2-0.3 m depth were taken. At every sampling location, thickness of the black topsoil D was determined by calculating the average thickness over the 5 augerings at that location (in m).


Figure K5: Measurement of soil thickness in augering hole, in a 5x5m compartment.

The method of Walkley-Black (Walkley and Black, 1934) was used for soil organic carbon determination (in %C) of the composite soil samples. Analysis was performed in the laboratory for soil chemistry, Mekelle University. The method of Walkley-Black is a reliable and standard chromic acid wet oxidation method. Oxidisable matter in the soil is oxidised by potassium bichromate solution. There is heat generation when sulfuric acid is mixed with the dichromate. The remaining dichromate is titrated with ferrous sulphate. The titre is inversely related to the amount of C present in the soil sample.

Soil organic carbon content (SOC, in ton C/ha) was calculated using the following equations (Mekuria et al., 2011; Hoff et al., 2002; Snowdon et al., 2002):

$$SOC(tonC/ha) = (\%C.\%100).Bd.D.\alpha$$

Where Bd is the bulk density (ton/m^3), D is the thickness of the black topsoil (fixed at 0.2m), and α is 10.000 m^2/ha. As bulk density values for North Ethiopian topsoils vary between 1.28-1.38 g cm^{-3} (Girmay et al., 2009), we use a median bulk density of 1.33 g cm^{-3} in this PDD as a realistic value that is based on a reliable regional study. The literature value cannot affect the carbon benefit estimations, as the same value will be used in the future to monitor soil carbon stocks over time.

Biodiversity monitoring

Based on the vegetation survey, we could calculate the total number of plant species in the community (richness S), as well as the proportion of species *i* relative to the total number of species (p_i). Including the natural logarithm of this proportion ($\ln(p_i)$), we calculated Shannon's diversity index as a robust index for biodiversity status in the EthioTrees project areas:

$$H = -\sum_{i=1}^{S} p_i \ln(p_i)$$

Socio-economic impacts

Quantitative interviews were performed during a systematic survey. The interviewees consisted of two groups: a group with participants who are joining our project, and a control group of randomly selected farmers.

In order to avoid interference, all 49 interviews were held individually by the local project coordinator, who filled in the questionnaire together with the interviewees. The full questionnaire is given in Annex 4.

Then, answers to the questionnaires were digitized in a spreadsheet. Standard statistical tests were applied, as well as non-parametric tests to compare the group of participants with the control group. Results of the baseline study are discussed in Part G.

The systematic survey will be repeated every 4-5 years. The first survey repeat took place over the course of 2023.

Hydrological and hydrogeological monitoring

Initially the project wanted to monitor groundwater recharge using catchment discharge measurements. To date, no data are available yet. Due to several field difficulties, the results were incomplete and unreliable. The project will monitor on an annual basis the activity of spring water or groundwater availability in the project areas, using semi-quantitative interviews.

Figure K4. Water discharge measurements near the Adi Lehtsi catchment outlet.

Governance monitoring

EthioTrees wishes to help organizing (and measure the number of) publications and events conducted by local authorities in Dogua Tembien about the potentials of sustainable community forestry.
EthioTrees also wishes to help organizing (and measure the number of) field activities organised by Mekelle University about the sustainable management of community forest hizaéti.
Finally, EthioTrees wishes to follow-up the number of landless famers M/F (non-beneficiaries) that replicate the model of chain of value management of good quality honey and/or frankincense oil from their forest hizaéti within the Tigray region, outside the Dogua Tembien district.

Annual monitoring

As certificates will be issued based on the expected carbon benefits, rather than direct measurements, annual progress reports will present activity-based indicators to determine whether the project activities are being carried out as needed to achieve the expected benefits.
The annual activity-based indicators will include:

Ecosystem Services Monitoring

Activity	Activity Indicator (measure annually)	Annual Targets			Results
		Full Target Achievement	Partial Target Achievement	Missed Target	
Restoration activities	Area of each exclosure undergoing active restoration activities	>10%	=10%	<10%	
Tree Planting	Number of seedlings	>=10000 seedlings	<10000 and >=5000	<5000 seedlings	
	Survival Rate	>=60%	<60 and >=40	<40%	

** If one or more of the indicator values is below its performance target for one monitoring period, the full issuance is received but corrective actions must be implemented. In 2023, seedlings will be planted again.*

Socioeconomic Monitoring

Activity	Activity Indicator (measure annually)	Annual Targets			Results
		Full Target Achievement	Partial Target Achievement	Missed Target	
Capacity-Building	Number of organized trainings for landless farmers (M/V) per year per exclosure	1		0	
	Participants from more vulnerable groups (women, youth, elderly people)	>25%		<25%	
Availability of grass fodder	Beneficiaries of grass fodder per exclosure	>=3	<3 and >=2	0	
Countering displaced grazing	Index for number of observations of displaced grazing mentioned during the yearly meeting of association, other NTFP users and the village council and corroborated in the field by EthioTrees staff(*)	<2	2	>2	
Countering timber harvesting on public lands	Index for number of observations of timber harvesting on public lands mentioned during the yearly meeting of association, other NTFP users and the village council and corroborated in	<2	2	>2	

	the field by EthioTrees staff(*)				

* The indexes are categorized in five scores with 2 being medium pressure. A category 2 for grazing pressure agrees with little presence of livestock dung and hoofmarks, soil not compacted and grasses abundantly available. A category 2 for harvesting pressure agrees with little evidence of illegal stem or branch cuttings. These indices are mapped every year as "disturbance maps" that are publicly available in the EthioTrees dataroom:
https://drive.google.com/drive/u/4/folders/1mdCAvwTZZ1ixZKfx4KktqTwSAm5Ihjxq

Environmental Monitoring

Activity	Activity Indicator (measure annually)	Annual Targets			Result and mitigating actions
		Full Target Achievement	Partial Target Achievement	Missed Target	
Water Management	Number of Percolation Ponds per exclosure	>=2	<2 and >=1	0	

There are the following consequences for certificate issuance and corrective actions that will be implemented if the yearly performance targets are not met:

(i) If the values for all indicators meet or exceed their performance target, the full issuance is received;

(ii) If one or more of the indicator values is below its performance target for one monitoring period, the full issuance is received but corrective actions must be implemented;

(iii) If one or more of the indicator values is below its performance target for two consecutive monitoring periods, certificate issuance is withheld until corrective actions have been implemented and the performance target(s) have been reached.

Annexes

Annex 1. List of key people involved with contact information

Name	Function	Adress	Mobile
Sil Lanckriet	Coordinator Climate Lab	Begijnenweide 51, 9860 Oosterzele, Belgium (home)	+32491758599
Miro Jacob	Coordinator Climate Lab	August Sniedersstraat 11, 9000 Gent, Belgium (home)	+32484988177
Seifu Gebreslassie	General Coordinator EthioTrees Association	Ethiopia, Tigray Mekelle	+251914112493
Gebrekidan Mesfin	Operational Coordinator EthioTrees Association	Ethiopia, Tigray, Mekelle	+251914159782

Annex 2. Information about funding sources

Available upon request

Annex 3. Agreement template

COMMUNITY PES Agreement

Payment for Ecosystem Services Contract between EthioTrees association and the participating communities in the Dogua Tembien district.

EthioTrees
25/10/2017

This document lays out the terms of mutual commitment between **EthioTrees** and the participating project **villages in Dogua Tembien district**. The mutual commitments contained in this contract agree as follows:

1. Introduction

1.1 The Community Payments for Ecosystem Services (PES) contract describes the roles and responsibilities of the project partners, including the involved village councils, and the terms and conditions governing the generation of and payment for ecosystem services from forest protection, non-timber forest products and related management activities. The project partners are EthioTrees vzw Belgium, EthioTrees Association Ethiopia, the Exclosure Associations of Adi Lethsi, Gidmi Gestet and Meam Atali and the village and community representatives of the participating villages. This PES agreement is valid from ………/…………/……………. and is valid for 20 years.

1.2 Ecosystem services (ES) arise from the processes by which the environment produces resources needed by humans, such as clean air, water, food and materials. For the purposes of this contract, carbon sequestration services, as a result of forest protection and related management activities are considered. Nevertheless, The provision of all ecosystem services from forest protection are indicated by monitoring changes in tree and forest cover, spring activity, biodiversity, carbon sequestration and socio-economic development. The delivery of the ecosystem services will be indicated by monitoring changes in ES.

1.3 The PES project is intended to facilitate community forest protection and management efforts by strengthening exclosure associations of landless farmers that sustainably manage the forest area in consensus with the community. Forest protection consists of a restriction on livestock grazing and fuelwood collection from the exclosures. Such protection provides community-wide benefits and valorization of non-timber forest products improve the wellbeing of the most disadvantaged members of the community. In support of this intention both, the exclosure associations and the local community will be considered beneficiaries of this contract. EthioTrees will enter into a benefit-sharing contract governing the management and distribution of payments received under this contract.

2. Roles and obligations of the parties

2.1 ***EthioTrees*** serves as the Coordinator of the PES project. As the Coordinator, EthioTrees is responsible for planning and coordinating forest and socioeconomic monitoring, making PES payments, producing and submitting reports to the Plan Vivo Foundation, undertaking corrective actions as needed during the course of the contract and any negotiated extension and overseeing the negotiation and implementation of the PES agreement. More specifically, EthioTrees will:

a. Plan and coordinate monitoring activities
b. Monitor socioeconomic development
c. Organize a yearly meeting with the village council to discuss the project impact on the village and on the potential threat of grazing displacement
d. Organize PES investments (as described in Annex A) for the involved exclosure associations in mutual agreement with the local community and in accordance with forest monitoring results in relation to the targets and thresholds described in Annex B.
e. PES will be made at annual interval or upon agreement pulled over several years to enable larger investments.

f. Produce and submit annual monitoring reports

g. In the event that PES payments are withheld based on annual forest monitoring results outlined in Table 2, negotiate for corrective actions and a contract extension with the involved association; and

h. Oversee the negotiation and implementation of the PES agreement.

2.2 The ***exclosure associations*** will serve as the implementer of the PES project. As implementer, these associations are responsible for the generation of ecosystem services and for the implementation of the terms of the PES agreement between the exclosure association and the village council. More specifically, the exclosure associations will:

a. Manage activities to protect the exclosure forest and thereby generate ecosystem services;

b. Perform yearly minimally one community meeting: keep records and follow-up the issues raised during this meeting

c. Strive for gender balance, create awareness of the issue and actively encourage women participation in the association and by doing so, provide an example for administration bodies that are mandatory to maintain gender balances.

d. Keep a complaint and suggestion book and inform the community about its existence

e. PES investments are made in consensus between the associations and the wider community of the village. Both the association and the community are direct beneficiaries. While, the benefits arising from PES investments are an additional benefit for the associations. Moreover, no potential impact on gender issues should be assured before the investment is made.

f. Monitor in cooperation with the village council potential grazing displacement and actively promote cut and carry to discourage potential grazing displacement

g. Work with EthioTrees association to ensure all the forest and socioeconomic monitoring responsibilities are met, as described in Section 3;

h. As necessary, agree with EthioTrees as to any corrective actions and negotiate with EthioTrees for a contract extension.

3. Monitoring and payment system

3.1 Monitoring. ES monitoring activities, annual activity-based indicators and methods are described in Annex B. A simple set of ES monitoring indicators will be used and monitoring observations will concentrate on four main aspects:

a. Biodiversity
b. Carbon sequestration
c. Spring activity

d. Socio-economic development

The ES monitoring and payment system is set forth in Annex B, table 1.The system shows the monitoring indicators, performance targets and thresholds, and corresponding payments that apply under this contract. It uses a traffic light system to link payments with monitoring results: green for full payment, orange for partial payment, red for zero payment.

3.2 Payments. PES will be linked to monitoring results in relation to the targets and thresholds described in Annex B. PES are directly dependent on sales; this means that in case that there are no sales of carbon credits, there will be no payments. PES will only be made if responsibilities and, where applicable, corrective actions are carried out by the parties to this ecosystem contract.

3.3 Payment allocation. PES monies are divided between the exclosure associations using allocation key (f1). This means that 50% of the PES monies is divided equally between the exclosures, while the remaining 50% PES monies are shared based on the generated ES per hectare of the exclosure area. Using this allocation key there is a threshold minimum of PES monies for all exclosures, which allows all exclosures to do valuable investments in mutual agreement with the community, regardless of their size.

$$\text{PES allocation} = 1/3 * 50\%\ \text{PES} + \text{ES/ha}(\%) * 50\%\ \text{PES} \qquad (f1)$$

3.4 PES buffer. There is a deduction of the risk buffer (10% of achieved annual emission reductions), which is pooled by Plan Vivo and therefore not available for participants to claim.

4. Use of Payments

4.1 PES investments under this contract are made in consensus with the community and should be gender balanced. The PES balance will be used to make PES investments in accordance with forest monitoring targets and thresholds (see Annex B).

4.2 Plan Vivo management plans are consulted for PES investments. Investments should strengthen 4 main activities (1) forest restauration and protection, (2) water recharge, (3) support economic livelihood through non-timber forest products, (4) improve capacity building of local people.

5. Corrective action

5.1 In the event that corrective action is required during the term of this contract, EthioTrees and the exclosure associations will reach agreement on the corrective actions necessary, a schedule for the corrective action, and an extension of this contract.

5.2 All stakeholders (participants, villagers or other stakeholders) are encouraged to use the complaint/suggestion book. Mitigation actions to follow up complaints will be performed in mutual agreement between the association and the community and will strive towards consensus. In the event that there is a dispute between different stakeholders the village council will be consulted. If they are unable to agree corrective actions a third party arbitrator, approved by both parties, will be appointed to oversee dispute resolution.

5.3 The exclosure associations will pay the costs of monitoring any corrective actions under any contract extension out of the money remaining for PES payments under this contract.

6. Contract term

This contract will remain in force for a period of 20 years from the date of signing, unless PES payments are withheld in any year, in which case the parties shall agree to a contract extension and corrective actions as set forth in section 6. This contract expires in case a new contract is negotiated and signed by all parties or in the case, that one of the signing parties withdrawals from this contract in accordance with the Ethiopian contract law.
The parties agree to the terms and conditions contained in this contract and all Annexes.

EthioTrees, Project Coordinator:	**Exclosure association:**
Signature:	Signature:
--	--
Name:	Name:
--	--
Post:	Post:
--	--
Date:	Date:
--	--

Annex A: Contract details

The mechanism through which payments will be transferred is described here. A bank account has been established at the Commercial Bank of Ethiopia by EthioTrees Association to house all PES payments. EthioTrees Belgium will transfer PES payments once a mutual agreement between the exclosure association and community is agreed upon a certain investment and a fitting investment budget is estimated. Payments will be made directly to the contractor that wins the bid of the investment. Investments will be subject to standard contracting practice, allowing fair competition for regional contractors.

Annex B: Forest monitoring activities and methods

B1. The annual activity-based indicators include:

Ecosystem Services Monitoring

Activity	Activity Indicator (measure annually)	Annual Targets			Mitigating actions
		Full Target Achievement	Partial Target Achievement	Missed Target	
Restoration activities	Area of each exclosure undergoing active restoration activities	>10%	=10%	<10%	
Tree Planting	Number of seedlings	4000 seedlings	3000-4000?	<4000 seedlings	
	Survival Rate	>30%	25-30	<30%	

Socioeconomic Monitoring

Activity	Activity Indicator (measure annually)	Annual Targets			Result and mitigating actions
		Full Target Achievement	Partial Target Achievement	Missed Target	
Capacity-Building	Number of organized trainings for landless	1		0	

	farmers (M/V) per year per exclosure				
	Participants from more vulnerable groups (women, youth, elderly people)	>25%		<25%	
Availability of grass fodder	Beneficiaries of grass fodder per exclosure	>3	<3	<1	
Countering displaced grazing	Number of observations of displaced grazing mentioned during the yearly meeting of association, other NTFP users and the village council	<2	2	>2	
Countering timber harvesting on public lands	Number of observations of timber harvesting on public lands mentioned during the yearly meeting of association, other NTFP users and the village council	<2	2	>2	

Environmental Monitoring

Activity	**Activity Indicator (measure annually)**	**Annual Targets**			**Result and mitigating actions**
		Full Target Achievement	**Partial Target Achievement**	**Missed Target**	
Water	Number of	2	<2	<1	

Management	Percolation Ponds per exclosure				

There are the following consequences for certificate issuance and corrective actions that will be implemented if the yearly performance targets are not met:

(i) If the values for all indicators meet or exceed their performance target, the full issuance is received;

(ii) If one or more of the indicator values is below it performance target for one monitoring period, the full issuance is received but corrective actions must be implemented;

(iii) If one or more of the indicator values is below its performance target for two consecutive monitoring periods, certificate issuance is withheld until corrective actions have been implemented and the performance target(s) have been reached.

B2. ES monitoring targets

Table 1. Exclosure monitoring and payment system – targets and payments

Yearly monitoring targets				
Exclosure		**Green Level – all activity based indicators are fulfilled (5/5)**	**Orange Level – minimum three of the activity based indicators are fulfilled (4-3/5)**	**Red Level – less than three of the activity based indicators are fulfilled (<3/5)**
Benefit Allocation		**100%**	**50%**	**0%**
5 yearly carbon sequestration targets should equal				
Village	**Total area (ha)**	**75% or more of the 5yr carbon target**	**25% to 75% of the 5yr carbon target**	**< 25% of the 5yr carbon target**
Adi Lethsi	412	15 tC/ha/5yr	From 11.25 - 3.75 tC/ha/5yr	< 3.75 tC/ha/5yr
Meam Atali	83	12 tC/ha/5yr	From .9 - 3 tC/ha/5yr	< 3 tC/ha/5yr
Gidmi Gestet	46	8 tC/ha/5yr	From 6 - 2 tC/ha/5yr	< 2 tC/ha/5yr
Benefit Allocation		**100%**	**50%**	**0%**

Annex: Agroforestry PES agreement

This agreement is valid between EthioTrees Association, Hagere Selam (Tigray, Ethiopia) and ....
....

(the Agroforester), living in ....

While the Agroforester is the owner of land described below, it is agreed to contribute towards carbon sequestration along the scheme described in the table below, by raising, using and managing the land under an Agroforestry system approved by Plan Vivo.

The Agroforester will draw a plan vivo map of his/her plot and/or the catchment, indicating exactly where the project trees are going to be located and also how many existing trees are present on the plot. It is clear to all parties that Agroforesters who cut trees for the purpose of planting project trees will be disqualified from participating in the project.

- ✓ Name(s):
- ✓ Organization/Individual:
- ✓ Location:
- ✓ Unique Code:
- ✓ Estimated size to be raised (ha):
- ✓ Trees expected to be raised (species and numbers):
- ✓ Estimated Carbon tones saleable:
- ✓ Contribution to Community Fund:
- ✓ Smallholders payment:
- ✓ Size of the risk buffer: 10%
- ✓ Type of plantation (woodlot, boundary, homegarden, homestead):
- ✓ Gudjle Im'at or watershed committee:
- ✓ Monitoring period:
- ✓ PES payment period:
- ✓ Overall duration of commitment to the plan vivo:

Payments will be made upon the verification of monitoring targets according to the following schedule:

Time of mea-sure-ment (yr)	**Performance-based milestone**	**Method of measurement**	**% of payment per ha to smallholder (ex ante):** homestead intercropping and high-density home garden planting	**Payment per ha (ex post):** boundary planting, low-density home garden planting, woodlot planting
0 (within one year of planting)	At least 50% of the planned number of trees is raised and protected against grazing	Physical counting of *all* new trees raised by smallholder	20%	Unlocking of annual smallholder payments during 35 years if the targets continue to be met (see*)
1	100% of the planned number of trees raised, protected against grazing and micro-irrigation happened	Physical counting of *all* new trees raised by smallholder	20%	
3	At least 65% of the raised trees surviving	Physical counting of *all* the surviving trees	20%	
5	An average DBH of at least 4cm	DBH measurements, based on a representative sample of at least 10%	10%	

		of the trees concerned		
7	Average DBH of at least 6cm	DBH measurements, based on a representative sample of at least 10% of the trees concerned	10%	
10	An average DBH of at least 9cm	DBH measurements, based on a representative sample of at least 10% of the trees concerned	20%	
11 to 35	Permanence of the existing tree	Annual counting, based on a representative sample of at least 10% of the trees concerned, or remote-sensing equivalent	Continued free training upon request	

**Successful evaluation of the performance milestone is determined by a combination of on the ground technician judgement and in-office data analysis. If both the technicians and the data suggest that the producer has met the target, full payment is received every year, over 35 years. If the target has not been met but the threshold is achieved, partial payment is made and corrective actions are implemented. If the threshold is not met, payments are withheld until targets are reached the following year. In that case the project will explore jointly with the smallholder(s) how tree growth in the field can be supported. In accordance with the technical specification, the majority of the producers will reach 100% of the planned number of trees after one year. If they miss the target, they will supplement towards 100% capacity by the following year.*

***In case of density or survival targets being missed, corrective actions may include to plant extra seedlings or raise extra saplings, to implement extra protection against grazing or to micro-irrigate more, until the target is met. In case of DBH targets being missed, corrective actions may include, among others, to plant extra seedlings, to micro-irrigate, to mulch or to manage shading, until the target is met. If the threshold is not met, payments are withheld until targets are reached the following year. Farmers are suspended from the project if they leave before the end of their monitoring period or miss two yearly targets in a row. It is then assumed that all trees have been cut.*

This agreement does not alter in any way the rights of the smallholder to harvest food, fuel, timber or other products. In the case of any discussion or conflict arising from the implementation of the project, the parties will first try to solve the issue amicably, with consultation of the Woreda, during a period of 45 days. If no amicable settlement is possible in that time frame, the case will be referred to the relevant courts of Mekelle.

For agreement,
Signature(s) and date of approval and implementation

Annex: Plan Vivo Map

Annex 4. Survey database template

<u>SOCIO-ECONOMIC SURVEY</u>

Household code: ....
Date of interview: ....
Village: ....
Part A: General characteristics
Age of the respondent: .... years
Age of the household head: .... Years
Project participant? Yes - No
Gender: male / female
Marital status: single / married / living together / widowed / divorced / separated
Religion: orthodox / Muslim / protestant / no religion
Family size: .... members

Family member	Sex	Age	Relation to household head *	Level of education*	Main occupation*
1=Household head					
2					
3					
4					
5					
6					
7					

Codes*
Relation to household head:

1=Husband	2=Wife	3=Son	4=Daughter	5=Close relative	6=Dependent	7=Hired worker

Level of education:

1=Illiterate	2=Read & write	3=Primary I (1-4)	4=Primary II (5-8)	5=High school (9-10)
6=Preparatory (11-12)	7= Vocational	8=Diploma	9=Degree and above	

Type of occupation

1= Crop farming	2= Livestock production	3= Trade	4= Handicraft	5= Daily labour	6= Other

Part B: Wealth status of the household

Do you own livestock units? ....
If so, please fill in the following table:

Livestock type	Number	Unit price(Birr)
Oxen		
Cows		
Bulls (korma)		
Calves (tja)		
Heifer(gider)		
Goats (fyel)		
Sheep (beg)		
Mule (beklo)		
Donkey		
Chicken (poultry)		
Honey bee (in hives)		

Main sources for household's income: ....

(choose from: Crop farming, livestock production, trade, share cropping, daily labour, employment, frankincense production, honey production, other)

Do you own materials and furniture? Please fill in the following table:

Furniture and Durables	Quantity			Agricultural Equipment	Quantity		
	5 years ago	Now	Current price		5 years ago	Now	Current price
Radio				Mofer + kenber			
Tape recorder				Maresha			
Television				Hoe (Mekoferia)			
Motor vehicle				Spade (akafa)			
Beds (alga)				Sickle (Machid)			
Chairs				Medosha+ Doma)			
Tables				Axe + Fas (misar)			
Gold (gm)				Saw (megaz			
Watch/Clock				Traditional beehive			
Cupboard (kumsatin)				Modern beehive			
Bicycle				Knapsack Chemi Sprayer			
Mobile phone							
Barrel (bermil)							
Jerikan/ensra							

Do you have access to public facilities? Please fill in the following table:

Item	5 years ago	Now
Household Access to electric power (hours in a day)		
Distance to nearest farming company (minutes)		
Distance to nearest extension agriculture service (minutes)		
Distance to nearest market (minutes)		
Distance to the nearest kebelle admin office (minutes)		
Distance to nearst health clinic (minutes)		
Distance to drinking water source (minutes)		
Distance to nearest road (minutes)		
Distance to nearest credit institution (minutes)		
Distance to nearest bank (minutes)		
Access to telephone services?		
Distance to nearest telephone network area(minutes)		

Do you sell your agricultural products? Please fill in the following table:

Crops sold	Amount sold	Unit Price (Birr)	Total Income (Birr)
Maize			
Sorghum			
Barley			
Sesame			
Groundnut			
Soya bean			
Pea			
Other, specify			
Fruits			
Banana			
Mango			
Lemon			
Avocado			
Other			
Vegetables			
Pepper			
Cabbage			
Onion			
Potato			
Other			

Crop	Amount Sold	Unit Price (birr)	Total Income (Birr)
Tomato			
Other vegetables			
Garlic			
Other spices			
Other			

Other sources of household income

Income source	Monthly Income (Birr)	Yearly income (Biir)
Employment wage		
Sale of livestock		
Sale of gold		
Remittance		
Sale of fire wood		
Sale of charcoal		
Sale of honey		
Aid		
Petty trade		
Pottery		
Share cropping		
Other		

Part C: Background Information of Exclosures

1. Since when are the nearby exclosures established ---
2. Who initiate the establishment of the exclosure (the community, government, NGO et) and how --
3. What are the main needs/reasons to establish exclosures ---
4. what were the challenges as a result of exclosure practices at the beginning ---
5. what coping mechanisms you used to overcome the challenges ---
6. Are the challenges existing still now and why --
7. Are you willing to keep additional exclosures and why ---

Part D: Non-timber forest products

How many kg of honey do you produce per year: ....
How many kg of frankincense do you produce per year: ....
Are there different qualities or grades in the honey or frankincense? ....
....
What is the sales price per kg (last year)? ....
Who is the buyer and how do you find the buyer? ....
Was there an evolution in the price and volume over the past years? ....
....
How important are the sales of honey or frankincense for your total income (in percentage)?
....
What is the biggest problem of the production of honey or frankincense for you?
....
What is the biggest problem in your village? ....
If you work in a cooperative: how many members are in the cooperative? ....
If you work in a cooperative: how many kg production is there per year? ....

Part E: Water

Where do you get your water in the dry season? ....
Who in your household fetches the water on a daily basis? ....
How many time does it consume per day to get the water? ....
Are there any groundwater wells nearby? ....
How was the evolution of the groundwater availability over the past years? ....

Part F: Access to Exclosures and Institutional Arrangements

1. Who has the use right of the exclosures?--
2. Are there any by-laws to manage the exclosures in your village?

   1= Yes 2= No
3. Who formulates the rules/regulations/by-laws?

   ----

4. Are the local communities involved in the process of making the rules/by-laws

1.Yes 2. No

5. Are there special rules for women, youth, or any vulnerably group? 1= Yes 2= No

If yes to Q 5 what does it state about?---

Part G: Other

Do you use the exclosure for grass cutting? If so, how much grass do you get? ....
Do you use the exclosure to gather pruned wood? If so, how much wood do you get? ....
If you are involved in agroforestry, which products (fruit, timber, fodder, firewood) do you get? ...
....
How many fruits, timber or fodder to you get per year? ....
Do you sell these? At which price? ....

Annex 5. Example (agro)forest management plans/*plan vivos*

Meam Atali

Preparation of the plan vivo map:

Plan vivo map (desired future situation):

The participants recommend, among others, to introduce sustainable forest management, to avoid deforestation and to add different structures such as percolation ponds, stone bund structures, hand pumps and gabion check dams.

Gidmi Gestet

Preparation of the plan vivo map:

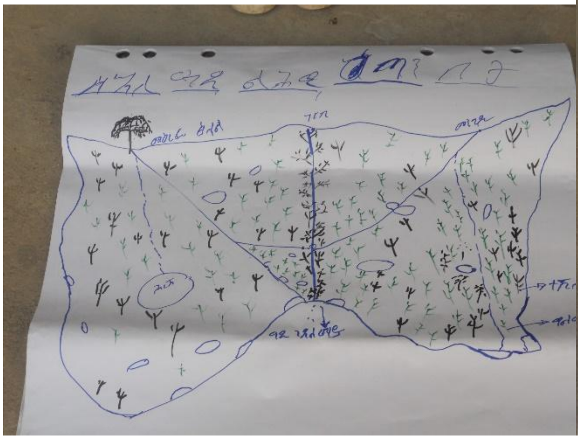
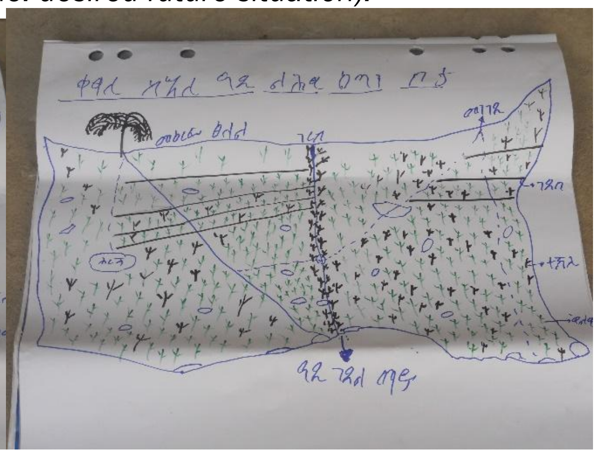
Plan vivo map (desired future situation):

The participants recommend introducing sustainable forest management, avoiding deforestation and adding different structures such as percolation ponds, stone bund structures. In the Northern side they want to introduce honey bee production and would like to see the area covered by olive trees.

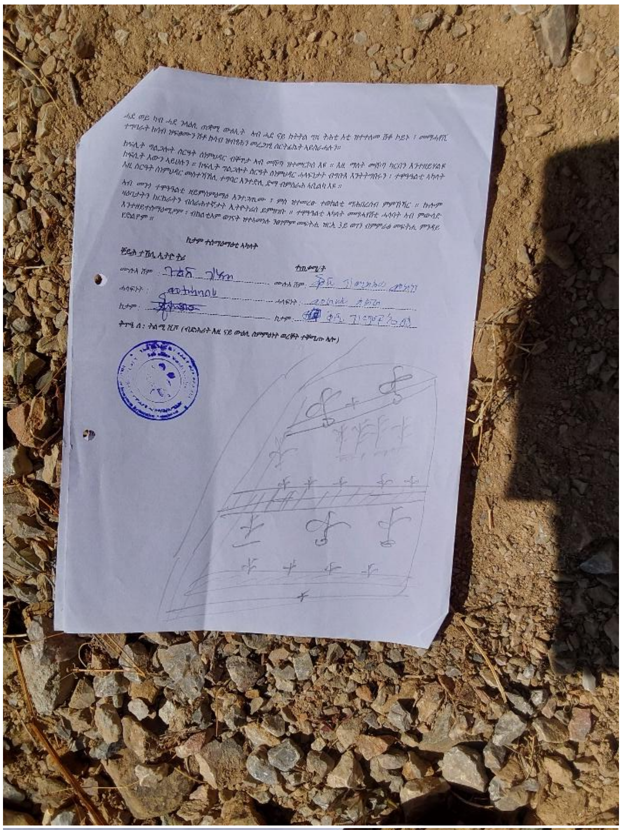
Adi Lehtsi

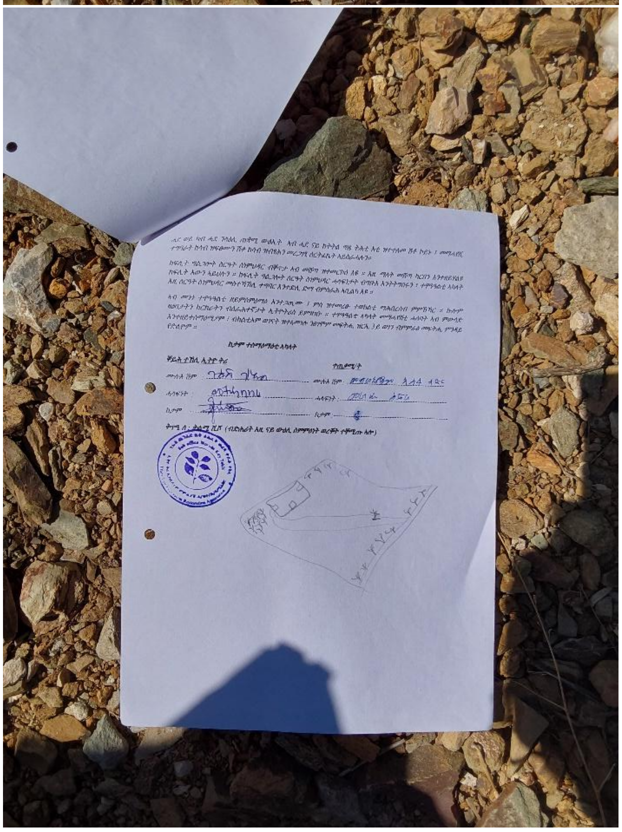
Preparation of the plan vivo map:


Plan vivo map (left: baseline map; right side: desired future situation):

The participants prepared the baseline and desired plan vivo map of this young hizaéti. In the future map of the hizaéti, they want to add sustainable forest management, avoid deforestation and free grazing, and install stone bund structures on the bare areas. They would like to see much more *Boswellia papyrifera* species as indicated by green colour in the map.





Example of smallholder plan vivo maps (agroforestry)

Annex 6. Permits and legal documentation

EthioTrees

Ecosystem restoration and valuation in the Ethiopian Highlands

Memorandum of Understanding between EthioTrees Belgium and EthioTrees Ethiopia

EthioTrees aims to improve value creation from ecosystem services in the Woreda Dogua Tembien. Specifically, objectives of EthioTrees in Dogua Tembien are to increase biodiversity, water infiltration and carbon storage through improved soil and biomass status in exclosures and to encourage sustainable and fair production of non-timber forest products such as essential oils from frankincense trees.

In accordance with this Memorandum of Understanding between the Ethiopian entity EthioTrees, as represented by Mr. Seifu Gebreselassie (here named as Party 1) and the Belgian entity EthioTrees, as represented by Mr. Sil Lanckriet (here named as Party 2), the parties agree on the following:

Concerning **ecosystem restoration (1)**

Party 1 agrees to support reforestation activities in different tabias in Dogua Tembien. Therefore EthioTrees plans to:

1a) help to improve the status of (young) exclosures by improved management in these exclosures, aiming at 300 hectares per year;

1b) work using a community-driven approach, following the demand of the local communities and complying with international standards on participatory project management;

1c) provide all seedlings required for enrichment planting activities;

1d) provide free training sessions on planting and consultancy on exclosure management to the communities;

1e) monitor the evolution in biodiversity, groundwater recharge, social and economic standards and carbon storage within the project zones.

Party 2 agrees to support these activities by:

1f) transferring at least 60% of any future financial revenues from carbon sequestration to the communities (farmers associations) in a clear and transparent manner. Revenues should be allocated to (new or existing) social and environmental community projects, to be agreed on with the communities.

1g) providing the necessary funding and consultancy for the activities.

Party 1 agrees to

2a) providefree training sessions and consultancy on management of frankincense trees and cultivation of the resins to all interested individuals or entities linked with the activities of EthioTrees and requesting these services;

2b) thoroughly check on the environmental sustainability of frankincense processing with limitations on grazing and overexploitation, and proceed only with sustainable production;

2c) actively involve in setting up the distillation units in the villages and setting up the distillation activities by associations of (landless) farmers and provide training on the distillation;

2d)provide fair prices and aim for fairtrade and biological certification of the oil products at international standards.

Party 2 agrees to support these activities by:

2e) transferring any profit derived from sales of oil products on the international market to (new or existing) social and environmental community projects, to be agreed on with the communities.

2f) providing the necessary funding and consultancy for the activities.

Concerning **support from the Woreda (3)**

Party 1 and Party 2 agree to

3a)work closely with the Woreda and comply with all Ethiopian laws.

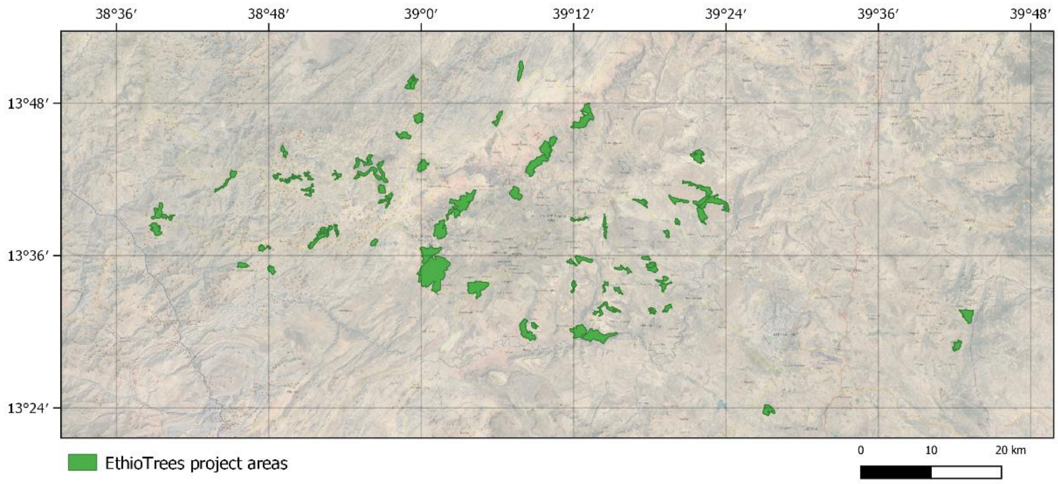
For agreement of party 1,

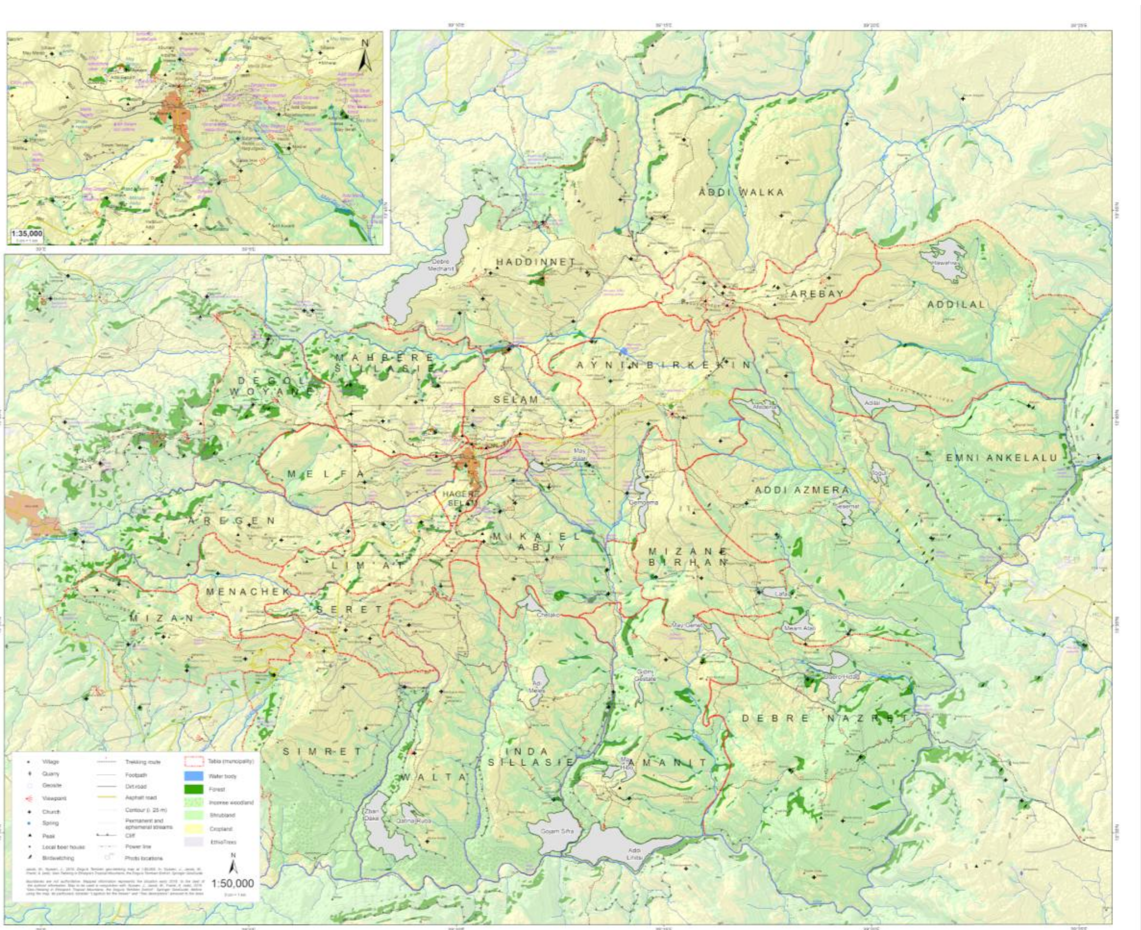
For agreement of party 2,

Annex 7. Evidence of community participation

See Annex 5; videos have been made and are available upon request

Annex 8. Project map of the EthioTrees project sites





Annex 9. Paper by Mekuria et al. (2011)

Available online:

https://onlinelibrary.wiley.com/doi/pdf/10.1002/ldr.1001?casa_token=a0NgRPwMUVEAAAAA%3ATh_a9Kdfc5w0UZYYgmEogexKQUSt2AC3LsPkPALk2CC7vqto9Pe0pd3Xw0dzXRgABoRck3bmJD1rUA

Annex 10. Surface Area Calculation

Before 2025, we calculated the total carbon benefits based on the Planimetric Projected project area and not on the Landscape Surface Area. The planimetric surface area is calculated using flat, two-dimensional coordinates, while landscape surface area accounts for topographic variation, revealing the surface as it would appear on the ground. Since the project areas are particularly located steep slopes in the Tembien Highlands, it is more accurate to use the landscape surface area for calculating the area A "Extent of the project area" (PU001).

Methodology

This is described by Jenness (2004) in his published scientific paper: "Calculating landscape surface area from digital elevation models". Clearly, surface area provides a better estimate of the land area available to biomass and soil carbon sequestration than planimetric area. Following the approach of Jenness, we used the ASTER Global Digital Elevation Model V003 and the SAGA 'real surface tool' to make the conversion from planimetric area to Landscape Surface Area. When calculating the landscape surface area of project areas, which represents a polygon in geographic space, a Digital Elevation Model (DEM) enables the conversion of the polygon's 2D geometry into a 3D surface, accounting for topographic variation.

Results

The landscape surface areas are significantly different from the projected surface areas. There is a weighted average difference of 9% between the projected surface area and the real landscape surface area (see table A3.1). The carbon sequestered in the project areas has been consistently underestimated by using the planimetric surface area.

Tabel A3.1: Total planimetric area and landscape surface area of the project exclosures

Area ID	Total Planimetric Area (ha)	Real Landscape Surface Area (ha)
*Adi Lehtsi**	412	472
*Gidme Gestet**	46	51
*Meam Atali**	83	87
*May Getnet**	51	54
*May Hibo**	53	58
*Afedena**	81	84
*Adilal**	148	153
*Gemgema**	93	105
*Zban Dake**	300	333
*May Baeti**	46	51
*Lafa**	45	48
*Daero Hidag**	112	118
*Togul**	36	37
*Sesemat**	46	48
*Adi Meles**	65	70
*Chele Quot**	50	55
*Katna Ruba**	44	47
*Gojam Sefra**	275	293
*Debremed hanit**	647	755
*Hawahiwa**	199	214
*Dawsira **	1319	1414
*Adienkrti (AdEn)**	447	486
*Adikilte (AdKl)**	171	188
*Akeb hidmo (AkHd)**	42	45
*Ba'ati Haile (BtHl)**	167	176
*Barajira (Brjr)**	150	178
*Chemate***	92	96
*Chike**	452	455
*Daengule**	132	146
*Daerotimqet**	97	103
*Da'kakwey**	66	69
*Dakuakuat**	130	140
*Dastenay**	91	97
*Da'tsehagat**	198	231
*Deguagush**	159	180
*Emba**	54	57
*Emba newi**	142	156
*Emure**	314	328

*Endahibey**	142	158
*Endalibanos**	70	75
*Endanebrey**	57	61
*Fereqdre**	99	111
*Gedmi tsitsewhiey**	51	55
*Gogon-Kojejar**	134	138
*Gra emba araya**	100	107
*Hzaeti B'eray (HzBr)**	302	314
*Jira**	123	130
*Kbret**	175	190
*Maekeldur**	141	165
*May agualat-Enderta**	219	238
*Mhdar Abuer**	120	129
*Mierafchege**	337	366
*Miska**	90	95
*Quaya**	260	294
*Sequrti**	355	391
*Shegalu**	121	129
*Shegere**	53	55
*Sito**	196	234
*Wetlaqo**	65	69
*Wukro and gdmi awuhi**	168	196
*Zaka**	256	281
*Kurara**	46	49
*Werasige**	267	284
*Busha**	79	85
*Tsiwtsiwa**	80	91
*Farqua**	93	98
*Wedigets**	69	81
*Endahibye**	192	209
*Alogen***	200	244
*Betmarya***	254	299
*Endabanow***	44	49
*Sekela Koyetsa***	295	333
*Seqere***	95	106
*Tata***	106	118
*Abaqo***	173	196
*Adi Degol***	182	206
*Rubalemin***	564	642
*Debre Ango***	92	99
*Endemariam***	66	68
*Endatahses***	71	75
*Mshig***	65	77

*Gdmi Segenet***	106	119
*Menji Giratmango***	86	90
*Hohole (Gra Atami)***	115	123
*Lehama (Gorgue)***	86	90
*Mekno***	65	71
*Menji Moro***	126	137
*laelay kurkura***	167	185
*Kalay Sfra***	104	124
*Tsehay Zerei***	82	92
*Humer***	61	68
*Guma Amaru***	115	119
*Adishm Tnsae***	383	419
*Adi Agobay***	186	198
*Adikurtuman****	54	57
*Adichomo****	466	530
*Koyetsa****	64	71
*adi shihak****	293	313
*Gra jumut****	86	93
*Mftah korecha****	107	123
*Endamedhanialem****	52	55
*Moranfo****	99	109
*Gonou****	194	198
*Beherawi****	93	101
*Jerquawe****	401	484
*Gorgoro****	173	206
*Embay kome****	118	129
*Beati geretsahmo****	300	332
*Mewlad agam****	83	97
*Tsgaba****	242	253
*Adi mereta****	114	118
*mayta muz****	133	139
*Beati nebri****	57	59
*Flika****	52	54
*Tsariya****	86	95
*Tiemti wushita****	62	68
*Gulcheda****	98	102
*filfle****	96	105
*Dramba/endagebeta****	261	292
*may korabit****	205	229
*May Bhri****	190	205
TOTAL	**19582**	**21526**

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Appendix 11: Resampling data of first monitoring round

(available as Excel files)