Australian Government
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World Agroforestry

CGIAR RESEARCH PROGRAM ON Forests, Trees and Agroforestry

TREES FOR FOOD SECURITY-2 PROJECT

ETHIOPIA HIGHLIGHTS

Ethiopian Environment and Forest Research Institute

Oromia Agricultural Research Institute

Mekelle University

World Vision

anafe African Network for Agriculture, Agroforestry & Natural Resources Education

CSIRO

Project overview

The 'Developing integrated options and accelerating scaling up of agroforestry for improved food security and resilient livelihoods in Eastern Africa' project also known as Trees for Food Security phase 2[1] (T4FS-2) is an Australian Centre for International Agricultural Research (ACIAR) funded project aimed at improving food security and smallholder livelihoods through the widespread adoption of appropriate locally adapted agroforestry practices in key agricultural landscapes.

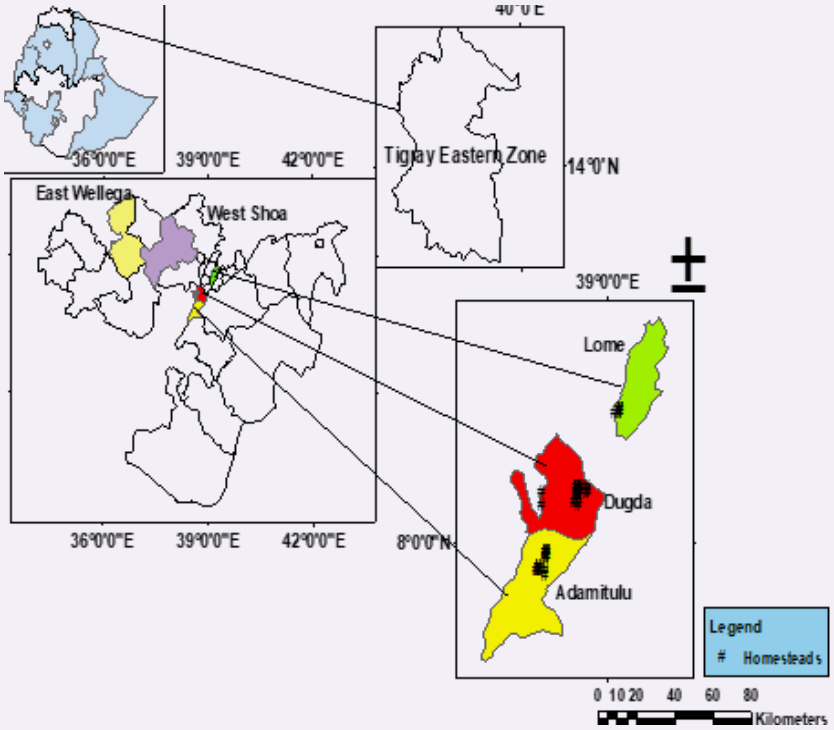
In Ethiopia, the second phase was launched in February 2017 and attended by key government officials including Dr. Eyasu Abraha, Minister for Agriculture and Natural Resources. In his remarks, Dr. Eyasu highlighted that the project aligns with Ethiopia mega strategies and plans, such as Climate Resilient Green Economy (CRGE) and Growth and Transformation Plan II (GTP-II) and emphasized on the Ministry's support towards the project's initiatives. The focus of the project in Ethiopia was on promotion of locally adaptable agroforestry options, as the cornerstone of smallholder system intensification. Through the different activities, the project has succeeded in influencing national policies that has led to embedding agroforestry in development initiatives, enhancing informed decision making, enhancing knowledge on the impacts of tree cover diversity on crop productivity, water, nutrients and livelihoods; introducing appropriate water management technologies and sustainable grazing options; establishing communities of practice for promoting locally adaptable agroforestry options supported by appropriate input systems; informing on tree value chain development; introducing agroforestry curriculum in tertiary institutions, and strengthening capacities of communities and local institutions on agroforestry innovations.

Soil erosion control structures in Tigray, Ethiopia

[1] Trees for Food Security-2. *https://www.worldagroforestry.org/project/trees-food-security-2-developing-integrated-options-and-accelerating-scaling-agroforestry*

Project sites

The T4FS-2 project operates in Oromia and Tigray regions. In Oromia, the project was implemented in the semi-arid and sub-humid agroecologies. Districts in the semi-arid area include: Adami Tulu Jido Kombolcha, Dugda, Bora and Lume in East Shewa zone. Those in the sub-humid area include Guto Gida, Jima Arjo in East Wollega and Bako Tibe in West Shewa zone. The project was also implemented in Tsaeda Emba district located in the dry highlands of Tigray.



Map 1: T4FS-2 project sites in Ethiopia

Project partners

The World Agroforestry (ICRAF) partnered with Ethiopian Environment and Forest Research Institute (EEFRI), Oromia Agricultural Research Institute (OARI), Mekelle University (MU), World Vision-Ethiopia (WVE), The African Network for Agriculture, Agroforestry and Natural Resources Education (ANAFE) and Commonwealth Scientific and Industrial Research Organisation (CSIRO).

Project achievements

1. Project reach

Different approaches were used to take project technologies to scale with the number of people directly reached by the project being more than 4,000 and above 17,000 community members having been indirectly reached. Among the scaling out strategies used include: participatory trials, tree planting activities, capacity development, agroforestry curriculum engagement and Rural Resource Centres (RRCs) activities such as tree distribution, training and demonstrations (Table 1).

Table 1: T4FS-2 project participants in Ethiopia

Activity	Number of people directly participating in the project	Total number reached*
Capacity development	1292	5168
Farmers involved in Participatory trials	1454	5816
Tree seedling distribution in RRCs	880	3520
Tree seedling distribution outside RRCs	821	3284
Other activities: sensitisation meetings, farmer exchange visits etc.	30	120
Post graduate students	5	5
Total	**4482**	**17913**

*Multiplied by 4 which is the average number of people in a household

2. Enabling environment for the adoption of agroforestry

The T4FS-2 project in Ethiopia has been fundamental in informing agroforestry strategies and policies at the national level. Borrowing lessons from the project, a National Agroforestry Platform (NAP) which contributed to achievement of Ethiopia's agricultural transformation agenda was formed. The platform has been chaired by the Ministry of Agriculture (MoA) and ICRAF has been serving as permanent secretariat. This further led to formation of a National Watershed and Agroforestry Multi-Stakeholder Platform (NWAMP) with various government ministries and NGOs. Unlike in the previous years, the agroforestry component was introduced in national watershed management programme where more than 135 watersheds were targeted for rehabilitation. Borrowing from the project's options by context approach, the platform aims to have a holistic approach in its implementation suitable for the various sites.

The Integrated Watershed Development and Productive Safety Nets Programmes financed by the World Bank picked up project results such as the participatory trials approach. The Rural Resource Centres (RRC) approach has been widely adopted. More than 16 RRCs (by ICRAF through other projects and other NGOs) have already been established across different sites in the country. There are ongoing discussions with the Job Creation Commission and MasterCard on how the RRC approach can widely be scaled up to create jobs for unemployed youths. Furthermore, the RRC model was also picked up by the Packard Foundation financed project to create women and youth-centred green jobs.

Official launch of a National Agroforestry Platform presided over by H.E. Dr. Kaba Urgessa, State Minister for Agriculture and Natural Resources and the core group members during the launch of National Watershed and Agroforestry Multi-Stakeholder Platform

3. Embracing the options by context approach through the farmer participatory trials

Cognizant that farmers are cautious of the technologies offered to them and select only those technologies that appear the most useful and/or profitable for their specific conditions, the project engaged farmers and other relevant stakeholders from the onset in setting up farmer participatory trials. These trials were aimed at testing agroforestry innovations on farmers' fields and homesteads and further adoption. A total of 1933 trials involving 1454 farmers were set up (Table 2).

Table 2: Farmer participatory trials established in T4FS-2 sites in Ethiopia

Site	Type of trial	Total farmers	Total trials
East Shewa (Semi-arid)	Fruit tree trial	182	260
	Home garden fodder and Guava trial	37	33
	Lead farmer fodder trial	3	3
	Multipurpose Tree (MPT) distribution	461	461
East Wellega/West Shewa (Sub-humid)	Fruit tree and MPT trial	131	287
	MPT distribution	210	210
	Forage development trial (WP2)	15	75
Tsaeda Emba-Tigray (Dry highlands)	Fruit tree and MPT trial	90	189
	Apple root stock distribution	22	22
	MPT with Rainwater Harvesting structures	63	63
	Fruit tree trial (Apple, Guava and Coffee)	90	180
	Multipurpose tree distribution	150	150
Total		**1454**	**1933**

In the semi-arid site, fruit tree trials mainly included improved avocado and papayas. Analysis results of tree survival rates indicated a relatively higher survival of papaya seedlings in Lume (47.4% compared to Adami tulu (30.9%) and Dugda (27.8%). Overall, the survival rate of all avocado varieties was highest in Lume (Figure 1). In the sub-humid site, participatory trials were established using *Grevillea robusta* and improved avocado varieties (Hass, Ettinger and Fuerte), coffee tree seedlings and improved mango.

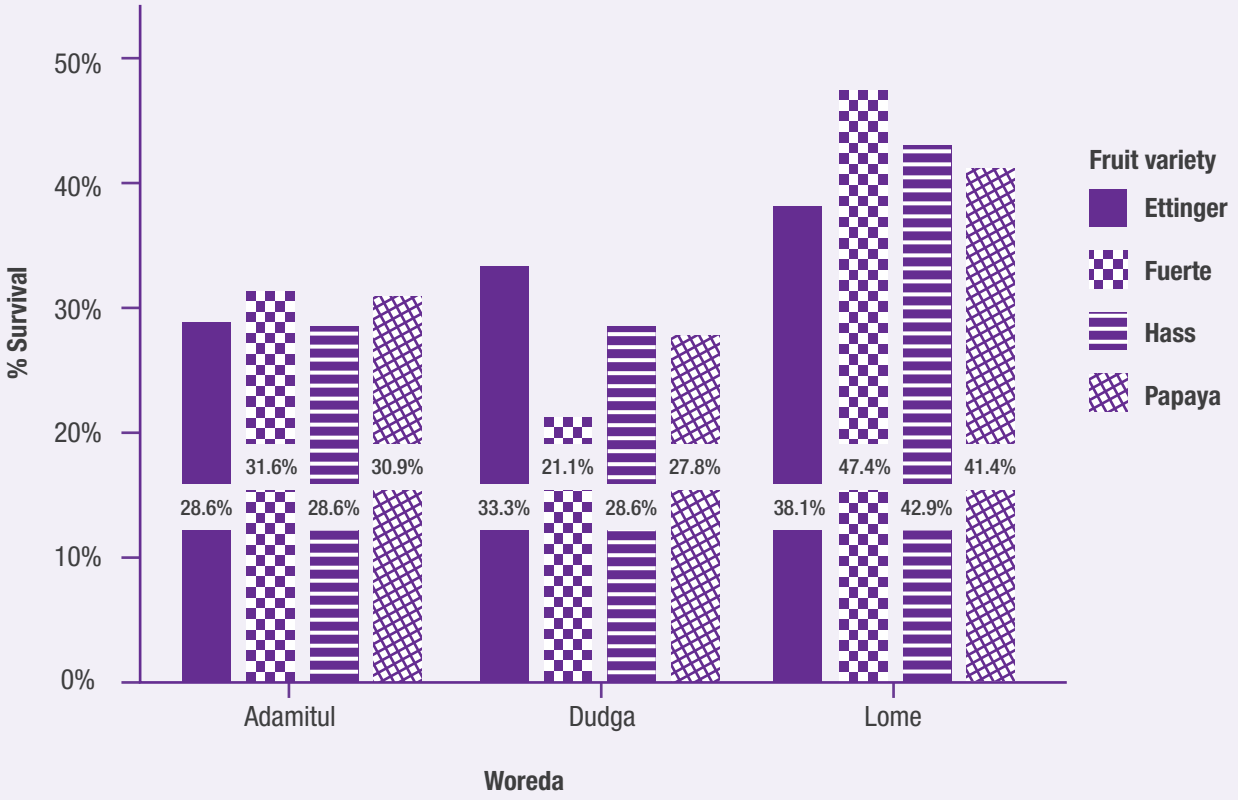


Figure 1: Survival rates of Avocado varieties and papaya in East Shewa Ethiopia

Further lessons on farmer led approaches for increasing tree diversity on farms[2] indicated that the actual tree planting didn't fully reflect priorities as the seedling production and planting mainly depended on the tree seeds that could be availed from nurseries or the fruit tree seedlings that could be procured and availed during planting time (Figure 2). Differential survival between species and niches meant that the connection between desired and realised tree diversity was further reduced. The overall mean survival of the seedlings in both agroecologies was 45.6 (± 32.6) at 6 months and 33.6 (± 25.5) at 14 months.

Findings further revealed that farmers in Ethiopia have an interest in high species diversity. Farmers' preference of tree species was determined by: availability of space and the already available tree stock and its composition; ease of tree protection and care after planting; the challenges that free grazing poses to seedling survival and growth; and potential conflict with neighbours. Understanding the species and planting niche preferences with appropriate seedling supply and management was proposed as a means to increase the diversity of trees in farmed landscapes.

[2] Derero, A., Coe, R., Muthuri, C. et al. Farmer-led approaches to increasing tree diversity in fields and farmed landscapes in Ethiopia. Agroforest Syst (2020). *https://doi.org/10.1007/s10457-020-00520-7*

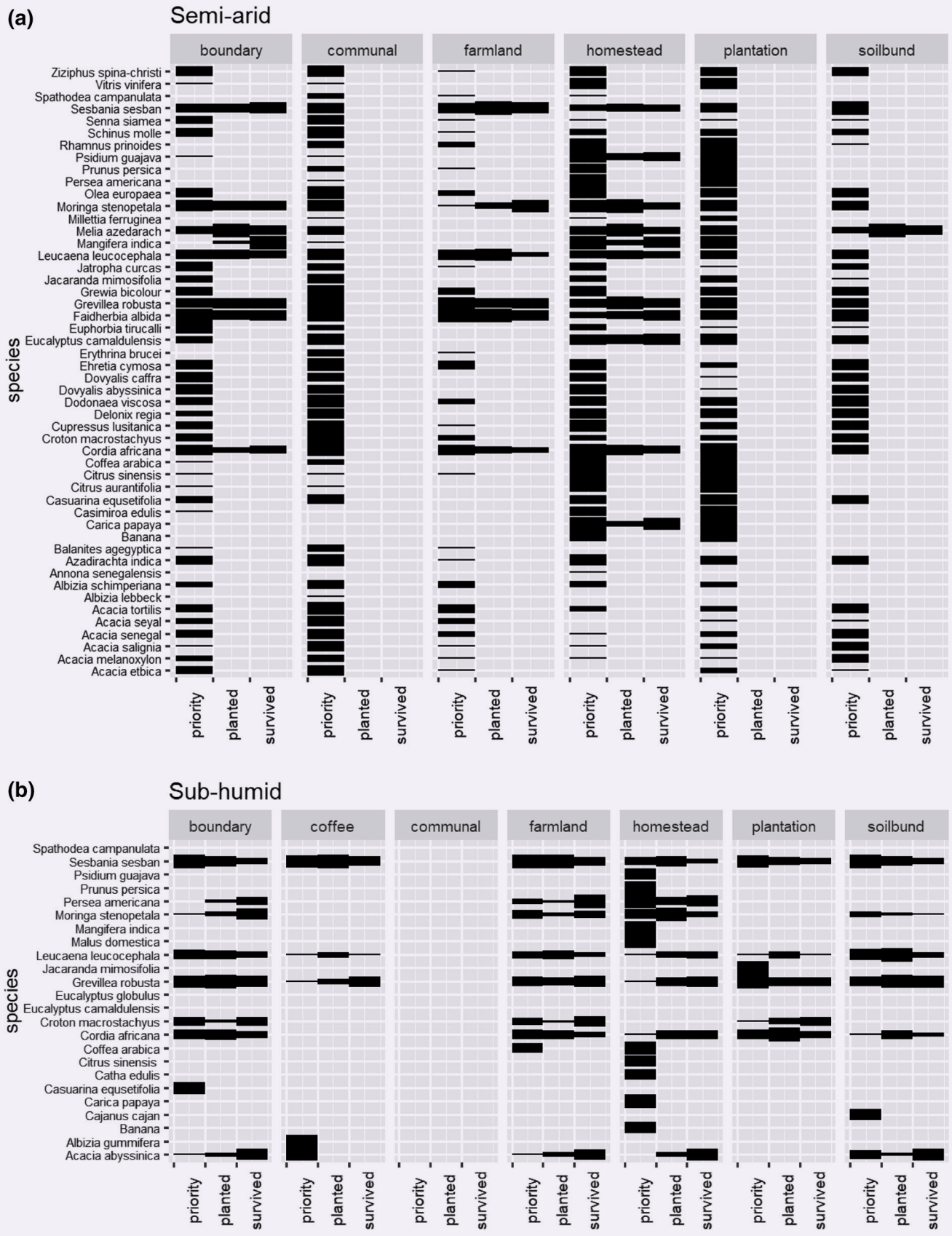


Figure 2: Species priorities, trees planted and surviving in on-farm niches in semi-arid (a) and sub-humid woredas (b) of Oromia. Line width is proportional to priority, numbers

4. Tree-crop interactions

Two long term trials in Melkassa (semi-arid) and Bako (sub-humid) sites were established and managed over the entire project period. The main objective of the long term experiments was to assess effects of tree species and management on crop productivity[3], water resources and nutrients at field, farm and landscape scales to inform scaling up to improve food security and enhance adaptability to climate change.

In Melkassa four tree species were studied namely: *Faidherbia albida, Moringa stenopetala, Acacia nilotica* and *Cordia africana*. These were used in the intercropping trial arranged in Randomized Complete Block Design (RCBD) with four replications. A block comprised four plots measuring 35m by 35m of each tree species intercropped with a cereal, a mix of tree species intercropped with a cereal and a sole crop plot that would give six plots of treatment combinations per block. Data for 2017, 2018 and 2019 on tree survival indicated that there was a significant difference at p=0.05 in survival of tree species tried out in the trial after five years of planting; *Acacia nilotica* showed significantly higher survival rate (>90%), followed by *Cordia africana* (>70%) while *Faidherbia albida* had a significantly lower survival rate (15%) statistically comparable to that of *Moringa stenopetala*. Crop yield and biomass under plots of different treatments revealed significant differences across years and between treatments at alpha=0.05.

All the tree-based treatments revealed a significantly higher teff yield compared to the yield under sole crop plots. Within the years under study, teff yield and biomass under all tree + crop treatments revealed a significant increase (α =0.05). The highest teff yield was obtained under *Faidherbia albida* trees. These results imply that agroforestry trees would not cause significant crop yield reduction (as farmers anticipate) compared to monocropping on the same unit of land. Instead they would add to product diversification and resilience. Teff yields in tree-based systems were also found to be significantly higher than sole crop systems as the years progressed implying that agroforestry systems are more suitable in increasing crop yield compared to sole crop systems (Figure 3).

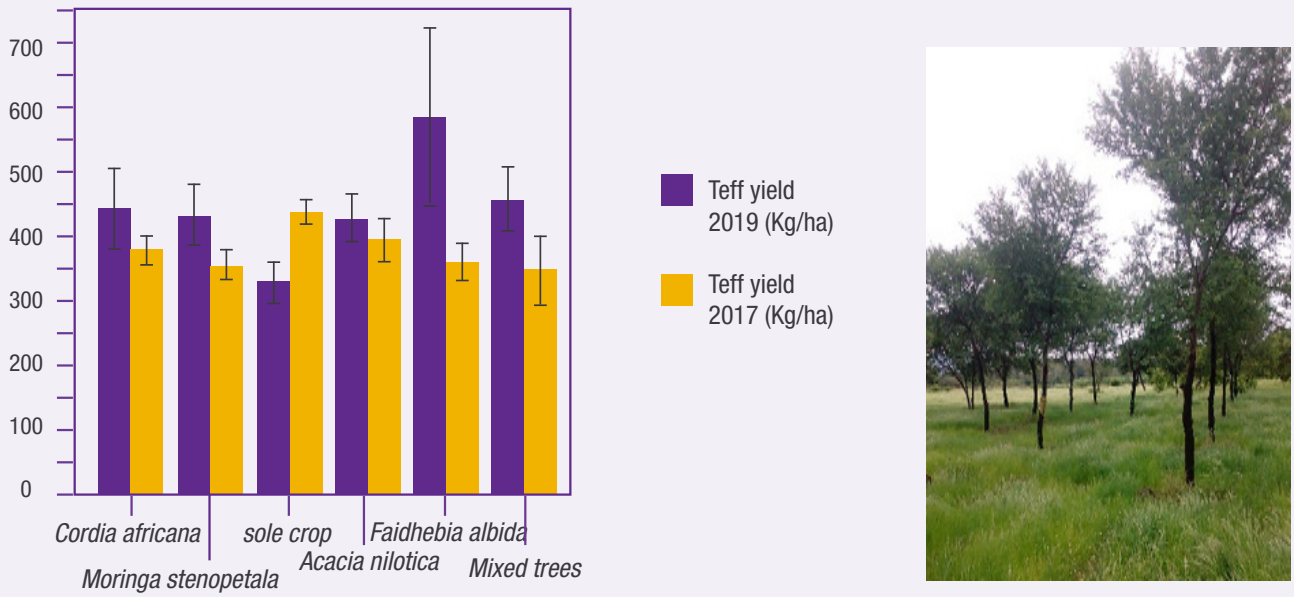


Figure 3: Teff yield under variable intercropping conditions Melkassa LTT

[3] Tadesse, S., Gebretsadik, W., Muthuri, C. et al. Crop productivity and tree growth in intercropped agroforestry systems in semi-arid and sub-humid regions of Ethiopia. Agroforest Syst 95, 487–498 (2021). *https://doi.org/10.1007/s10457-020-00520-7*

In the sub-humid area, teff, maize and finger millet were intercropped with *Cordia africana, Grevillea robusta, Croton macrostachyus* and *Acacia abyssinica*. The highest average tree height was recorded for *Grevillea robusta* grown with maize and finger millet at 7m and 6.66m respectively. For *Cordia africana*, height for sole trees was higher (5.33 m) than that grown with maize (4.23 m), finger millet (3.57m) and teff (4.39). The growth for *Acacia* was slower compared to the other trees whereby the height ranged between 3.21 m (with teff) and 3.45 m (with maize). Teff yield was found to be significantly higher under tree-crop treatments than the sole crop (Teff alone) treatments. However, crop yields (teff, finger millet, and maize) under *Acacia abyssinica* were found to be significantly lower than crop yields under tree-crop, tree mix, and sole crop conditions. On the other hand, tree plus crop treatments produced significantly greater biomass than the sole crop and sole tree treatments. Maize yield was significantly greater under all tree-crop and tree mix conditions compared to yields of finger millet and teff under the same treatment conditions (Figure 4).

Figure 4: Crop yield in Bako under different treatments (left) Tree-crop mix (right)

To understand how pruning affects water use and growth of the trees as well as on the understorey wheat productivity[4], sap flow gauges were installed on pruned and unpruned *Faidherbia albida* in Ejerssa Joro site. Results showed that pruning *F. albida* inhibits its growth, reduces soil moisture and availability of the soil macronutrients in wheat fields, despite reduced tree water use. The understorey wheat productivity was significantly higher under unpruned *F. albida* trees compared to pruned trees, even though water uptake, as sap volume, by unpruned trees was much higher than in pruned trees - 52% higher daily sap volume during the rainy season and even much higher in the dry season (Figures 5 and 6). Grain yield and aboveground biomass of wheat were reduced by 27% and 14% under pruned compared with unpruned trees respectively.

[4] Toib AA.2020. Ecophysiology of *Faidherbia albida*; effect of pruning on tree water relations, cambium dynamics and understorey wheat productivity in Ejerssa Joro, Ethiopia. (Doctoral thesis, Addis Ababa University, Addis Ababa, Ethiopia). *http://etd.aau.edu.et/handle/123456789/22968*

Findings further showed that pruning disrupts leafing phenology when trees are partially covered with leaves during the rainy season (July-September) stirring competition for water with wheat. With absence of shade, wheat under pruned trees is exposed to high temperatures hence affecting growth and yields. Therefore, complementary benefits get diminished and farmers suffer from reduced wheat yields and incomes by pruning. The study recommended that awareness be created to communities on the importance of *F. albida* trees to the accompanying crops and discourage pruning the branches in order to boost agricultural productivity.

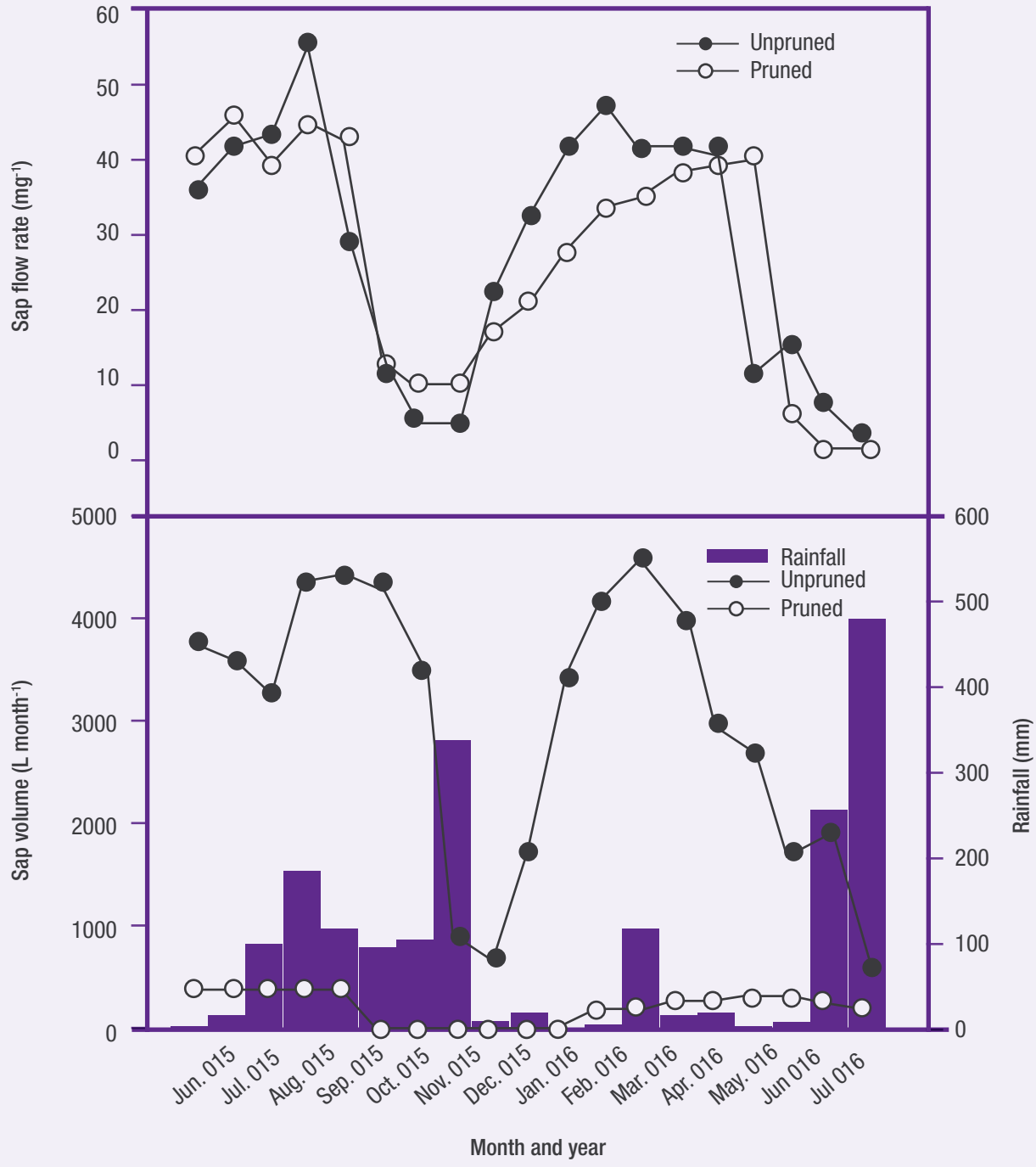


Figure 5: Monthly sap flow rate (a) sap volume and rainfall (b) of unpruned (●) and pruned (○) F. albida

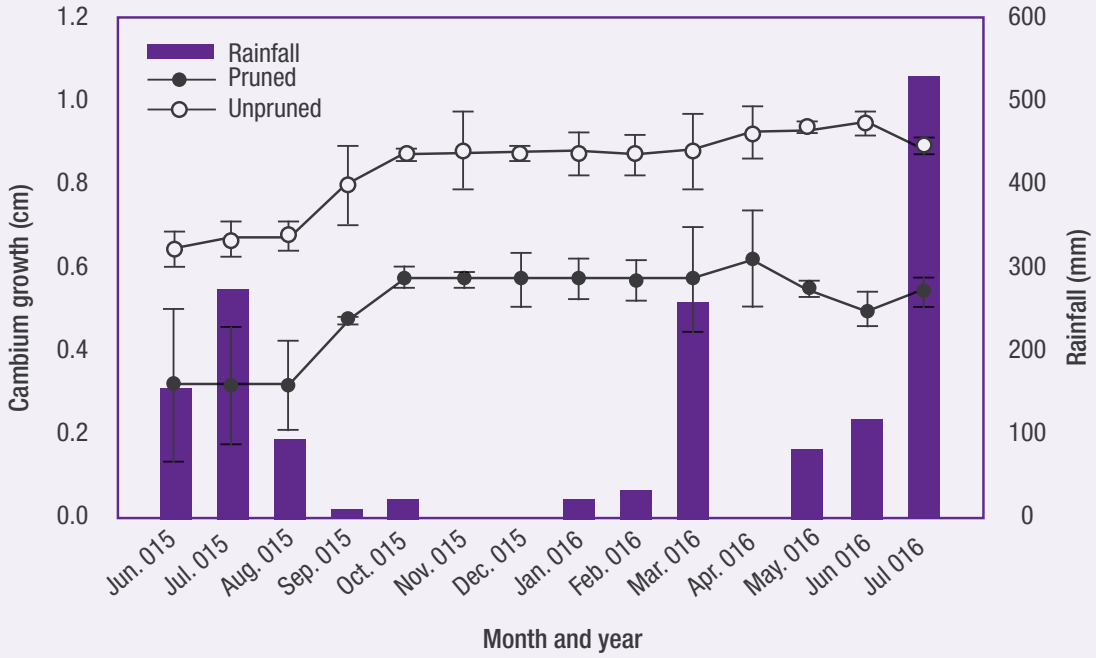


Figure 6: Monthly cambium growth of pruned (●) and unpruned (○) F. albida and rainfall from January 2015 to July 2016

5. APSIM and SIMILE modelling

In the Faidherbia-maize parkland system of the Central Rift Valley, Ethiopia, effects of Faidherbia albida on maize productivity and carbon sequestration[5,6] showed that maize yields were maximised with 50% pruning and NP fertilization in the 2-6 m zone (Figure 7).

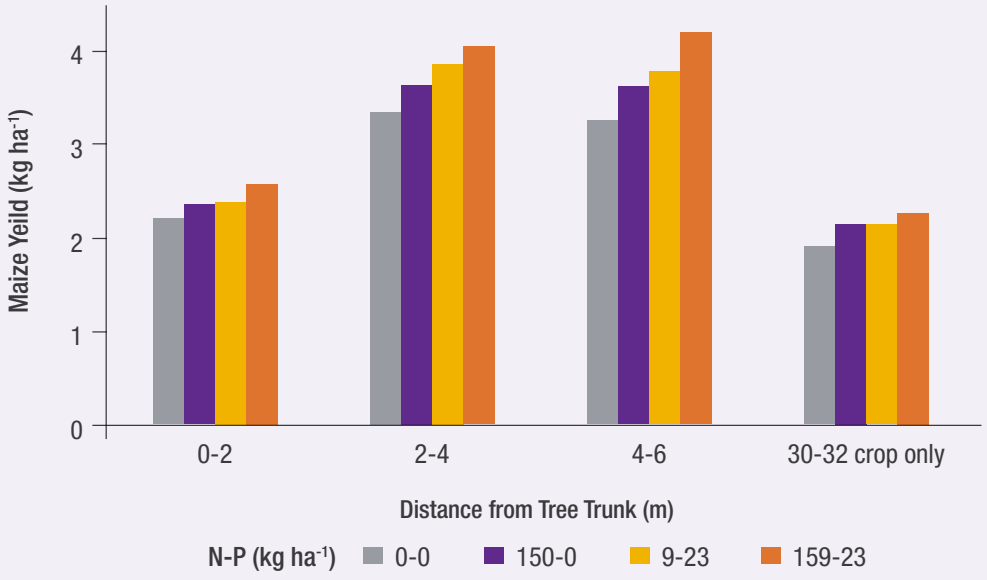


Figure 7: Maize yield in relation to distance form tree trunk pruning level and fertilisation

[5] Dilla AM, Smethurst PJ, Barry K, Parsons D (2019) Preliminary estimate of carbon sequestration potential of *Faidherbia albida* (Delile) A. Chev in an agroforestry parkland in the Central Rift Valley of Ethiopia. Forests, Trees and Livelihoods. *https://www.tandfonline.com/doi/abs/10.1080/14728028.2018.156414*

[6] Dilla AM, Smethurst PJ, Parsons D, Denboba MA, Barry K. Faidherbia albida Improves Maize Productivity and Carbon Sequestration in a Parkland Agroforestry System in Ethiopia. Poster.

Factors influencing maize production include rainfall, distance from tree, pruning and fertiliser, but higher rates of fertiliser would have led to further increases in maize yield. The study concluded that 50% pruning (instead of 100% pruning, i.e. pollarding) reduces shading enough to maximise maize grain yield under trees. Fertilizers increase yield and are best used in normal or wet seasons. If *F.albida* trees were the cause of higher soil fertility, incorporating more trees into these farmlands could improve crop production and deliver ecosystem services including carbon sequestration.

The effects of each of these factors (rainfall, distance from tree, pruning and fertiliser) were adequately simulated (Figure 8), and then the model used to develop hypotheses about the effects of untested management scenarios on wood production and maize yields. The simulations suggested that maize yield could be improved by applying fertilisers (particularly on crop-only plots) and by at least 50% pruning of trees. Optimal maize yield could be obtained at a higher rate of fertilization under trees than away from them due to better water relations, and there is scope for improving the sowing date and cultivar. Across a 34 year range of recent climate, small increases in yields due to optimum Nitrogen (N)-fertilizing and pruning were probably limited by nutrient limitations other than N, but the highest yields were consistently in the 2–4 m zone under trees. Increasing tree density in these systems was simulated to maintain or increase carbon sequestration (mainly in soil), with important factors needing further study being micro-climate, tree litter inputs, manure inputs that transfer crop residue carbon (C) from crop-only areas, preferential tree establishment on re-existing fertile microsites, soil organic matter transfers via erosion from crop-only areas, and bird manure stimulating crop growth and residue loads.

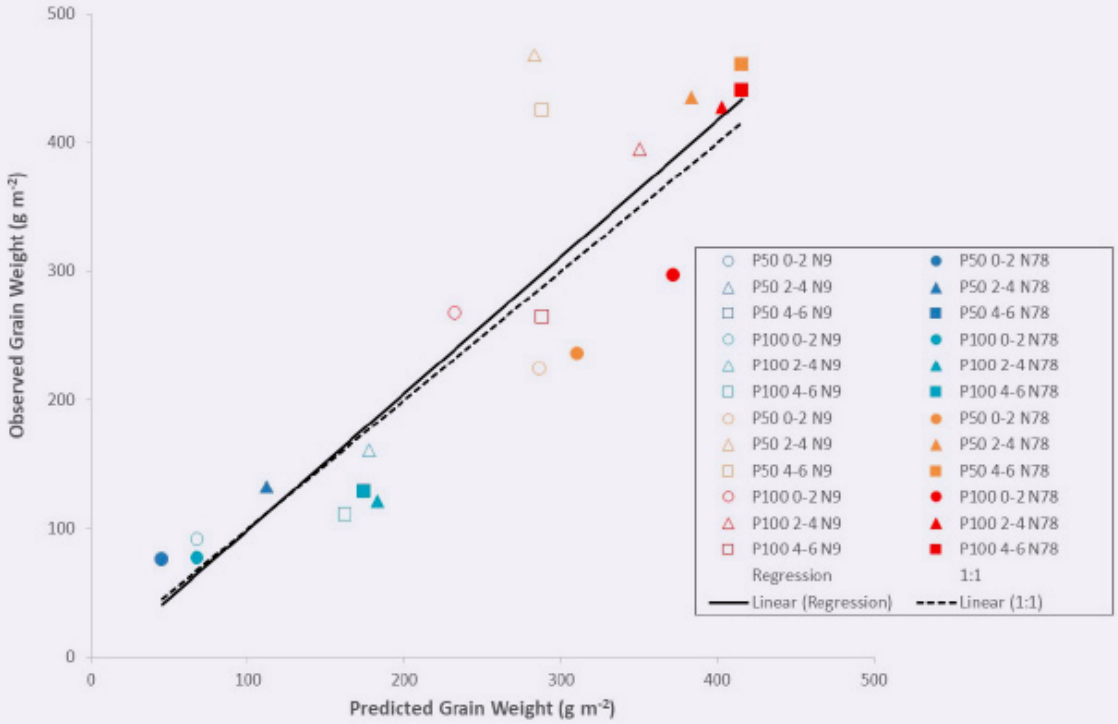


Figure 8: Comparison of observed and predicted maize grain yield grown in all zones under trees in the 2015 (blue symbols) and 2016 (orange and red symbols) cropping seasons that were not used for model calibration. Lines are linear regression (solid) and 1:1 (broken)

APSIM-SIMILE modelling that dynamically integrates plot-scale biophysical modelling with farm-scale livelihood modelling also developed (https://www.simulistics.com/help/submodels/communication.htm[7]) and its application commenced for the Faidherbia-wheat system in Tigray.

6. Land and Water Management Options for Semi-arid and Sub-humid sites

The study team produced 24 maps depicting slope, land use/cover, soil texture, rainfall, runoff potential, potential soil loss, and recommendations on the appropriate land and water management interventions given. Findings indicated that East Shewa is gently sloping with average annual rainfall, making the zone's runoff potential low with low to moderate soil loss potential.

In East Shewa, out of a total of 10,009 Km^2 mapped, the predominant land use is cropland (7,133Km^2). Therefore, on cropland, there is a need to promote soil and water conservation practices such as level bunds, grass strips, and Zai pits. Conservation farming promotes minimum tillage, soil cover with crop residues or green manures and crop rotations for increased productivity. Such a farming system will help to conserve the land and increase farmer income. There is also a need to incorporate agroforestry practices such as boundary planting, woodlots, orchards and soil fertility trees to increase the rainwater productivity on the cropland. On slopes of 5-16%, farmers should be encouraged to use terraces and agroforestry practices to combat erosion.

The forest cover in East Shewa is too low, covering 163 Km^2 or one per cent of the mapped area. The government and other stakeholders should sensitise the community on increasing forest cover to at least 10 percent of the total area. The promotion of farmer-managed natural regeneration and Agroforestry could help to increase the tree cover in the area.

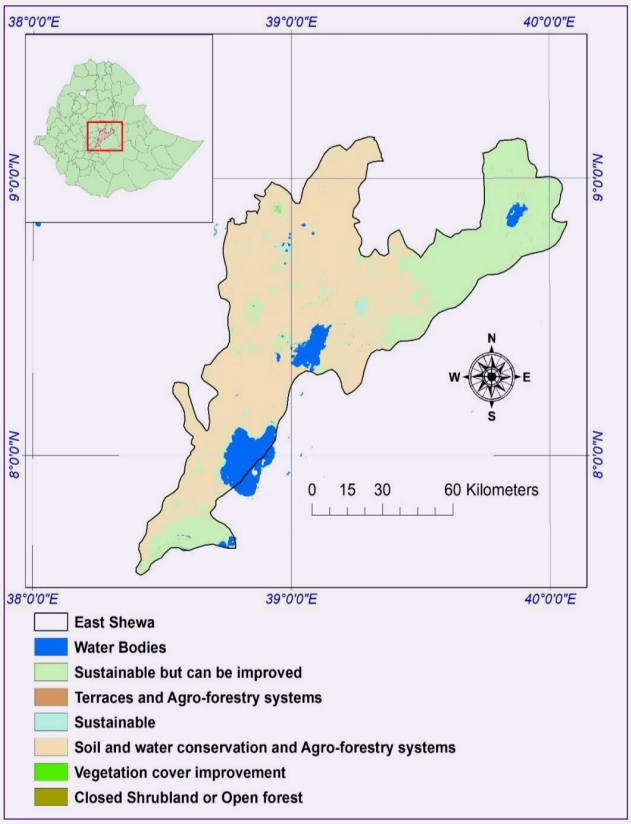
Most of the East Wellega zone is gently sloping but with some sections of steep slopes. Annual rainfall in this area varies from medium to high, making the runoff potential range from low to high. Soil loss in this zone varies from low, medium to high in the different sections. West Shewa zone has slopes varying from gentle to steep. However, most of the area is gently sloping. Annual rainfall in the area is average making the runoff potential in the zone low to moderate. Soil loss varies from low to moderate. However, some sections have high to extreme soil loss potential.

In the East Wellega region, out of the total area mapped (13,947 Km^2), the major land-use types are forest cover (43%), cropland (40%), grassland (14%), and others put together (3%) are shrubland, wetland/irrigated land, bare ground, built-up areas and water bodies. Sixty per cent of the region mapped is sustainable, although it requires some maintenance efforts such as controlled cutting of trees, farmer-managed natural regeneration and controlled grazing. Terracing and Agroforestry are necessary on 4983 Km^2 or 36% of the cropland. The area requiring soil and water conservation measures is 4% or 560 Km^2.

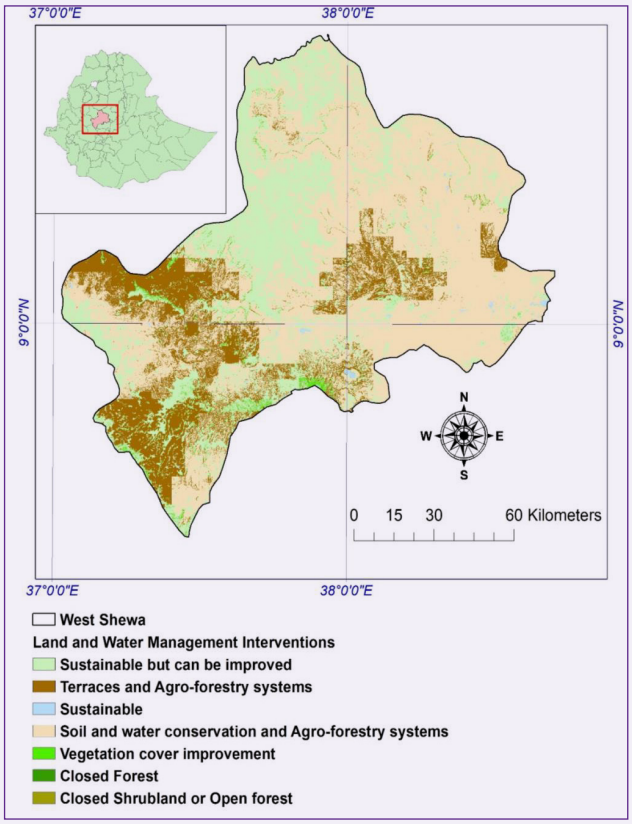
The West Shewa region requires soil and water conservation and Agroforestry on 55% of the total area (15,271 Km^2), whereas Terraces and Agroforestry systems are necessary on 17% of the area mapped. Although 27% of the region is considered sustainable, there is a need to promote forest conservation and controlled grazing.

[7] *https://www.simulistics.com/help/submodels/communication.htm*

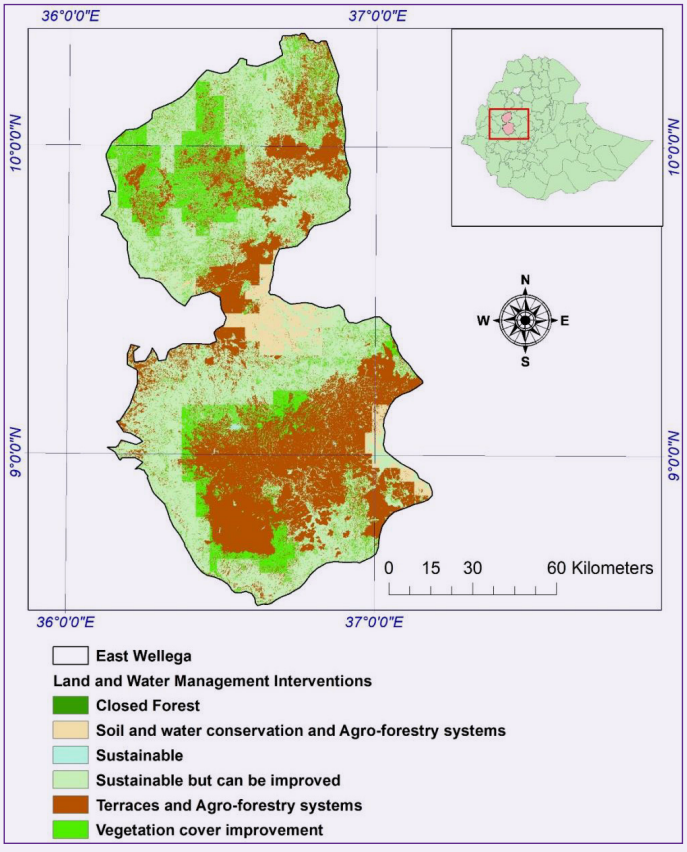
East Shewa - Land and Water Management Interventions



West Shewa - Land and Water Management Interventions



East Wellega - Land and Water Management Interventions



Maps indicating Land and Water Management Interventions for East Shewa, West Shewa, and East Wellega Ethiopia

7. Sustainable grazing management options

A review of grazing policies, strategies and institutional set up revealed sustainable grazing management practices were challenged due to main bottlenecks including, but not limited to lack of clear land use policies, regulations and directives, weak institutional set up, top-down approach, lack of inputs, lack of improved grazing-based incentives and payments for environmental services, weak coordination between key stakeholders and weak enforcement due to poor governance. Discussions on existing policies and strategies on grazing were held and sustainable grazing management options were agreed upon during the presence of officials from three government ministries- Ministry of Agriculture; Ministry of Livestock and Fisheries; and Ministry of Environment, Forest and Climate Change as well as officials from four regional states, Universities and research institutions, district experts, development agents, farmers, and different faith and cultural leaders.

Free grazing practices on (a) the border of farmland and gully, and (b) designated to open common grazing area, (c) free grazing on farmlands

Appropriate recommendations were given to policy makers, research organizations and other relevant actors to enable them to integrate sustainable grazing options within agroforestry[8] at local andnational levels. This further resulted to formation of a Sustainable Grazing Platform and development of a policy brief highlighting sustainable grazing policy recommendations. In addition, sustainable grazing management trials were established in Endacherkos and Batu in Tigray and Oromia regions respectively. Further research work on enhancing grazing management is ongoing through two PhD studies.

[8] Integrating Water Management Technologies and Sustainable Grazing Options with Promotion of Agroforestry. 2019. PowerPoint Presentation. Trees for Food Security Phase-2 Steering Committee Meeting. Nairobi, Kenya. *http://apps.worldagroforestry.org/downloads/Publications/PDFS/CP19099.pdf*

Discussions with different faith leaders on sustainable grazing management in Oromia ad Tigray

8. Rural Resource Centres as hubs for community empowerment and distribution of quality germplasm

Members of Margarrisa Group grafting tree seedlings at Batu RRC, Oromia region, Ethiopia

Batu[9] and Bako Rural Resource Centres (RRCs), established in Zeway and Bako respectively are special hubs for wide scale dissemination of agroforestry knowledge and quality germplasm to end users. They are technically backed up by the project through provision of inputs for production of quality planting materials and facilitating trainings related to agroforestry technologies Through the project an irrigation scheme was installed at the RRC to aid in watering the tree nurseries as well as the demonstration plot. To date more than 2 million tree seedlings of various species have been produced from the RRCs out of which more than 1.1 million quality planting materials have been provided to farmers and the government through the green legacy national project.[10] In addition, more than 900 community members have benefitted from training/ capacity development activities on tree nursery management, production of quality germplasm, entrepreneurship among others from the RRCs.

[9] Mekuria A, Carsan S, Kiptot E et al. 2016. Batu Rural Resource Centre: A community-based approach to deliver agroforestry technologies to rural farmers. Factsheet. Addis Ababa, Ethiopia: World Agroforestry (ICRAF. *https://www.worldagroforestry.org/publication/batu-rural-resource-centre-community-based-approach-deliver-agroforestry-technologies*

[10] Getahun, E. 2020. Ethiopia to grow 5 billion trees in the Second Green Legacy Campaign. *https://www.worldagroforestry.org/blog/2020/06/09/ethiopia-grow-5-billion-trees-second-green-legacy-campaign*

Irrigation activities at the RRC nursery in Ziway, Oromia region, Ethiopia

Owing to production of high-quality germplasm at the RRCs, a generally high tree survival rate has been recorded to date (Figure 8). Survival of fruit trees such as *Psidium guajava (Guava), Carica papaya (Pawpaw)*, and *Persea americana (Avocado)* was above 50% in most sites. This could be attributed to the watering treatments introduced for the fruit trees through the participatory trials. This indicates that with enhanced post-tree management practices, higher survival of trees can be achieved.

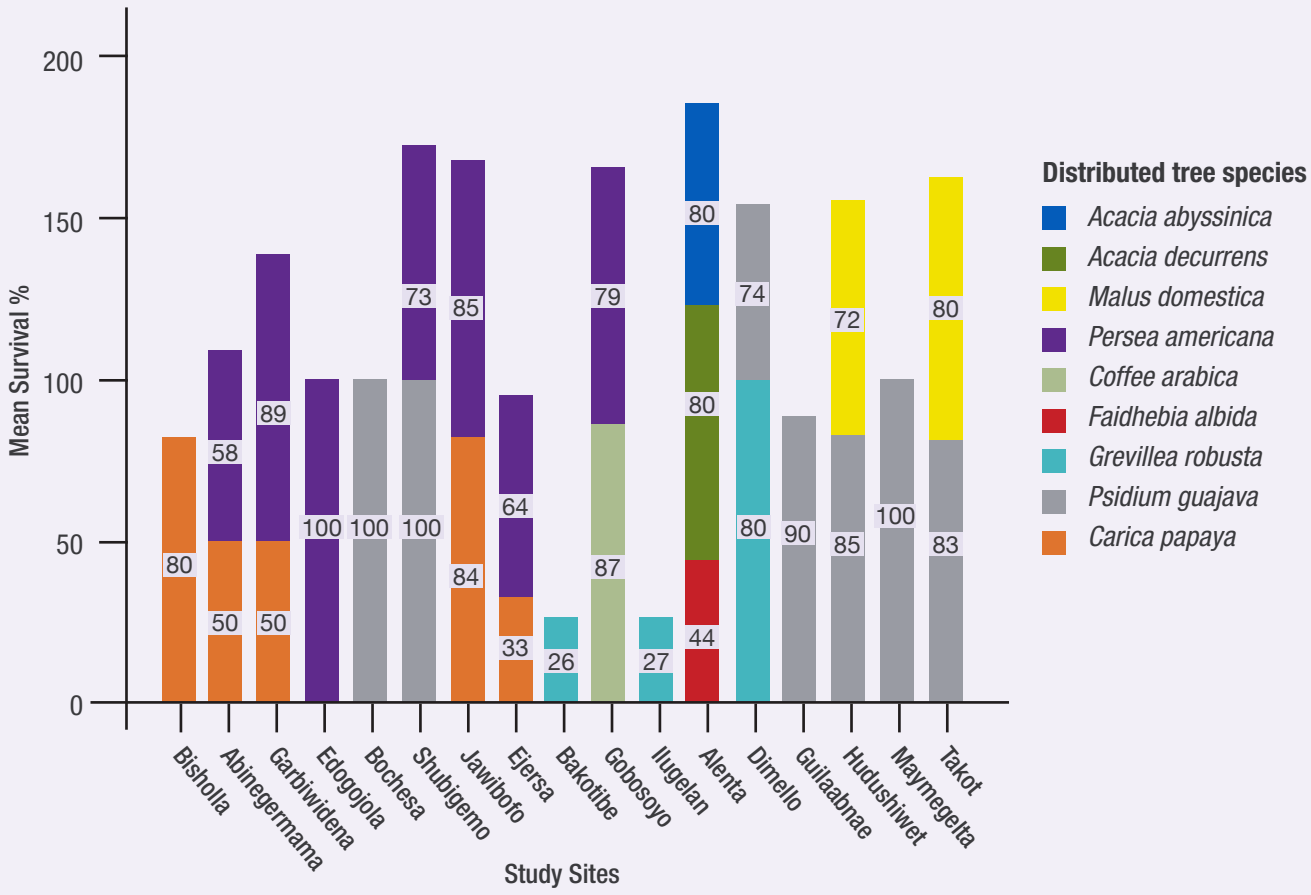


Figure 8: Survival of tree seedlings in various project intervention sites

Margarrisa Group continues to benefit economically from the Batu RRC where the group members earn a net income of approximately USD 200 per month from nursery operations and sale of quality germplasm. The group is now formally organized and has a Tax Identification Number (TIN) as an identification by the woreda revenue and tax administration office.

Similarly, the 11 youths in Bako have taken up management of the RRC activities. Through the leadership of the project coordinator in Bako and Head of Agriculture and Natural Resources for Bako Tibe district, the group continues to work at the RRC in producing tree seedlings that have been distributed to project's participatory trials and tree planting activities. In 2019, the group earned an income of 25,000 Ethiopian Birr (USD 600).

Bako RRC tree nursery and training hall

The youths working at the RRC, Oromia region, Ethiopia

The RRCs have attracted visits from other projects and NGOs with the aim of replicating the model to their contexts. The project prides in adoption of the RRC model at the national level by the government where more than 16 RRCs have been established across the countries. This includes Gergera RRC established as part of the Irish Aid funded project- Enhancing integrated Watershed Management with Climate Smart Agriculture in Gergera Watershed in Tigray.

9. Tree-based value chains and financing options

Discussions on potential tree-based value chains with a trader in Zeway market, Oromia region, Ethiopia

Knowledge gap on smallholders and other market actor's ability to participate effectively and profitably in tree product value chains was identified and validated with farmers and other value chain actors through key informant interviews and Focus Group Discussions in Oromia and Tigray regions. Potential tree-based value chains were identified as Mango in Zeway, Avocado in Bako and Apple in Tsaeda Emba, Tigray.

An existing demand for all the fruits was reported by farmers, traders and processors. However, farmers are not able to produce surplus for sale. In Adami Tulu Woreda, farmers opted to produce vegetables that fetch them instant income because they take a very short term to grow unlike most fruit trees which are perennial. In Bako region, farmers were found to earn income from production and sale of maize, teff, coffee and fruits such as banana, oranges and lemons. This implied that this value chain needed to be developed at the production level. Water scarcity was reported to be the main factor contributing to low production of tree products hence the need for concerted efforts in rainwater harvesting and soil and water conservation. These findings informed the establishment of project's participatory trials on soil moisture retention to enhance improved Papaya seedlings and improved Avocado varieties under varying watering and management schemes at homesteads in Oromia region. Apple fruits were positively taken up in Tsaeda Emba Woreda. The project facilitated this through awareness creation and provision of planting materials to the farmers at subsidized costs. No traders or processors were identified for the apple value chain. However, the value chain is expected to develop and include other actors such local and regional traders if the number of producers and the quantities produced increase.

10. Adoption of the revised agroforestry curriculum in learning institutions

Institutional assessment of the status of agroforestry curricula and extension training gaps was conducted in university, colleges and technical and vocational education and training (TVET) institutions. Among the institutions assessed were Wollo, Mekelle, Adigrat, Aksum, Selale and Addis Ababa University; Wukro Agricultural Polytechnic, WAPT Polytechnic; Wukro St. Mary College; Shire and Maychew TVETs. These institutions offered

forestry or agroforestry training as independent courses or as courses embedded on other course contents, topics or chapters.

Based on the findings from the institutional assessments, similar modules were taught across the university and TVET level. However, it was found that the TVET institutions allocated more contact hours for learning as compared to the universities. Additionally, the findings revealed that the training staff in the learning institutions had poor knowledge and low competency on many of the agroforestry related modules/courses/topics being offered. Following the assessment, it was suggested that extension training should be an important part of agroforestry training. Moreover, it was also recommended that project planning and management need to be included in agricultural extension training.

Owing to the gaps identified during the institutional assessment of the agroforestry curricula within the project regions, ANAFE organized a regional agroforestry curricula development workshop which was held in Kenyatta University, Nairobi. Tertiary training staff from Mekelle and Addis Ababa university participated in the regional workshop. ANAFE also conducted an online training workshop on training material development that drew participation of teaching staff from Mekelle University. Using the agroforestry curriculum guide developed during the ANAFE regional workshop, Mekelle University conducted an agroforestry curriculum review on agroforestry courses offered at different departments both at the BSc and MSc levels.

11. Capacity development

About 1,292 people have benefitted from various capacity development initiatives such as training on high-value agroforestry tree species, multi-purpose trees and benefits, tree planting and management, nursery management, soil management, grazing management, watershed management among others. Fourteen participants were trained on data collection and management through Open Data Kit (ODK). Refresher training on high-value agroforestry tree species was regularly provided for the farmers. In addition, the project organized lesson learning and experience sharing visit in Semere district where farmers, Development Agents and experts got to experience homestead agroforestry practices integrated with vegetable production, and fruits. Through this visit rich insights were gained on nursery management, fruit seedling handling and planned comparison on the seedlings' performance under different watering

Participants during the Agroforestry Curricula and Extension Training validation workshop at Mekelle University, Ethiopia

and mulching regimes. Mekelle University further engaged 130 participants during the agroforestry curriculum survey. The project further supported three PhD students. One has completed his studies while two are in progress.

Table 3: Number of people reached through the various capacity development activities in Ethiopia

Capacity Development activity	Male	Female	Total
Open Data Kit (ODK) Training in Addis Ababa	11	3	14
Participants engaged in agroforestry curriculum survey by Mekelle University	97	33	130
Refresher training for farmers and extension agents on high-value agroforestry tree species extension agents in East Shewa	55	21	76
Training on sustainable grazing management, multipurpose trees, exchange visit in East Shewa	39	19	58
Capacity building on multipurpose trees and agroforestry practices at Freweini town	72	28	100
Capacity building for extension agents at Freweini town	13	3	16
Lesson learning and experience sharing visit in Semere district	40	3	43
Training of youth on agroforestry technologies in Bako	8	3	11
RRC Margarrisa group, farmers and woreda Natural Resource Management (NRM) experts trained on water management options	18	7	25
Farmer training on the construction of cost-effective community water harvesting technologies at Alenta sub-watershed	52	11	63
Farmer training on the impact of tree cover on crop productivity, water, nutrients, and livelihoods, cost-effective water harvesting technologies in Adami Tulu	56	24	80
Training on intercropped seedling management, mixed cropping and soil acidity management	85	9	94
Field visit and awareness creation about Bako RRC to Bako area woreda officials, NRM experts and youth group	19	3	22
Farmer training at Ziway RRC on fertilizer application and crop productivity conducted by Adami Tulu Woreda Agricultural Office	64	21	85
Farmer training on agroforestry practices in relation to In-situ water management options (WV)	61	22	83
Woreda Experts and Development Agents training on Dryland agroforestry practices (WV)	13	7	20
Farmer training on home gardens, on-farm tree planting and management practices (BARC)	28	5	33
Sensitization training in collaboration with Bako Tibe Woreda Agricultural Office at Bako tree nursery site (ICRAF & BARC & BOA)	71	4	75
Farmer training on tree planting, awareness creation and participatory tree species selection by Ziway RRC Group in collaboration with Self Help Africa	135	129	264
Total	**937**	**355**	**1292**

Other highlights in Ethiopia

Project activities in Ethiopia have been instrumental in contributing to scientific knowledge. Six peer reviewed articles have been published in various journals and seven have been submitted for publication. In addition, project activities in Ethiopia have been featured in various events both internationally and nationally. In May 2019, the project supported four scientists to present their work in the World Congress on Agroforestry held in Montpellier, France. The project results presented at the congress include the 15. Farmers preferences on high tree diversity in the semi-arid and sub-humid areas of Ethiopia, effects of pruning *Faidherbia albida* on crop yields in the semi-arid site, APSIM modelling on Faidherbia-maize systems as well as sustainable grazing management.

Results were further shared during the National Workshop for establishing the National Watershed and Agroforestry Multi-Stakeholder Platform in October 2019 at International Livestock Research Institute (ILRI) Campus in Addis Ababa, Ethiopia.

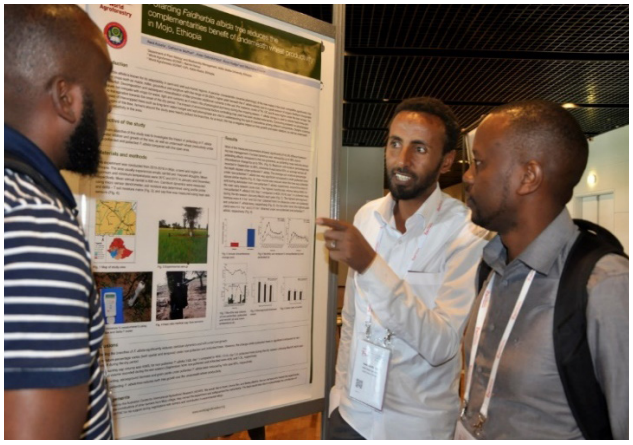
The RRC activities in Bako were featured by Ethiopian TV in November 2020. Shiferaw Tadesse, the T4FS-2 Focal Person had this to say, "*This land was fallow for over 15 years due to soil degradation and the vegetation cover before establishment of the agroforestry trial was unpalatable for grazing. Maize crop productivity was very low before the establishment of the trial (500 kg/ha for maize) but now this has increased to 5000 – 6000 kg/ha and from 60 kg/ha for teff to 1500-1600 kg/ha.*"

T4FS-2 farmers, Weyessa Adugna and Shibiru Wegari, from Bako district in Oromia region during a press briefing with Ethiopia TV

Two farmers Weyessa Adugna and Shibiru Wegari were also interviewed during the feature. The two farmers had intercropped *Grevillea robusta* trees with maize. *"The soil under the trees' canopy is always moist and good for maize productivity. Maize under the canopies performs better than maize in open fields,"* explained the farmers. Both farmers protected their fields from open livestock grazing and maintained over 75% of Grevillea seedlings. Shade, firewood and construction materials are

among the tree product benefits acquired from the trees.

Another key highlight was the visit by ACIAR's Chief Executive Officer, Professor Andrew Campbell accompanied by General Manager of Global Program, Mellissa Woods and the project management team to the project sites in June 2018. The team visited the Rural Resource Centre in Zeway, interacted with farmers hosting the participatory trials and partners implementing the project. The key message from Prof. Campbell was that ICRAF as an active partner implementation of the project, needs to maintain constant communication with ACIAR to ensure success of the project. He also emphasized on the need for project activities and successes to be publicized more through both ICRAF and ACIAR communication channels.



Awol Assefa (centre) at 2019 World Congress on Agroforestry (left). Kiros Hadgu explaining RRC activities to ACIAR's Chief Executive Officer, Prof Andrew Campbell and TF4S-2 Project Manager, Prof. Catherine Muthuri (right)

13. Project recommendations in Ethiopia/take home message

Despite the challenges related to political unrest and COVID-19 pandemic, substantive outcomes have been achieved in Ethiopia. The project embedded research in development initiatives and aligned with the national priorities of Ethiopia such as the Climate Resilient Green Economy (CRGE) strategy to rehabilitate 22 million hectares of degraded land by 2025, improve food security, environmental resilience, and carbon storage. The project has contributed to this by facilitating planting of over one million tree seedlings across Oromia and Tigray regions.

Success of the project is attributed to the strong network of partnerships and complementary projects such as the Drylands Development Programme[11] in which T4FS-2 project leveraged

[11] *https://www.worldagroforestry.org/project/drylands-development-programe-drydev*

on the World Vision Ethiopia led activities to reach out to more farmers especially in Tigray area. Other complimentary projects include Provision of Adequate Tree Seed Portfolio[12], Regreening Africa[13] and Enhancing Integrated Watershed Management with Climate Smart Agriculture in Gergera Watershed.[14]

The main achievement of the project is the influence on national policies whereby findings from the project have informed on policy reviews and guided in establishment of national agroforestry and watershed platform which will present an opportunity for scaling up and out agroforestry related options.

Adoption of the RRC model at the national level will be considered a project legacy as the model will be utilized by various institutions to create employment for the youths. The RRCs initiated by the project will continue to act as hubs for capacity development and distribution of quality germplasm to the communities as well as sources of livelihood for the youths and women working at the centers. Both staff and students from higher learning institutions will continue benefiting from the new agroforestry curriculum guide that will result in well-trained agroforestry specialists who can take the agroforestry agenda forward.

Lessons from the project point to the need for participatory approaches in conducting research for development activities in agroforestry. Emphasis is placed in the need for farmer-centered approaches which should be demand-driven. In conclusion, there is no one-fits all technology and therefore options should be assessed, and best-fit options implemented in specific contexts.

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[12] *https://www.worldagroforestry.org/project/provision-adequate-tree-seed-portfolio-ethiopia*

[13] *https://regreeningafrica.org/*

[14] *https://www.irishaid.ie/media/irishaid/allwebsitemedia/30whatwedo/climatechange/Ethiopia-Country-Climate-Action-Reports-2016.pdf*

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