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# Livelihood benefits and challenges of *Acacia decurrens*-based agroforestry system in Awi Zone highlands, Northwest Ethiopia

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**ABSTRACT**

*Acacia decurrens* (hereafter *Acacia*) agroforestry system has been expanding rapidly in the northwestern highlands of Ethiopia. The agroforestry system provides multiple eco-environmental services; however, there is inadequate quantitative evidence on its livelihood benefits. This study, therefore, investigated the livelihood benefits and challenges of *Acacia-based* agroforestry system in the Awi area, Northwest Ethiopia. Data was collected through household survey quetionnaires (296 randomly selected *Acacia* growers), focused-group discussions, interviews, and observations. A combination of quantitative and qualitative methods was used for the data analysis. The findings showed that crop production, charcoal making, animal rearing, and fuelwood selling were the major sources of livelihood. Notwithstanding the complex challenges (*Acacia* pests/diseases, traditional charcoal-making, limited road access and market opportunities, negative human-health impacts, and high production cost), *Acacia*-based agroforestry positively affected farmers livelihoods. Comparatively, the natural, physical, financial, human and social capital indices of farmers were higher by 0.25, 0.24, 0.43, 0.25, and 0.06, respectively, in the post-than pre-*Acacia* periods. The overall livelihood index of farmers increased from 0.47 (pre-*Acacia*) to 0.71 in the post-*Acacia* period. The study concluded that this agroforestry practice has immense livelihood benefits, although diverse challenges question its sustainability. Therefore, short and long-term strategies should be designed to strengthen the opportunities and address the challenges.

**KEYWORDS**
*Acacia*-based; agroforestry; challenges; livelihood assets; livelihood benefits; northwest Ethiopia

## Introduction

Forests are crucial for livelihood stability, environmental equilibrium and socioeconomic development (Oldekop et al. 2020; UN 2021; EIB 2022). Globally, nearly 1.6 billion people depend on forests for their livelihoods, utilizing them as sources of food, shelter, energy, medicines, and income (Bhattacharya 2018; UN 2021). In Africa, about two-thirds of the continent's population directly or indirectly depends on forests for their livelihoods (CIFOR 2005; Somorin 2010). Forests also contribute to environmental sustainability by improving soil quality, controlling erosion and pollution, stabilizing the hydrological cycle, conserving biodiversity and regulating the climate (Cheng et al. 2017). Despite their irreplaceable importance, global forest resources, especially natural ones, are dwindling (FAO 2020;

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FAO & UNEP 2020). The degradation of natural forests and the continuously growing human population create a significant gap between the demand and supply of forest products (McEwan et al. 2020), leading to the expansion of tree plantations (FAO 2020; McEwan et al. 2020).

Tree plantations in Ethiopia have a long history, dating back to the 15th century, during the reign of King Zera-Yakob. However, the plantation of non-indigenous tree species in the country began in the late 1800s (Eshetu 2014; Getnet et al. 2022). Ethiopia's current green development strategy prioritizes afforestation and reforestation (EFCCC 2020). Consequently, the plantation forests of the country have been increasing (Lemenih and Kassa 2014; FAO 2020) though there is limited species diversity. Trees from the genus *Eucalyptus, Cupressus, Pinus*, and *Acacia* are the most widely planted (Bekele 2011; Zerga et al. 2021), with *eucalypts* accounting for 90% of the national plantation forest cover (EFCCC 2020). Tree plantations have become an integral part of rural life (Nigussie et al. 2021), benefiting the community economically, environmentally, and socially through income generation, soil and water conservation, biodiversity preservation, climate change mitigation, and cultural and aesthetic services (Ingram et al. 2016; FAO 2020; EIB 2022).

Subsistence rain-fed agriculture was the main livelihood means of farmers in the Awi highlands before the 1990s (Chanie and Abewa 2021). However, this livelihood mean was threatened by land fragmentation and degradation, soil acidification, and the resultant low agricultural outputs (Tamirat and Wondimu 2019; Chanie and Abewa 2021). In the meantime, growing acidic-tolerant crops and *eucalypt* trees was used as a coping strategy for the prevailing problems. To enhance soil fertility and crop yields, local farmers introduced *Acacia* as fallow trees in the early 1990s (Tamirat and Wondimu 2019; Bazie et al. 2020; Amare et al. 2022). *Acacia*, an Australian species, soon became the most widely planted non-native tree in the Awi highlands due to its wide socioeconomic benefits, environmental friendliness, and compatibility with other land uses (Tamirat and Wondimu 2019; Chanie and Abewa 2021). Above all, it has proven potentially in restoring degraded land and improving soil fertility (Bazie et al. 2020; Amare et al. 2022; Beshir et al. 2022).

The *Acacia*-based agroforestry system (hereafter, *Acacia* system) in Awi highlands involves short-rotations of tree plantations (Tamirat and Wondimu 2019; Nigussie et al. 2021; Amare et al. 2022), which act as improved fallows (Amare et al. 2022). In this agroforestry system, *Acacia* are planted along intercrops first (Partey et al. 2017; Tamirat and Wondimu 2019). Gradually, when the tree canopy covers the land, the intercrops are replaced by natural vegetation (Tamirat and Wondimu 2019; Nigussie et al. 2021; Amare et al. 2022). The *Acacia* system in the study area has various advantages: feeding livestock, charcoal production and improvement of soil fertility (Tamirat and Wondimu 2019; Amare et al. 2022). On average, the *Acacia* trees are cut down and harvested at age of 4–5 years. After harvesting the trees, the land is used for crop cultivation initially and then for a new agroforestry rotation. This cyclic land use practice considerably enhances farmers' financial capital and the various ecosystem services in the study area (Wondie and Mekuria 2018; Bazie et al. 2020; Nigussie et al. 2021).

Among the districts in the Awi highlands, *Fagita Lekoma* is the pioneer in *Acacia* system establishment. The *Acacia* system in the district started three decades ago on degraded lands and acidic soil areas. Initially, local farmers had limited awareness of the benefits of this new land use system, as they were primarily engaged in traditional subsistence agriculture. However, with the help of development agents and pioneering growers, awareness grew, especially in the early 21st century. Consequently, many farmers in *Fagita Lekoma, Banja*, and *Ankesha-Guagusa* districts started converting their cropland into *Acacia* system. The fast-growing nature of *Acacia* trees and their positive attributes, including attractive economic returns, soil fertility improvement, erosion control, and environmental friendliness, as well as the increasing demand for charcoal and fuelwood, were the main contributing factors to the rapid expansion of the *Acacia* system (Wondie and Mekuria 2018; Chanie and Abewa 2021).

Nowadays, the *Acacia* system is integrated in the everyday life of the Awi community, particularly in *Fagita Lekoma, Banja, and Ankesha-Guagusa* districts. This agroforestry system is a source of income, employment, fuelwood, fencing poles, construction material, and soil fertilizers for the local people. Not only for farmers, but *Acacia* also created livelihood opportunities for different segments of society, mainly landless youth, daily workers, traders, brokers, and transport service providers. Considering such multiple roles, the local people called it *'black gold*.' Although *Acacia* system and charcoal production have immense socioeconomic and environmental contributions and are expanding rapidly in the northwestern highlands of Ethiopia, little attention has been given to their livelihood impacts and challenges. The only publication we found on the subject (Nigussie et al. 2021) focused on the perceptions of local farmers and used only qualitative methods to assess the livelihood changes related to adopting the *Acacia* system. The study also did not address the contemporary challenges associated with this agroforestry system (Nigussie et al. 2021). Our study aims to document quantitatively the livelihood impacts of the *Acacia* system and to uncover all the current challenges associated with this system in the Awi highlands, Ethiopia.

Specifically, this study seeks to answer the following research questions: (1) What are the livelihood benefits of the *Acacia*-based agroforestry system in the study area? More precisely, what were the quantitative effects of the adoption of the *Acacia* system on the five livelihood capitals? (2) What are the current challenges facing *Acacia* grower farmers?

## Materials and methods

### *Description of the study area*

The study covers three districts in Awi administrative zone: *Ankesha-Guagusa, Banja*, and *Fagita Lekoma*. Addis Kidam, Injibara, and Gimija Bet serve as the capital towns of *Fagita Lekoma, Banja*, and *Ankesha-Guagusa* districts, respectively. The study area is situated between 10° 43′ 00″ to 11° 10′ 00″ North and 36° 40′ 00″ to 37° 10′ 00″ East, covering a total area of about 1,666 km$^2$ with an altitudinal range of 1,799 to 2,968 m asl. (Figure 1). The study area has a diverse topography, including plains, plateaus, valleys, mountains, hills, and gorges. There are four seasons in the study (Summer, Autumn, Winter, and Spring), of which Summer (June to August) is the rainy season, and Winter (December to February) is the dry season. The Metrological data obtained from the WMO database shows that the mean annual temperature of the study area ranges from 15 to 24 °C and has an average rainfall of over 1,800 mm (https://climexp.knmi.nl/get_index.cgi, accessed on 23 May 2022).

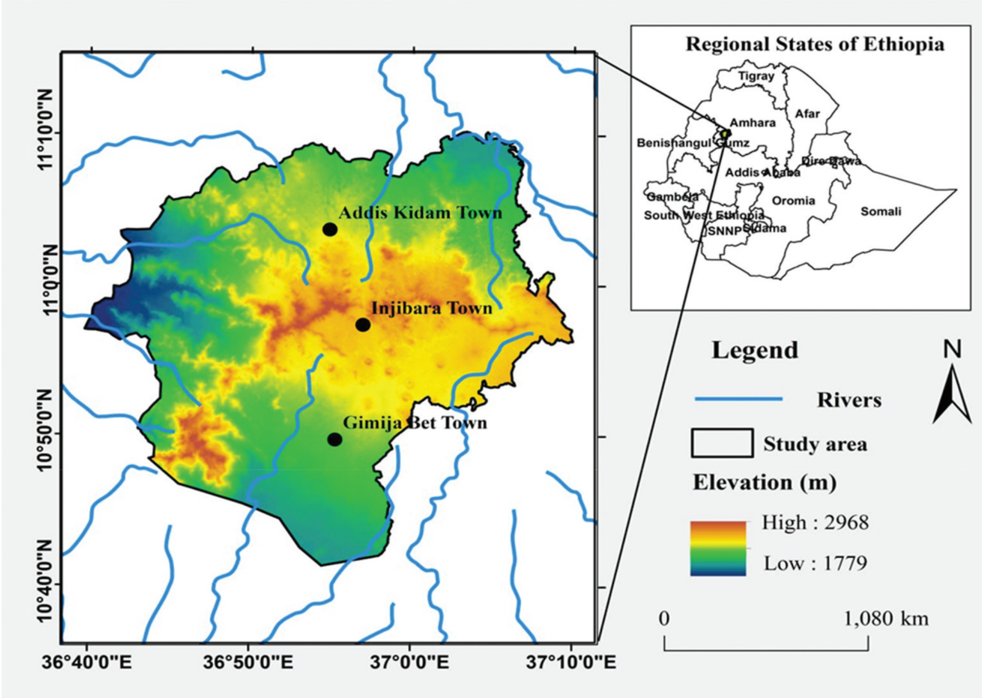


**Figure 1.** Map of the study area.

According to Awi Zone Finance and Economic Development Bureau (2021), the study area's population was estimated at 419,379, with 206,013 males (49%) and 213,365 females (51%). Mixed agriculture and plantation forestry are the main livelihood sources in the study area (Tamirat and Wondimu 2019; Nigussie et al. 2021). The dominant crops in the area include potato, wheat, barley, and teff (Tamirat and Wondimu 2019; Belayneh et al. 2020). The major land use/cover types are cropland, grassland, settlements, shrubland, and forestland (Wondie and Mekuria 2018; Belayneh et al. 2020; Worku et al. 2021).

## *Sample size and sampling procedure*

This study employed a multi-stage sampling technique to select sample households. Firstly, three districts (*Ankesha-Guagusa, Banja*, and *Fagita Lekoma*) were purposefully chosen for their fast expansion and extensive coverage of *Acacia* system. Secondly, representative sample kebeles1 from *Ankesha-Guagusa, Banja*, and *Fagita Lekoma* districts were purposefully selected based on their experience in establishing *Acacia* system and their transportation accessibility (Table 1). Thirdly, 296 sample respondents were selected randomly, with proportional representation from each study district and from each kebele (for more details, see supplementary file 1: sampling method).

**Table 1.** Distribution of sample households by *districts and kebeles.*

| Selected districts | TNK | Sample *Kebeles* | Total *Acacia* growers | Sample households | Percent |
|---|---|---|---|---|---|
| *Ankesha-Guagusa* | 18 | Bekafta | 1091 | 53 | 18 |
| | | Tulta | 801 | 39 | 13 |
| **Sub-total** | | **2** | **1892** | **92** | **31** |
| Banja | 27 | Asem Selassie | 365 | 18 | 6 |
| | | Bida Jogola | 375 | 18 | 6.4 |
| | | Surta | 682 | 33 | 11 |
| **Sub-total** | | **3** | **1422** | **69** | **23.4** |
| Fagita Lekoma | 30 | Azemach Lolista | 656 | 32 | 11 |
| | | Endewuha | 872 | 43 | 14 |
| | | Fury Jogola | 841 | 41 | 14 |
| | | Zenbella Grayita | 378 | 19 | 6.5 |
| **Sub-total** | | **4** | **2747** | **135** | **45.5** |
| **Total** | **75** | **9** | **6061** | **296** | **100** |

TNK= total number of kebeles.

## *Data sources and collection methods*

Primary data were collected through a household survey, key informant interviews (KIIs), focus group discussions (FGDs), and field observations from sample respondents, local officials, agricultural experts, and the environment. The fieldwork was conducted in three phases: a pilot study with 25 households in December 2021, the main household survey from January to March 2022, and FGDs and KIIs conducted between April and May 2022.

A combination of close and open-ended questions (on the socioeconomic and demographic conditions of respondents and their livelihood assets as well as on the benefits and challenges of the *Acacia* system) was prepared for the household survey. The survey questionnaire included a pre-test with 25 randomly selected *Acacia* growers. These 25 growers helped us improve the questionnaire and were not included in the final analysis. The final version of the questionnaire was translated into *Amharic (the area's working language)* and distributed to the sampled households from each Kebele with the help of data enumerators and supervisors. Additionally, five FGDs were conducted with local farmers and development agents, using a mixed grouping approach that considered sex, age, *Acacia* system experience, and job diversity. In-depth interviews were conducted with 40 purposefully selected informants, including local elders, experienced *Acacia* growers, and officials/experts.

The livelihood asset indicators used in the study had different response types and measurement units. These indicators were mathematically standardized, so they all have the same range, between 0 and 1 (see details in supplementary file 1, part B: livelihood assets indicators).

The overall livelihood index was determined by adding the values of the five livelihood capitals (human, natural, social, financial, and physical) and dividing the sum by five. Lastly, an asset pentagon was drawn using the mean livelihood indices of these capitals.

## *Data analyses techniques*

The data collected through questionnaires were analysed quantitatively using descriptive (mean, frequency, cross-tabulation, and range) and inferential (paired sample t-test and correlations) statistics. Correlation analysis examined the association between *Acacia* land size (ALS) with landholding size, farmers' age, educational status, and plantation experience. Paired sample t-test was employed to test differences in livelihood asset indicators between pre-and-post-*Acacia* periods. Qualitative data from KII, FGDs, and observations were analysed thematically. Qualitative and quantitative findings were combined, triangulated, and supported by relevant literature.

## Results and discussion

### *Acacia-based agroforestry system in the study area*

Acacia system in the study area involves different land use practices from early planting to harvesting the trees, mainly for charcoal making (Figure 2). In the first year, *Acacia* grower farmers plant rows of *Acacia* trees along with crops (mainly teff/wheat) in the inter-rows. Two to three years after planting, the tree plantation canopy is too close for crops to be grown, so that farmers use the *Acacia* planted land as their main source of grasses for their livestock, using cut-and-carry practices. From 3 years to *Acacia* trees harvesting time, the tree plantation canopy is completely close, preventing almost any plant to grow.

We found that *Acacia's* average area per household was less than 1 ha, with over three-fourths of respondents owning ≤1 ha of *Acacia* system. Most respondents (85%) may be considered as having had a fair experience, with more than 10 years since they began. Only a small percentage (14.5%) had a recent history (≤10 years) in *Acacia* production (Table 2).

Table 3 reveals a moderate but significant positive correlation between ALS and farmers' plantation experience and between ALS and landholding size. This indicates that as plantation experience and landholding size increase, the area allocated for *Acacia* planting also increases. There is only a weak (but still significant) positive relationship between ALS and farmers' age (r = 0.251), while there is no significant association between farmers' educational level and ALS.


**Figure 2.** *Acacia* system with teff cultivation (a); *Acacia* system along with grasses (b); matured *Acacia* plantation (c); *Acacia* wood harvested for charcoal production (d); and three stages of the *Acacia* charcoal production process (e-h).

**Table 2.** Households' distribution based on their *Acacia* land holding size and experience of implementation.

| Number of years since first *Acacia* system | *Acacia* system area (ha) | | | | | Total | % |
|---|---|---|---|---|---|---|---|
| | ≤0.5 | 0.6–1 | 1.1–1.5 | 1.6–2 | Above 2 | | |
| ≤10 years | 31 | 10 | 2 | 0 | 0 | 43 | 14.5 |
| 11–15 years | 52 | 74 | 26 | 1 | 0 | 153 | 51.7 |
| 16–20 years | 20 | 29 | 25 | 5 | 1 | 80 | 27 |
| 21–25 years | 2 | 4 | 2 | 6 | 1 | 15 | 5 |
| Above 25 years | 0 | 2 | 1 | 0 | 2 | 5 | 1.7 |
| Total | 105 | 119 | 56 | 12 | 4 | 296 | 100 |
| Percentage (%) | 35.5 | 40.2 | 18.9 | 4.1 | 1.3 | 100 | |

**Table 3.** Correlations of *Acacia* land size with plantation experience, landholding size, farmers' age & education.

| | | Number of years in *Acacia* system | Landholding size | Age of respondents | Respondents educational status |
|---|---|---|---|---|---|
| *Acacia* planted land size | Pearson Correlation | .582** | .497** | .251** | −.093 |
| | Sig. (2-tailed) | .000 | .000 | .000 | .000 |
| | N | 296 | 296 | 296 | 296 |

**Statistically significant at $p< 0.01$.

## Livelihood strategies of households

The three top sources of livelihood of *Acacia* growers in the study area were crop production (98.3% of our respondents), charcoal production (93.2%), and livestock rearing (82.7%). Moreover, about 67.9%, 23.3%, 13.5%, and 9.5% of the sampled households supplement their livelihoods through fuelwood selling, small-scale trade, daily labour, and beekeeping, respectively. A small proportion of households acknowledge the importance of handicrafts, carpentry, and traditional alcoholic beverage selling in supporting their livelihoods. The results demonstrate the valuable roles of off-farm and non-farm activities in improving farmers' livelihoods. These multiple livelihood sources boost the socioeconomic welfare of grower households.

## Livelihood benefits of the Acacia system

### Natural capital

The overall nature and accessibility status of the natural capital were assessed using eight indicators (Table 4). The livelihood indices of crop productivity, clean water access, land quality, forest contribution, soil erosion in agricultural land, and fuelwood availability increased since the beginning of the *Acacia* system. Substantial positive changes were observed in forest resource contributions and fuelwood availability, with net increments of 0.53 and 0.51, respectively. Respondents noted that women previously travelled long distances to collect firewood, but the *Acacia* system has eased this burden. These findings are consistent with those of Tamirat and Wondimu (2019), Chanie and Abewa (2021), Nigussie et al. (2021). Additionally, Kassie et al. (2016), Molla and Linger (2017), Bazie et al. (2020); Beshir et al. (2022)reported the important role of *Acacia* trees in improving soil fertility and crop yield, as confirmed by our respondents. The World Agroforestry Centre has also reported the benefits of improved fallows with leguminous trees. Indeed, they enhance soil quality and crop yields (Sileshi et al. 2009; Van Noordwijk et al. 2015; Partey et al. 2017), provide fuelwood and charcoal (Matata et al. 2010; Partey et al. 2017), and serve as safety nets during crop failures (Partey et al. 2017). Additionally, FGDs discussants underlined the crucial role of *Acacia* trees in reducing soil erosion and runoff. With regard to this, many studies (Kassie et al. 2016; Tamirat and Wondimu 2019; Bazie et al. 2020; Nigussie et al. 2021; Amare et al. 2022) underlined the crucial benefits of *Acacia* trees in reducing soil erosion, rehabilitating degraded lands, and in the reclamation of acidic soils.

Conversely, the livelihood indices for households' land size, and extent of grazing land substantially decreased compared to *pre-Acacia* values. Interviewees linked the decline in farmland size with land redistribution during the initial years of *Acacia's* introduction and land sharing for children. They also noted that grazing lands were being converted into *Acacia* system and farmland, reducing pastureland. However, our findings related to grazing land contradict with those of Wondie and Mekuria (2018), Belayneh et al. (2020), and Worku et al. (2021).

Aggregately, farmers' average natural capital index before *Acacia* system was 0.47, with most indicators below 0.5 except for grazing land. After introducing *Acacia*, the mean natural capital index substantially increased to 0.72. Likewise, the livelihood indices of most indicators were greater than 0.5 in the post-*Acacia* period (Table 4, Figure 3). This reveals the substantial contribution of the *Acacia* system in improving the natural capital in the area.

**Table 4.** Natural capitals of households' before and after the *Acacia* system adoption.

| | | *M*/P values | | MLI | | |
|---|---|---|---|---|---|---|
| Indicators | Response | BAS | AAS | BAS | AAS | t-test (p-value)* |
| Farmland size | Ha | 1.24 | 1.08 | 0.41 | 0.35 | 11.73 (.000) |
| Average crop production (*Quintal*)[a] | Below 10 | 83.5 | 30.5 | | | |
| | 10–20 | 13.9 | 58.1 | 0.39 | 0.59 | −12.67 (.000) |
| | Above 20 | 2.6 | 11.4 | | | |
| Extent of clean water access (*tap water provision status*) | Low | 71.3 | 12.5 | | | |
| | Medium | 23.0 | 39.9 | 0.45 | 0.78 | −22.05 (.000) |
| | High | 5.7 | 47.6 | | | |
| Perceived quality of cropland | Low | 77.7 | 11.8 | | | |
| | Medium | 18.9 | 33.8 | 0.31 | 0.81 | −23.75 (.000) |
| | High | 3.4 | 54.4 | | | |
| Degree of soil erosion in agricultural land | Low | 11.5 | 52.4 | | | |
| | Medium | 34.8 | 40.5 | 0.52 | 0.81 | −13.62 (.000) |
| | High | 53.7 | 7.1 | | | |
| Forest resources' in local development | Low | 73.6 | 1.7 | | | |
| | Medium | 22.3 | 7.1 | 0.43 | 0.96 | −39.24 (.000) |
| | High | 4.1 | 91.2 | | | |
| Status of fuelwood availability | Low | 69.6 | 2.4 | | | |
| | Medium | 28.4 | 10.1 | 0.44 | 0.95 | −43.06 (.000) |
| | High | 2.0 | 87.5 | | | |
| Size of grazing land | Low | 18.2 | 57.8 | | | |
| | Medium | 30.4 | 35.1 | 0.77 | 0.49 | 13.75 (.000) |
| | High | 51.3 | 7.1 | | | |
| **Natural capital index** | | | | **0.47** | **0.72** | |

*Note: *p-value for all indicators were statistically significant at 1% probability level.*
BAS = before *Acacia* system; AAS = after *Acacia* system; MLI = mean livelihood index; *P* = percentage; *M* = mean;
[a]*Teff* and Wheat: the dominant crops used in the improved fallow.

The qualitative data supported the quantitative analysis, confirming *Acacia's* roles in land conservation, soil fertility enhancement, and fuelwood supply. FGDs participant mentioned that '*Chigegn*2 *considerably improved the natural capital of the local community, addressing past threats to our lives, such as soil fertility, environmental degradation, energy supply, and food security problems. It also substantially improved ecosystem services, including soil quality and crop productivity.*' Consistent with this, Nigussie et al. (2021) confirmed *Acacia's* positive impact on natural capital in rural Ethiopia. Bazie et al. (2020) also found that *Acacia* improves soil fertility and crop productivity. Similarly, Li et al. (2020) recognized the importance of dynamic land allocation and diverse planting for poverty alleviation and environmental sustainability.

### Physical capital

We used 19 indicators to measure the physical capital of sample households (Table 5). Our results showed significant positive changes in housing conditions ($t = -10.36$, $p < 0.01$) after the establishment of *Acacia* system. Besides constructing better iron-roofed houses, *Acacia* helped farmers buy/build extra houses in nearby towns. Livestock ownership of participants decreased from 4.8 to 3.1 TLU ($t = 31.5$, $p < 0.01$) in the *Acacia* period due to the encroachment of *Acacia* and farmland on grazing land. Irrigation access also increased after *Acacia* ($t = -5.28$, $p < 0.01$), enabling farmers to purchase motor pumps and other irrigation materials. Consistent with this, Nigussie et al. (2021) confirmed the positive and negative impacts of Acacia system on the housing and livestock ownership of rural households, respectively. Conversely, Chanie and Abewa (2021) and Nigussie et al. (2021) reported the negative adverse impacts of *Acacia* system on irrigated lands and they described the expansion of *Acacia* plantations towards the irrigated land, and wetlands. In countries like Ethiopia where livestock resources are the main sources of power and cash income, reduction in livestock size could greatly hinder farmers' risk resistance ability and their overall socioeconomic welfare (Teshager et al. 2019; Nigussie et al. 2021).

The average annual fertilizer consumption was reported mainly as high (72.7%) and medium (21.5%) before the introduction of the *Acacia*, but it was low (56.7%) and medium (30.7%) in the post-*Acacia* time. With a net difference of 0.37, there was a statistically significant difference in fertilizer usage before and after *Acacia* ($t = -21.5$, $p < 0.01$). Several studies (Kassie et al. 2016; Molla and Linger 2017; Tamirat and Wondimu 2019; Bazie et al. 2020; Chanie and Abewa 2021; Nigussie et al. 2021; Amare et al. 2022; Beshir et al. 2022; Afework et al. 2023) recognized the valuable contribution of *Acacia* in enhancing soil quality, indirectly reflecting the potential contribution of the plantation in reducing artificial fertilizer usage. However, Addis et al. (2016) generalized that farmers' participation in *Acacia* and *Eucalyptus* tree plantation had no impact on the use of modern agricultural inputs. The mean distance to get potable water was nearly 20 min before the introduction of *Acacia*; this figure reduced to 11.8 min after the introduction of the system with a statistical significance of $t = 16.1$, $p < 0.01$. Following the introduction of *Acacia*, a slight improvement in market access was observed in the study area. Although market distance has mostly stayed the same, the abundance of cash products (charcoal) helped *Acacia* farmers to sell their products from home or agricultural fields without going to the market.

Table 5 shows that ownership of various housing utensils (radio, television, shelf, table, chair, bed, water filter, clothing box, and solar-powered lamp) was low before *Acacia*, and significantly increased afterwards. This difference in ownership status was statistically significant, highlighting the positive impact of *Acacia* on farmers' durable asset ownership. FGD participants narrate this condition: '*In the pre-Acacia period, we lacked modern household utensils and durable assets. We were forced to take loans from different institutions to feed our family. The onset of Acacia system changed this scenario and significantly improved our living conditions. Nowadays, thanks to Acacia, many farmers have moved beyond subsistence and owned various durable assets, including cars. If you visit the homes of some Acacia-growers, you may get confused to differentiate them from urban lifestyles*'. Progresses in physical capitals including housing utensils could improve farmers' well-being and further facilitate rural–urban transformation (Gebeyehu and Afework 2022).

A small proportion of households (11.1%) had a mobile phone before *Acacia*, but this proportion increased tremendously afterwards. The significant improvements ($t = -40.04$, $p < 0.01$) in mobile ownership would help farmers to easily get market information through creating market linkage with different actors in the charcoal marketing system (Haile et al. 2019; Nigussie et al. 2021).

Additionally, ownership of transport vehicles, both motorized and non-motorized, has improved compared to the *pre-Acacia* period. Initially, a negligible proportion of households owned transport vehicles. At the time of study, the index values for motorized and non-motorized transport were 0.12 and 0.31, respectively, with statistical significance ($t = -5.00$, $p < 0.01$) and ($t = -11.08$, $p < 0.01$). Farmers could generate additional income through animal-drawn carts, while some purchase motorcycles and Bajajs for commercial transport.

We found significant variations in basic infrastructure accessibility indices before and after *Acacia*, with a difference of 0.17 ($t = -19.82$, $p < 0.01$). This reflects the positive impact of *Acacia* on enhancing basic infrastructure accessibility. However, field observations highlighted ongoing challenges, particularly with road infrastructure. The provision and quality of roads in the study area need to be improved. Many internal roads connecting kebeles and even kebeles to the Woreda center are seasonal and only provide services during dry seasons.

As shown in Table 5, participation in development activities increased significantly ($t = -16.32$, $p < 0.01$) since the beginning of the *Acacia* system. FGD participants noted that the *Acacia* system substantially improved farmers' socioeconomic well-being and involvement in development projects. They also mentioned increased community engagement in basic infrastructure development and maintenance through financial support.

With all physical indicators improved, the mean physical capital index of farmers in the *Acacia* period was higher than before *Acacia*, increasing from 0.28 to 0.52 (Table 5, Figure 3). Our results show the significant role of *Acacia* in enhancing physical capital in the study area, and confirm the positive effect of *Acacia* system on households' physical capital reported by Nigussie et al. (2021).

**Table 5.** Physical capitals of households before and after the *Acacia* system adoption.

| Indicators | Response | *M/P* values BAS | *M/P* values AAS | MLI BAS | MLI AAS | t-test (p-value)* |
|---|---|---|---|---|---|---|
| Housing type | Thatch/hut | 26.4 | 0.7 | | | |
| | Corrugated iron | 73.6 | 98 | 0.58 | 0.66 | −10.36 (.000) |
| | Concrete blocks | 0 | 1.3 | | | |
| Livestock possessions | TLU | 4.8 | 3.1 | 0.54 | 0.34 | 31.5 (.000) |
| Irrigation access | Yes | 12.5 | 27.7 | 0.13 | 0.28 | −5.29 (.000) |
| | No | 87.5 | 72.3 | | | |
| Annual fertilizer consumption | Low | 5.7 | 56.4 | | | |
| | Medium | 21.6 | 30.7 | 0.44 | 0.81 | −21.53(.000) |
| | High | 72.6 | 12.8 | | | |
| Potable water distance | Minutes | 19.6 | 11.9 | 0.17 | 0.26 | −16.11 (.000) |
| Market distance (nearest) | Minutes | 74.8 | 51.2 | 0.37 | 0.43 | −11.16 (.000) |
| Mobile phone | Yes | 11.1 | 95.6 | 0.11 | 0.96 | −40.04 (.000) |
| | No | 88.9 | 4.4 | | | |
| Table and/or chair | Yes | 45.3 | 85.8 | 0.45 | 0.86 | −13.45 (.000) |
| | No | 54.7 | 14.2 | | | |
| Bed | Yes | 76.4 | 94.3 | 0.76 | 0.94 | −7.67 (.000) |
| | No | 23.6 | 5.7 | | | |
| Radio/Tape | Yes | 41.6 | 81.8 | 0.42 | 0.81 | −13.35 (.000) |
| | No | 58.4 | 18.2 | | | |
| Television | Yes | 1.4 | 13.2 | 0.02 | 0.13 | −6.29 (.000) |
| | No | 98.6 | 86.8 | | | |
| Water filter | Yes | 3 | 31.1 | 0.03 | 0.31 | −10.72 (.000) |
| | No | 97 | 68.9 | | | |
| Shelf (traditional/modern) | Yes | 5.4 | 19.7 | 0.05 | 0.20 | −9.00 (.000) |
| | No | 94.6 | 80.3 | | | |
| Clothing box (traditional/modern) | Yes | 16.9 | 41.2 | 0.17 | 0.41 | −8.32 (.000) |
| | No | 83.1 | 58.8 | | | |
| Solar-powered lamp | Yes | 8.4 | 65.5 | 0.08 | 0.65 | −19.28 (.000) |
| | No | 91.6 | 34.5 | | | |
| Cart (animal-drawn) | Yes | 2 | 27.7 | 0.02 | 0.31 | −11.08 (.000) |
| | No | 98 | 72.3 | | | |
| Transport vehicles ownership (Bajaj/Motorcycle/Car) | Yes | 0.7 | 11.8 | 0.007 | 0.12 | −5.00 (.000) |
| | No | 99.3 | 88.2 | | | |
| Accessibility of basic infrastructures | Low | 38.4 | 21.5 | | | |
| | Medium | 60.2 | 52.1 | 0.54 | 0.71 | −19.82 (.000) |
| | High | 1.3 | 29.4 | | | |
| Participation in development activities | Low | 79.1 | 21.3 | | | |
| | Medium | 15.2 | 45.6 | 0.42 | 0.70 | −16.32 (.000) |
| | High | 5.7 | 33.1 | | | |
| **Physical capital index** | | | | **0.28** | **0.52** | |

*Note: *p-value for all indicators were statistically significant at 1% probability level.*

## *Financial capital*

We found that all financial indicators improved compared to before *Acacia* (Table 6). For instance, before *Acacia*, 45.9% of households had their income covering their expenses, which increased to 81.3% at time of study. Similarly, saving practices significantly improved *post-Acacia*, with a net difference of 0.67 ($t = -15.47$, $p < 0.05$).

The changes in the income–expenditure ratio and household savings coincide with farmers' involvement in off-farm and non-farm activities. Before *Acacia*, a small percentage of households (19.3% non-farm, 47.3% off-farm) engaged in non-agricultural work. The index difference for non-farm (0.81) and off-farm (0.26) was significant (Table 6). According to interviewed farmers, *Acacia* enabled them to diversify their income sources. Farmers' participation in non-agricultural work increased over time, particularly in the *post-Acacia* period when they had more free time. Alongside *Acacia* system and charcoal production, farmers engaged in animal fattening, dairy production, animal/grain trading, modern poultry, animal-drawn cart, and handicraft activities. These conditions greatly improved farmers' income and their socioeconomic well-being, confirming conclusions reported by (Mekonnen et al. 2021; Addis et al. 2016; Chanie and Abewa 2021).

Regarding loan burden and money lending, 60.8% of farm-households had loans before *Acacia*, which decreased to 19.4% after *Acacia*. The index difference of 0.42 indicates a significant change in loan burden between *the pre- and post-Acacia* periods. Initially, money lenders' share was insignificant, but after *Acacia*, over one-fourth of respondents engaged in money lending during hardships. Some households mentioned insufficient food crop production before *Acacia*, leading to reliance on loans from various sources, including Amhara Credit and Savings Institution. Nonetheless, farmers' debt/loan burden gradually declined as their economic condition improved due to *Acacia.*

FGD participants confirm our results regarding the significant increase in employment opportunities (Table 6), recognizing the remarkable role of the *Acacia* system in generating employment for various segments of the population, including farmers, landless youth, traders, brokers, and vehicle owners. *Acacia*-related jobs, such as planting, harvesting, charcoal making, transportation, and trading, are now prevalent in the area. Studies by Tamirat and Wondimu (2019), Chanie and Abewa (2021) and Nigussie et al. (2021) also support the positive impact of *Acacia* system on employment creation.

All financial capital indicators witnessed positive changes following the *Acacia* system adoption. The average financial capital index increased from 0.32 in the *pre-Acacia* to 0.75 in the *post-Acacia* periods (Table 6, Figure 3). This indicates that farmers' current financial capital index is nearly twice as high as before *Acacia*. Consistent with this, Chanie and Abewa (2021) reported the attractive financial returns of *Acacia* system compared to conventional crops. Consistent with this, Chanie and Abewa (2021) reported the attractive financial returns of the *Acacia* system compared to conventional crops. Additionally, studies by Addis et al. (2016) highlighted the important contributions of tree plantations (*Acacia*) in increasing income and livelihood security for households. In essence, improvements in financial resources including savings could positively affect farmers resilience to different threats (Kassie et al. 2016; Teshager et al. 2019).

**Table 6.** Financial capitals of households before and after the *Acacia* system adoption.

| | | *M/P* values | | MLI | | |
|---|---|---|---|---|---|---|
| Indicators | Response | BAS | AAS | BAS | AAS | t-test (p-value)* |
| Annual income covers expenditure | Yes | 45.9 | 81.4 | 0.46 | 0.81 | −10.39 (.000) |
| | No | 54.1 | 18.6 | | | |
| Save money in financial institutions | Yes | 12.8 | 80.4 | 0.13 | 0.80 | −15.47 (.000) |
| | No | 87.2 | 19.6 | | | |
| Participation in non-farm activities | Yes | 19.3 | 100 | 0.19 | 1 | −35.17 (.000) |
| | No | 80.7 | 0 | | | |
| Participation in off-farm activities | Yes | 47.1 | 73.3 | 0.47 | 0.73 | −9.84 (.000) |
| | No | 52.7 | 26.7 | | | |
| Debt/loan burden | Yes | 60.8 | 19.3 | 0.39 | 0.81 | −10.09 (.000) |
| | No | 39.2 | 80.7 | | | |
| Lend money to others | Yes | 9.8 | 27 | 0.10 | 0.28 | −6.17 (.000) |
| | No | 90.2 | 72 | | | |
| Employment opportunities | Low | 97.3 | 6.1 | | | |
| | Medium | 2 | 27.7 | 0.34 | 0.86 | −42.17 (.000) |
| | High | 0.7 | 66.2 | | | |
| Perceived economic status | Low | 42.9 | 16.6 | | | |
| | Medium | 38.5 | 60. 1 | 0.48 | 0.68 | −5.05 (.000) |
| | High | 18.6 | 23. 3 | | | |
| **Financial capital index** | | | | **0.32** | **0.75** | |

*Note: *p-value for all indicators were statistically significant at 1% probability level.*

### Human capital

The study assessed *Acacia*-grower farmers' health, knowledge, and skills conditions using seven key indicators (Table 7). The educational status showed slight non-significant changes (index difference: 0.01) compared to before *Acacia*. However, school access for children increased significantly ($t = -8.13$, $p < 0.01$) from 79.1% (*pre-Acacia*) to 98.9% (*post-Acacia*). One informant described the situation: *"Before the plantation, children were not largely sent to school. Instead, they were used as family labour and engaged in various income-generating activities. However, with the introduction of Acacia, farmers' living conditions improved, leading local communities to prioritize sending their children to school."*

Training on plantation management and improved agriculture is crucial for equipping farmers with technical skills and knowledge. However, the study found limited training access in pre-*Acacia*, with only 20.3% of farmers having access. Although the change was significant and the percentage doubled (40.5%) at time of study, it remains low considering the transformation of livelihood strategies in the area. The study found conflicting results from agricultural experts and farmers about training provisions. Agricultural experts claimed that training was provided adequately, but farmers disagreed, stating that the provided training was insufficient and lacked continuity. The degree of gaining new knowledge and skills was considered low by a majority of respondents but became medium and high at time of study, with a significant index difference, indicating an increasing trend in knowledge and skills acquisition since *Acacia*'s introduction.

In the *pre-Acacia* period, respondents had a moderate health status (48.3%) and limited access to healthcare services (17.2%). After the introduction of *Acacia*, there were significant improvements in access to healthcare services, but the health condition of farmers deteriorated significantly (Table 7). *Acacia* played a positive role in improving healthcare access through increasing financial and physical assets.

Most respondents (64.7%) perceived themselves as 'food insecure' before *Acacia*. This significantly decreased to 19.3% at time of study. FGD participants mentioned that although the expansion of *Acacia* had negative impacts on the area of cropland, the economic benefits and livelihood diversification provided by the *Acacia* system contributed to households' food security.

The comparative analysis showed positive changes in all human capital indicators used in this study, except for the health condition which deteriorated. Aggregately, farmers' human capital index was below 0.5 before the *Acacia* system, and increased to 0.69 at time of study (Table 7, Figure 3). This reflects that *Acacia* positively influenced farmers' human capital in the area, supporting the findings of Addis et al. (2019) and Nigussie et al. (2021) that participation in *Acacia* system significantly impacted investments in human capital, mainly education and health. Nigussie et al. (2021) also mentioned that the introduction of *Acacia* enabled people to acquire charcoaling skills.

**Table 7.** Human capital of households before and after the *Acacia* system adoption.

| Indicators | Response | % values BAS | % values AAS | MLI BAS | MLI AAS | t-test (p-value) |
|---|---|---|---|---|---|---|
| Household head's educational status | Illiterate | 58.1 | 56.8 | | | |
| | NFE | 25.3 | 26.4 | 0.52 | 0.53 | −0.52 (.601)[ns] |
| | FE | 16.6 | 16.9 | | | |
| School enrolment of school-age children | Yes | 79.4 | 99 | 0.79 | 0.99 | −8.13 (.000)*** |
| | No | 20.6 | 1 | | | |
| Access to training | Yes | 20.3 | 40.5 | 0.20 | 0.41 | −12.03 (.000)*** |
| | No | 79.7 | 59.5 | | | |
| Degree of gaining new knowledge/skills | Low | 60.3 | 12.8 | | | |
| | Medium | 31.6 | 47.6 | 0.49 | 0.75 | −15.76 (.000)*** |
| | High | 8.1 | 39.5 | | | |
| Financial capacity to get better healthcare services | Yes | 17.2 | 85.8 | 0.17 | 0.86 | −24.61 (.000)*** |
| | No | 82.8 | 14.2 | | | |
| Overall family health condition | Low | 39. 2 | 66.8 | | | |
| | Medium | 48.3 | 28.7 | 0.57 | 0.46 | 6.31 (.000)*** |
| | High | 12.5 | 4.6 | | | |
| Perceived food security condition | Secured | 35.1 | 80.7 | 0.35 | 0.81 | −15.14 (.000)*** |
| | Insecure | 64.9 | 19.3 | | | |
| **Human capital index** | | | | **0.44** | **0.69** | |

NF = non-formal education, FE = formal education, ns = not significant ($P > 0.05$). *** Significant at 1% probability level

## *Social capital*

The social capital indicators and their overall status are presented in Table 8. Farmers' membership in agricultural cooperatives increased significantly from 91% to 98% after *Acacia*. The participation of farmers in labour-sharing groups [*wonfel/debo*] slightly decreased from 98.2% (pre-*Acacia*) to 95.6% (post-*Acacia*), but the change was not statistically significant. This reflects the enduring culture of cooperation in this society. Farmers have actively participated in community-based associations like *edir*3 and *mahiber* (*a religious association for Orthodox Christians)* in both periods. These institutions thus play a vital role in fostering social cooperation and support in the community. The participation of farmers in *equib (a traditional saving association)* was minimum (17.6%) before *Acacia;* this figure rose to 42.8% in the *post-Acacia* time. This indicator showed the highest difference (0.25) compared to other social capital indicators ($t = -8.86$, $p < 0.01$). The increase in farmers' participation in *equib is* attributed to their financial capacity improvement because of the *Acacia* system.

The local communities in the study area have a good culture of supporting each other during hardship. The extent of supporting each other ranged from 97.6% (before *Acacia*) to 99.3% (after *Acacia*); this change is not statistically significant. The extent of conflict occurrences has decreased in the present compared with before *Acacia*. Consequently, there was a 0.06 index difference at $t$ =-7.35, $p < 0.01$. The qualitative analysis also showed high unemployment and thefts in the area before *Acacia*, but these significantly decreased in the *post-Acacia* period due to the employment and income-generation roles of the *Acacia* system. Most respondents rated their social interaction as 'high' both before (87.1%) and after (90.7%) *Acacia*, with no significant statistical difference. Supporting this, FGD discussants noted increased evidence of congratulatory calls for individuals who constructed better houses and bought modern transport vehicles due to *Acacia*. Additionally, investments in weddings, funerals, and social ceremonies expanded after *Acacia* in the area. This visibly reflects the strong social networks and ceremonial frequency in the community.

Generally, most social capital indicators showed insignificant positive changes except for *equib* participation, with a positive net increment of 0.25. Farmers' average social capital index was 0.82 before *Acacia*, which increased to 0.88 at time of study. Although the effect of *Acacia* on social capital was low, there was always a positive interaction between *Acacia* and the social capital of respondents. We thus did not find the strong positive impact of *Acacia* system on farmers' social capital reported by Nigussie et al. (2021).

**Table 8.** Social capitals of households in the *pre-and-post-Acacia* periods.

| | | % values | | MLI | | |
|---|---|---|---|---|---|---|
| Indicators | Response | BAS | AAS | BAS | AAS | t-test (p-value) |
| Membership in cooperatives/farmers' associations | Yes | 90.8 | 97.6 | 0.91 | 0.98 | −3.98 (.000)*** |
| | No | 9.2 | 2.4 | | | |
| Participation in labour-sharing groups [*wonfel/debo]* | Yes | 98.2 | 95.6 | 0.98 | 0.96 | 1.89 (.059)$^{ns}$ |
| | No | 1.8 | 4.4 | | | |
| Members of community-based associations like *edir* | Yes | 99.2 | 100 | 0.99 | 1.00 | −1.13 (.258)$^{ns}$ |
| | No | 0.8 | 0 | | | |
| Participation in *equib* | Yes | 17.6 | 42. 8 | 0.18 | 0.43 | −8.86 (.000)*** |
| | No | 82.4 | 57.2 | | | |
| Supporting each other during hardship | Yes | 97.6 | 99.3 | 0.98 | 0.99 | −1.89 (.0.59)$^{ns}$ |
| | No | 2.4 | 0.7 | | | |
| The extent of conflict occurrences | Yes (f) | 7.8 | 7.1 | | | |
| | Yes (r) | 49.3 | 32.5 | 0.78 | 0.84 | −7.35 (.000)*** |
| | No | 42.9 | 60.4 | | | |
| Overall status of social interaction | Low | 4.4 | 2 | | | |
| | Medium | 8.5 | 7.3 | 0.94 | 0.96 | −1.96 (0.50)$^{ns}$ |
| | High | 87.1 | 90.7 | | | |
| **Social capital index** | | | | **0.82** | **0.88** | |

Note: f = frequently, and *r* = rarely. ns =not significant (*P* > 0.05). *** Significant at 1% probability level

## *Livelihood assets pentagon*

The findings revealed significant changes in the livelihood assets of respondents since the adoption of the Acacia system. Before *Acacia*, grower households had a low aggregated livelihood index (0.47), with a strong social capital index (0.82) but low indices for all other assets (physical: 0.28, financial: 0.32, human: 0.44, natural: 0.47). Due to this, the shape of the asset pentagon was far from balanced (Figure 3). With the *Acacia* system, the aggregated livelihood index increased to 0.71, with improved indices for physical (0.52), natural (0.72), financial (0.75), human (0.69), and social capitals (0.88). Specifically, social capital had a negligible change (+0.06), while all other assets significantly improved (financial: +0.43, human: +0.25, physical: +0.24, natural: +0.25). Consequently, the shape of the asset pentagon changed to nearly balanced (Figure 3).

The findings generally show the valuable role of the *Acacia* system in improving farmers' livelihood assets in the study area, as shown recently by Akter et al. (2022) for other agroforestry systems.

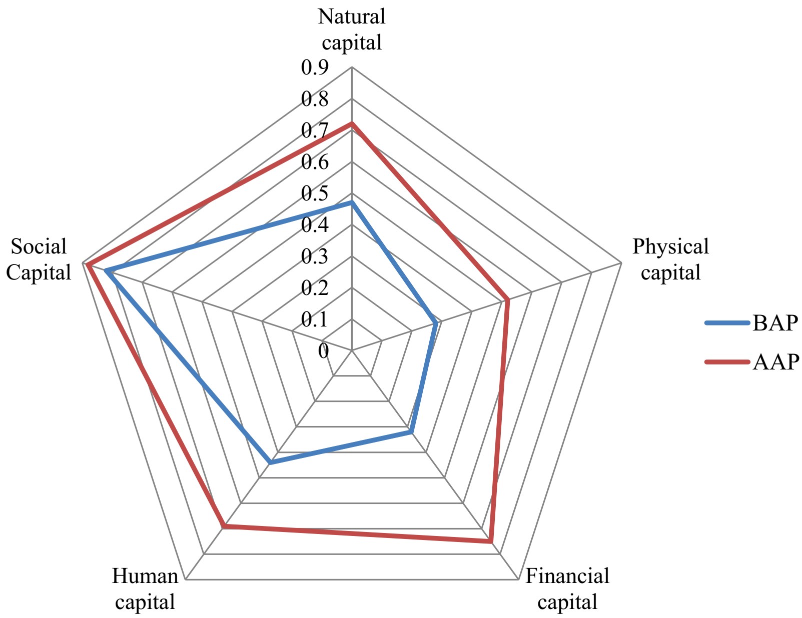


**Figure 3.** Livelihood assets pentagon of *Acacia*-growers during the pre- and post-*Acacia* periods.

### *Challenges facing Acacia system farmers in the awi area*

Farmers identified many factors that constrained *Acacia* system in the study area. The notable ones include pests and diseases, lack of modern charcoal-making technology, road infrastructure problems, limited market opportunities, and adverse health impacts of charcoal-making (Table 9). In addition, our analysis of the livelihood indicators has identified two other challenges: the decreasing size of farmland and grazing land, which may lead to a decline in livestock possession. The shortage of grazing land and reduction of food crops due to farmland dwindling greatly exacerbates the existing rise in crop prices and food insecurity in the study area.

The lion's share of farmers (98.9%) identified 'pests and diseases' as the main challenge. Agricultural experts confirmed the severity of this issue, emphasizing that pests and diseases significantly threaten tree plantation in Awi areas. FGDs and interview participants also highlighted pests and diseases as a primary challenge, prompting some farmers to convert their plantations into cropland before tree harvest. Field observations further revealed widespread infestation of *Acacia* trees. In the study sites, it is now common to see different pests causing for extensive *Acacia* disease. Therefore, collaborative efforts from stakeholders are necessary to address this problem. Supporting this, Lawson et al. (2023) identified the various pests and diseases and reported the significant impact of those on the *Acacia* trees in Ethiopia.

The other challenge identified by farmers, key informants, and FGD discussants, were all related to charcoal making. The lack of a modern charcoal-making technology was mentioned by 91.5% of respondents. Researchers have observed traditional charcoal-making methods, particularly the earth mound kilns, during data collection. Participants mentioned that this method negatively impacts the charcoal quantity, quality, and environment. This was confirmed by various studies (Tamirat and Wondimu 2019; Adugna 2020; Tassie et al. 2021).

About 85.5% of the respondents perceived limited access to road infrastructure as a challenge. Our findings showed that farmers primarily produce charcoal for sale, but rural roads' poor quality and availability hinder marketing. As a result, despite its inefficiencies, local farmers heavily depend on animal and human power transportation. Resolving this challenge requires improving accessibility by providing quality rural roads in the study area. Popova (2017) noted that the availability and quality of transportation facilities determine national and local economic efficiency.

The third challenge related to charcoal production and marketing, identified by 75.3% of the respondents, is limited market opportunities. FGD participants emphasized the absence of strong associations and institutions that work towards the benefits of *Acacia* growers in the study area. Participants added that most farmers had no choice but selling their charcoal to brokers at low sale price, and that brokers play thus a prominent role in determining the price of charcoal.

The fourth-ranked challenge, related to charcoal is related to one of our livelihood indicator (health condition, which was clearly deteriorating), was the adverse health effects of charcoal production, recognized by 68.2% of respondents and confirmed by discussants and key informants. A charcoal producer shared his lifelong experience: *'I learned charcoal-making skills when I was a migrant. The new place was not suitable for long-term stay, so I returned home and started producing charcoal as a livelihood strategy. However, I now face serious health problems. Doctors suspect that my work may be the cause. I suffer from severe coughing, which keeps me awake at night.'* We recommend further studies on the health effects of charcoal production and packing, as well as on the ways to protect charcoal makers from these detrimental health effects.

A majority of respondents (63%) identified high production cost as a constraint. It seems that this constraint emerged recently in relation with the rising cost of inputs such as bags for charcoal, labour and transportation, and that if input prices continue to soar, it may threaten the continuity and viability of the *Acacia* system.

Weak institutional support was identified as another challenge by half of our respondents. Since the *Acacia* system was new to the area, it was crucial to provide intensive training and capacity-building programs to enhance growers' benefit. Unfortunately, only 40.5% of respondents received training and support related to the plantation so that most farmers acquired their skill through pioneer farmers. In this regard, Tamirat and Wondimu (2019) documented the presence of significant structural gaps in the forestry sector, from regional to Woreda levels in Amhara National Regional State.

**Table 9.** Perceived challenges faced by *Acacia* system farmers.

| | Responses | | |
|---|---|---|---|
| Challenges | Frequency* | Percent (%) | % of cases |
| Pests and diseases | 293 | 16.7 | 98.9 |
| Traditional charcoal production system | 271 | 15.4 | 91.5 |
| Limited access to road infrastructure | 253 | 14.4 | 85.5 |
| Lack of good market opportunities | 223 | 12.6 | 75.3 |
| Adverse health impacts of charcoaling | 202 | 11.5 | 68.2 |
| High charcoal production costs | 188 | 10.7 | 63.5 |
| Weak institutional supports | 151 | 8.6 | 51 |
| Skill gaps in charcoal production | 108 | 6.2 | 36.5 |
| Others | 67 | 3.8 | 22.6 |

*Multiple responses table.

### *Farmland size and grazing land in the study area*

Crop land and grazing land are the most important natural assets for the rural community in Ethiopia. Participants of the study acknowledged the valuable roles of these capital assets and they mentioned that the *Acacia* system caused a reduction of farmland and pasture in the study area. More specifically, the findings of the study revealed that farmland size (ha) and livestock possession (TLU) declined by 12.9% (1.24: pre-*Acacia*, 1.08: post-*Acacia*), and 35.4% (4.8: pre-*Acacia*, 3.1: post-*Acacia*), respectively (Tables 4 and 5). The findings of many studies (Wondie and Mekuria 2018; Tamirat and Wondimu 2019; Belayneh et al. 2020; Chanie and Abewa 2021; Afework et al. 2023) coincide with the current study regarding the impacts of *Acacia* plantations on farmland size. Chanie and Abewa (2021) and Afework et al. (2023) further reported the adverse effects of *Acacia* expansion on grassland size.

Although the *Acacia* system is established on both crop and grazing land, it is highly integrated with the farming system and livestock production in the study area. Respondents stated that the system allowed farmers getting food crops, but also different livestock feeds, including grass, *Acacia* foliage and straw from intercropped crops from *Acacia* field in the first year of the plantation. Farmers then harvest grass from *Acacia* land by cut-carry system until the tree canopy prevents the growth of grasses, usually after 2–3 years. Above all, *Acacia* growers obtained fruitful economic returns from charcoal and *Acacia* branches/ residue selling. This financial earning enabled tree growers to purchase food crops and animal fodder and counter balance the gaps created due to farm and grazing land reduction in area. The *Acacia* system, therefore, introduced a new way of life in the local community by reducing farming burden and fostering non-farm activities.

The results of the study also revealed that the local community had larger livestock holding and communal grazing land prior to *Acacia* system, confirming the findings of Chanie and Abewa (2021). Even though free grazing is still practiced in the area; the size of grazing land is dwindling through time because of cropland and *Acacia* plantation encroachment. These conditions, together with the national policy direction, forced farmers to reduce livestock numbers and look for other livestock production options. Consequently, many farmers have now changed their focus towards livestock quality rather than quantity. Indeed, they engaged in animal fattening and rearing of few improved cow breeds. This practice is highly recommended to improve farmers' financial capital and their living standard.

## Conclusions and policy implication

This study was carried out to examine the farmers' livelihood before and after implementation of the *Acacia* system. The overall livelihood assets of *Acacia* growers improved compared to the *pre-Acacia* period. Livelihood indices for different assets ranged from 0.28 to 0.82, with an average of 0.47 before *Acacia*. All capitals had low indices (≤0.5), except social capital. After the adoption of the *Acacia* system, livelihood conditions significantly improved, with all indices above 0.5 and a mean of 0.71. Grower households have a strong social capital index (0.88) and comparatively low physical capital (0.52). The findings generally reflect the vital roles of *Acacia* in enhancing the livelihood assets of grower-farmers in the study area.

Pests and diseases of *Acacia* were identified as the main challenge impacting productivity and sustainability. Additionally, the study found that, according to farmers and other informants, traditional charcoal production methods constrained farmers' productivity and caused environmental and health problems. Lack of roads and market access also hindered *Acacia* production and marketing. High production costs, weak institutional support, and technical gaps further affected returns. Therefore, market linkage, institutional capacity upgrading, and skill-centred training are recommended to address these challenges. Efforts should also be made to protect farmers from the adverse health effects of charcoal making, as well as to enhance charcoal production efficiency and profitability through addressing its multifaceted challenges.

## Notes

1. The smallest administrative units in Ethiopia.
2. The local name for *Acacia decurrens* tree
3. A community-based institution that helps members during hardship.

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