Hindawi
International Journal of Forestry Research
Volume 2024, Article ID 5543119, 14 pages
https://doi.org/10.1155/2024/5543119

Research Article

Determinants of Farmers' Perceptions towards Socioecological Benefits of Agroforestry Practices in Northwestern Ethiopia

Mequannt Marie,[1,2] **Debissa Lemessa**,[3] **Ebrahim Esa**,[4] **Behailu Tadesse**,[1] **and Hossein Azadi**[5]

[1]*Department of Geography and Environmental Studies, University of Gondar, P.O. Box 196, Gondar, Ethiopia*
[2]*Department of Natural Resource Management, Oda Bultum University, P.O. Box 226, Chiro, Ethiopia*
[3]*Department of Plant Biology and Biodiversity Management, Addis Ababa University, Addis Ababa, Ethiopia*
[4]*Department of Environment and Climate Change Management, Ethiopian Civil Service University, Addis Ababa, Ethiopia*
[5]*Department of Economics and Rural Development, Gembloux Agro-Bio Tech, University of Liège, Gembloux, Belgium*

Correspondence should be addressed to Mequannt Marie; mequannt08@gmail.com

Received 31 October 2023; Revised 9 April 2024; Accepted 29 April 2024; Published 10 May 2024

Academic Editor: Nikolaos D. Hasanagas

Agroforestry practices provide multiple ecosystem services in agricultural landscapes. However, within the local context, local communities hold divergent perceptions regarding the various roles of agroforestry, particularly in the Afrotropical Region. Hence, understanding these drivers is critical for adopting and promoting sustainable agroforestry practices. Here, we examined the factors that influenced farmers' perceptions towards the socioecological benefits of agroforestry practices. A multistage stratified random sampling technique was applied to select 90 households along an urban-rural gradient. The data were gathered through semi-structured questionnaires and key informant interviews and analyzed using a descriptive statistics, chi-square tests, general linear model, and redundancy analysis with the help of R software version 4.3.2. The findings showed that approximately 69.7% of the respondents strongly agreed that agroforestry practices had benefits for society and the environment. However, 11.1% were neutral, and the others disagreed. The results of the general linear model analysis showed that household age, agricultural experience, access to land certification books, and training on tree conservation had a significantly positive effect on farmers' perceptions of the advantages of agroforestry practices. Furthermore, farmers' perceptions of the benefits of agroforestry in terms of income generation, educational and cultural values, and climate change mitigation were dependent on household age and farming experience. Overall, this study provides useful insights into the drivers of farmers' perceptions of the advantages of agroforestry practices in Northwest Ethiopia. The findings of this study underscore the need for policymakers and practitioners to consider sociodemographic and institutional factors that influence farmers' perceptions when developing policies and plans to advance the adoption and promote sustainable management of agroforestry practices. This supports the widespread adoption of agroforestry practices in tropical agroecosystems.

1. Introduction

Agroforestry practices are land-use management systems that integrate trees or shrubs with crops, livestock, or both within the same land unit in agricultural landscapes. They have gained worldwide recognition for their potential to promote sustainable agriculture and rural development, particularly in developing countries [1–3]. The benefits of agroforestry practices include improved soil fertility, increased crop yields, enhanced biodiversity, reduced soil erosion, and improved water quality [4–6]. Agroforestry practices also greatly contribute to improving rural farmers' livelihoods by providing income, food, fuelwood, fodder, and employment for youth and women in these countries [7–9]. However, the adoption and success of agroforestry practices depend significantly on socioeconomic and institutional factors and farmers' perceptions of their benefits in developing countries, such as Ethiopia. Understanding

the determinants of farmers' perceptions of the socioecological benefits of agroforestry is crucial for promoting its adoption and implementation [2, 10, 11].

Studies have shown that socioeconomic variables, information access, and training significantly impact farmers' decisions to adopt agroforestry practices in these countries [2, 3]. For example, a study conducted in Tanzania found that farmers' lack of knowledge and information about agroforestry practices was a major constraint to their adoption [12]. Similarly, a study in Kenya found that farmers' lack of access to credit and financial resources was a significant barrier to their adoption of agroforestry practices [13]. Moreover, previous studies conducted in different parts of Ethiopia have focused on examining the factors influencing farmers' intentions to adopt agroforestry practices and the contribution of agroforestry to farm income and livelihood resilience [11, 14–19]. However, none of these studies specifically investigated the determinants of farmers' perceptions regarding the ecological and socioeconomic benefits of agroforestry practices [11, 18]. However, understanding farmers' perceptions is a prerequisite for adopting agroforestry practices [20, 21]. This is because perception is one of the psychological factors influencing the adoption of agroforestry practices in smallholder communities [22, 23]. Perception is the process by which individuals select, organize, and interpret sensory information to create a meaningful understanding of their environment [24, 25]. The perception of agroforestry also refers to the way farmers view and understand the benefits of agroforestry practices. Several factors influence farmers' perceptions of agroforestry benefits [26]. These factors include socioeconomic variables such as land ownership, number of livestock, total income [2], agroforestry experience, and extension service [18]. Additionally, household head age, education, market access, and agricultural training also play a role in shaping farmers' perceptions of the benefits of agroforestry practices [27]. Collectively, these factors influenced how farmers perceived the benefits of agroforestry practices and their willingness to adopt them. This paradigm illustrates how sociodemographic and farm features affect farmers' perceptions of the socioecological benefits of agroforestry practices, which are the result of mental processes at the individual level [28, 29].

In Northwestern Ethiopia, including the study area, smallholder farmers have adopted agroforestry practices such as home gardens, parklands, and wood lots. However, the adoption of these practices is still limited, and farmers' perceptions of the benefits of agroforestry practices are not well understood [30–33]. Therefore, there is a need for research that specifically investigates the quantitative aspects of the factors affecting farmers' perceptions of the multiple benefits of agroforestry practices. This includes understanding socioeconomic variables, such as access to land certification books, age, wealth status, educational status, farming experience, length of stay in the area, and access to training on tree conservation, which influenced farmers' perceptions of the benefits of agroforestry practices [18, 19]. Therefore, this study is the only one that addresses the determinants of farmers' perceptions of the benefits of agroforestry practices. Hence, by studying the factors that influenced farmers' perceptions, this research provides insights into farmers' attitudes, beliefs, and knowledge regarding the benefits of agroforestry practices. Understanding these perspectives is essential for designing effective strategies to promote agroforestry adoption and ensure long-term success. This study identified the key determinants that shape farmers' perceptions of agroforestry benefits. This information is valuable for policymakers, extension services, and agricultural practitioners because it enables them to target specific factors that influenced farmers' attitudes. Identifying these determinants is fundamental for addressing knowledge gaps and misconceptions and providing tailored support to farmers. This study also contributes to further research on agroforestry practices. Although this research focused on Northwestern Ethiopia, the findings can be generalized to other countries with comparable socioeconomic conditions. Therefore, this study analyzed the determinants of farmers' perceptions towards the socioecological benefits of agroforestry practices in the Gondar Zuria District, Northwestern Ethiopia. To this end, we address the following questions: (1) Which type of agroforestry practice is preferred by farmers from socioeconomic and ecological perspectives? (2) How do farmers perceive different agroforestry practices from ecological benefits and socioeconomic perspectives? (3) What are the factors that influenced farmers' perceptions of the ecological and socioeconomic aspects of agroforestry practices? It is hypothesized that farmers have positive perceptions of the ecological and socioeconomic benefits of agroforestry practices in the local context [34–36].

2. Materials and Methods

2.1. Study Area. This study was conducted in the Gondar Zuria District in Northwestern Ethiopia (Figure 1). It is located at 12°10′–12°40′ N latitude and 37°20′–37°50′ E longitude. The entire area of Gondar Zuria District is 1,109 km^2 [37]. The average monthly temperature and precipitation are 17.5–27.5°C and 67.8 mm, respectively [38]. According to the Bekele-Tesemma and Tengnäs [39] Ethiopian agroecology classification, the district falls into two agroecological areas: Dega (highland) and Woina-Dega (mid-highland). Woina-Dega (mid-highland) agroecology refers to an elevation between 1,500 and 2,300 m, and Dega (highland) agroecology is defined as an elevation greater than 2,300 m above sea level. The midland agroecology zone constitutes the largest portion of the districts' overall area coverage compared with that of the highlands [37, 40]. The areas of land cover include farmland (56.5%), pasture (14.7%), forests and shrubs (10%), settlements (5.3%), and other land (13.5%) [41]. Moreover, the soil type in the area includes nitisols and vertisols. Compared with vertisols, nitisols contain deeper soil and are found in regions with sloping terrains. Conversely, vertisols inhabit lower slopes with inherent drainage problems [42].

Approximately 87.8% (201,880) of the population lives in rural areas, of which 55.4% (127,533) are men in the study area [43]. Mixed farming is prevalent in the district. Therefore, farmers are primarily engaged in mixed crop-livestock farming, which combines crop production with animal husbandry. Farming is generally characterized by traditional oxen-dependent agriculture, where a pair of oxen is used with traditional tools for tillage in the field [44]. Rain-fed agriculture

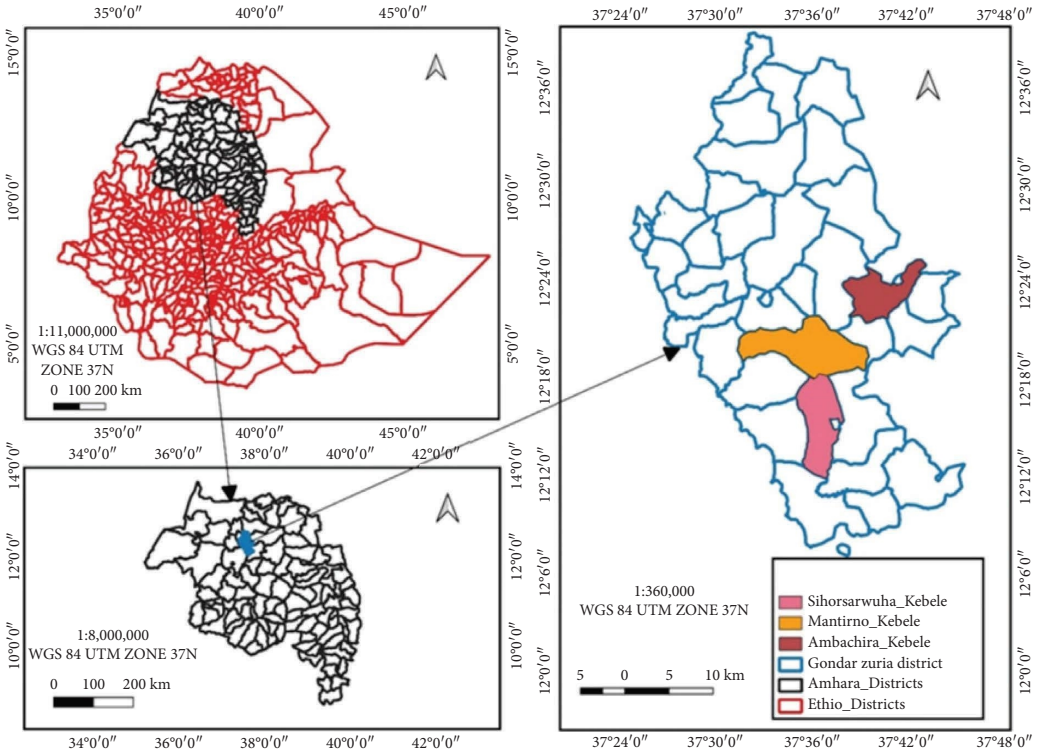

Figure 1: Study area in relation to maps of the Amhara Region and Ethiopia.

and traditional small-scale irrigation, which allow farmers to produce twice a year, are the major sources of income for the residents of the study area. Currently, new production techniques have been adopted, such as row planting as opposed to manual broadcasting of seeds and the supply of high-quality seeds. The most widely grown cereals in the study area are teff, maize, sorghum, and barley. On the other hand, common agroforestry practices in the area include the use of home gardens, parklands, and small-scale woodlots [33, 40, 45]. Common trees maintained and managed by local farmers in these agroforestry practices include *Croton macrostachyus*, *Cordia africana*, *Vachellia albida*, and *Vachellia seyal*. They are used for firewood, animal feed, flood control, soil enrichment, shade, and timber [33].

2.2. Site Selection. Based on the earlier study of Asfaw [46], informal key informant interviews, and field surveys, three main agroforestry types were identified from agricultural landscapes in this study. Accordingly, the common agroforestry types in the agricultural landscapes of the study area are home gardens, parklands, and woodlots.

2.3. Terminology. In this study, home garden agroforestry deals with the cultivation of multipurpose and multistoried trees blended with crops and/or animal husbandry around dwelling houses. Parkland is an area retained with scattered multipurpose trees that occur on farmland of farmers' choice. Woodlots are the only stands of tree species planted on farmland or degraded lands to support timber, construction, and land rehabilitation. The area is predominantly covered by Eucalyptus species.

2.4. Sampling Techniques. A multistage stratified random sampling technique, including purposive and stratified random sampling techniques, was used to select *kebeles* (i.e., a small administration unit) and household respondents for the study. In the first stage, the Gondar Zuria District was intentionally selected among the Central Gondar Zone districts because it had the largest coverage of agroforestry practices and different agroecological zones [32]. Then, two *kebeles* (i.e., Mantirno and Sihorsarwuha *kebeles*) were selected from the midland and one *kebele* (i.e., Ambachira) from the highland based on the accessibility and presence of common agroforestry practices. This is because approximately 34 *kebeles* (78%) are found in the midland agroecology zone, and 10 *kebeles* (22%) are found in the highland agroecology zone [33]. Finally, in the third stage, households' (HHs) lists were obtained from the local administrator (*kebele* manager). From the household list, the researchers identified HHs that practice at least one agroforestry practice (i.e., home garden, parkland, and wood lot) with the support of key informants, community leaders, and development agent experts. HHs practicing home garden, parkland, and wood lot agroforestry practices were stratified into three wealth groups (poor, medium, and rich) using local wealth classification criteria developed by key informants in each sample *kebele* (Appendix 2). Then, about 30 HHs (i.e., poor, medium, and rich) were chosen at random from those identified in the previous stage based on the rule of thumb, i.e., the central limit theorem, within each selected sample kebeles. As a result, about 90 HHs were used for the entire data collection (Appendix 1). In addition, a snowball sampling technique was used to select 27 key informants,

consisting of farmers, experts, traditional leaders, and local managers. Accordingly, six key informants including farmers and community leaders were selected from each study site using the snowball method, and three development agent local experts were also purposively selected from each of the three *kebeles*. The key informants of farmers and community leaders are those who have lived in the area for more than 30 years and are believed to be knowledgeable about the ecological and socioeconomic benefits of agroforestry practices. The development agents' local experts are key informants who have lived and worked in the area for more than six years and are considered knowledgeable about the benefits of agroforestry practices. In total, 27 key informants were included in the study.

3. Data Collection

A preliminary reconnaissance survey was conducted to obtain the overall baseline information before field data collection in the study area. To this end, the survey questionnaire was first prepared in English and translated into the local language (i.e., Amharic) followed by pretesting to evaluate the adequacy of the survey questionnaire, clarifying the questionnaire, and enhancing its reliability. As a result, the questionnaire survey was pretested on 10 randomly chosen HHs across three sample kebeles, and some questions were correspondingly amended. Finally, the questionnaire survey was conducted with the help of eight enumerators who are development agents and local experts in the fields of animal science, plant, and natural resource management. These enumerators had been trained for one day regarding the overall aim of the study, research ethics, and the significance of generating quality data before they started the interviews at the household level. The actual survey was conducted from February to April 2023.

Data were gathered at the household level using a semistructured questionnaire that asked about the sociodemographic characteristics of the households, the farmers' preferences for agroforestry practices from an ecological and socioeconomic standpoint, and the farmers' perceptions of the ecological and socioeconomic benefits of agroforestry practices using 27 questions on a 5-point Likert-type scale. To develop these questions, indicators were selected by reviewing previous research [4, 47–49], involving key informants from local communities, and exploring the existing frameworks such as the Millennium Ecosystem Assessment. A pretest was then conducted to refine and evaluate the selected indicators, updating them based on the insights gained from testing. To validate the data obtained by the survey questionnaire and to obtain details regarding the socioeconomic and ecological benefits of agroforestry practices, farmers' preferences for agroforestry practices, and the rationale behind farmers planting or keeping trees in agroforestry practices, key informant interviews were also conducted.

3.1. Data Analysis. Descriptive statistics were used to analyze the farmers' perceptions of the benefits of agroforestry and their preferences for agroforestry practices. Moreover, variations in the frequency distributions or associations of the responses to 27 questions among the different levels of explanatory variables (e.g., different years of residence of the farmers in the study area) were analyzed using a chi-square test. Identifying and applying an appropriate econometric model is crucial for predicting the combined effect of explanatory variables on the dependent variable. Therefore, this study used an econometric model to predict the effects of explanatory variables on dependent variables, specifically the influence of sociodemographic and institutional factors on farmers' perceptions of agroforestry benefits. Before conducting the model analysis, multicollinearity was assessed using the Pearson correlation matrix and variance inflation factor (VIF) among the predictor variables. As a result, there was no multicollinearity problem among the explanatory variables.

3.2. Generalized Linear Probit Model Specifications. A generalized linear model (GLM) with a probit link function and binomial distribution was employed to analyze the factors affecting farmers' perceptions of the socioecological benefits of agroforestry practices. The response variables were binary, such as "yes" or "no," in estimating the probability of perceiving or not perceiving based on a set of predictor variables [50, 51]. These predictable variables include farmers' age, gender, education, farming experience, length of residence, membership in a social group, access to forestry extension services, land certification books, media, training on tree conservation, and training on the role of agroforestry practices (Table 1). Correspondingly, the general linear probit model was specified as follows:

$$\text{Mode1} < -\text{glm}\left(\text{Y} \sim \text{X1} + \text{X2} + \text{X3} + \ldots + \text{XN}, \text{family} = \text{binomial}\left(\text{link} = ''\text{probit}''\right), \text{data} = \text{data}\right), \quad (1)$$

where Y = farmers' perception of the benefits of agroforestry practices (dependent variable), $X1$ = age, $X2$ = gender, $X3$ = education, $X4$ = farming experience, $X5$ = length of residence, $X6$ = member of a social group, $X7$ = access to training on tree conservation, $X8$ = access to media, $X9$ = access to training on the role of agroforestry practices, X10 = access to forestry extension service, X11 = access to land certification book, data are the data frame that contains the variables, and family is binomial ("probit"), which specifies the probit link function for a binomial family. After

Table 1: Explanatory variables used in the data analysis and their possible effects on farmers' perceptions of the socioeconomic and ecological benefits of agroforestry practices.

Variable	Description	Expected effects	Sources
Age	Age of the household head in years	+	[42, 52, 53]
Gender	Gender of the household head; 1 = male: 0 = female	±	[54, 55]
Education	Household heads' educational status; 1 = yes; 0 = no	+ +	[42, 47, 52, 53]
Farming experience	Farming experience of the household head in the year	+	[47, 53]
Length of residence	Length of stay in the area in the year	+ +	[42, 52]
Access to the forestry extension service	Having access to the various forestry extension services; 1 = yes; 0 = no	+	[53]
Access to media	Do you have access to electronic media (such as television, radio, and phone)? 1 = yes 0 = no	+	[53]
Access to training on the role of AFPs	Did you receive training on the role of agroforestry practices? 1 = yes 0 = no	+ +	[56]
Access to training on tree conservation	Did you receive training on tree conservation? 1 = yes 0 = no	+	[56]
Member of a social group	Are you a member of a social group like ikube, idir, and mahiber? 1 = yes; 0 = no	+	[18]
Access to the land certification book	Having access to the land certification book for your land; 1 = yes; 0 = no)	+	[57]

Note. AFPs = Agroforestry practices.

fitting the model, we used the summary () function to obtain information such as coefficient estimates, significance levels, and goodness-of-fit measures for the GLM fitted with the probit link function.

3.3. Variables Used in the Econometric Model and Hypothesized Effects

3.3.1. Dependent Variable. The response variables for the two models that were run in this study were derived from asking two questions separately: (1) Do you agree that the benefits of agroforestry practices at the study site are environmentally friendly, economically feasible, and socially acceptable? (2) Do planting or retaining trees in agroforestry practices cause disease, pests, or other problems?

3.3.2. Independent Variables. The independent variables that are hypothesized to affect the farmers' perceptions of various socioecological benefits of agroforestry practices are the combined effects of various factors such as demographic, socioeconomic, and institutional characteristics. Table 1 shows that the explanatory variables used in this study and their possible effects were identified based on a review of past studies [18, 42, 52].

Redundancy analysis (RDA) ordination was also applied to visualize the patterns of the relationships between the responses of the farmers to 27 questions with a 5-point Likert-type scale on the farmers' perceptions of the ecological and socioeconomic benefits of agroforestry practices and the explanatory variables (including age, farming experience, year of residence, education, and wealth status of the household head) using a *vegan* package. All the data were analyzed using R software (version 4.3.2).

4. Results

4.1. Sociodemographic Characteristics of the Respondents. This study examined the sociodemographic characteristics of sample households in the study area, including age, education, gender, access to electronic media, tree conservation training, and land certification books, to understand farmers' perceptions of agroforestry practices. Table 2 showed that the sociodemographic characteristics of the 90 farmers in the study area. Most of the respondents were male (93.3%), with age groups ranging from 46 to 64 (53.3%) and 65 to 64 (25.6%). The majority were illiterate (73.3%), with only 26.7% being literate. The study revealed that most farmers had access to electronic media (55.6%), but a significant proportion did not (44.4%). Most had access to tree conservation training (32.2%) but not formal training (67.8%). Most had land certification (92.2%), but only 7.8% did not have legal recognition.

4.2. Farmers' Preferences for Agroforestry Practices. This study revealed that farmers have various preferences for agroforestry practices from different perspectives. From an economic benefit perspective, most respondents (57.8%) preferred wood lot agroforestry. This indicates that they believe that wood lots offer more significant economic benefits than home gardens and parklands. Regarding the management perspective, most participants (81.11%) favored home garden agroforestry. This suggests that they consider home gardens to be more manageable than parklands and wood lots. This is because home gardens are near their home and are easier for the entire family to manage. Concerning increasing soil fertility and crop production, the majority of respondents (62.23%) chose parkland as the preferred agroforestry type. This indicates that parkland is the most effective in enhancing soil fertility and crop production, whereas home gardens are less preferred (37.77%). These results provide insights into the participants' opinions and preferences regarding different agroforestry types based on economic benefits, management perspectives, and soil fertility and crop production in the area (Table 3).

4.3. Farmers' Perceptions of the Socioeconomic and Ecological Benefits of Agroforestry Practices. The results of the descriptive analysis showed that farmers' perceptions of the different socioecological benefits of agroforestry are diverse. For example, 23% of the respondents strongly agreed, 40% agreed, 5.6% strongly disagreed, and 5.6% remained neutral about the benefit of agroforestry in income generation for farmers. Moreover, approximately 31.1% strongly agreed, 48.9% agreed, 8.8% remained neutral, and 11.2% disagreed that agroforestry was beneficial for adapting to climate change. Similarly, 48.9% of the respondents strongly agreed, 27.8% agreed, and 11.1% were neutral, but 12.2% disagreed that agroforestry contributes to biodiversity conservation in agroecosystems. In general, most respondents had a positive perception of all perceptional questions regarding the socioeconomic and ecological benefits of agroforestry practices. In contrast to expectations, 42% of the respondents strongly disagreed and disagreed (had a negative perception) that agroforestry practices help reduce resource conflicts. This showed that farmers believed that agroforestry practices were the root of their conflicts with neighbors because they affected other people's crops on their own (Figure 2).

4.4. Determinants of Farmers' Perceptions of the Socioecological Benefits of Agroforestry Practices. The frequencies of the distributions of the farmers' perceptions of the benefits of agroforestry for income generation, resolving conflicts on resources, spiritual values, education, and climate change adaptation were significantly dependent on the age of the respondents, the level of farming experience, and the length of the respondents' residence in the area ($p < 0.04$, Table 4).

The results of the generalized linear model analysis indicated that having a land certification book or not having a land certification book significantly influenced farmers' perceptions of the socioecological benefits of agroforestry practices ($p = 0.01$, Table 5). Similarly, whether farmers received training in tree conservation or not significantly affected their perception of the benefits of practicing agroforestry ($p = 0.04$). Moreover, the length of residence and

Table 2: Sociodemographic characteristics of the respondents in the study area ($n = 90$).

Characteristics	Category	Frequency	Percentage
Gender	Male	84	93.3
	Female	6	6.7
Age	27–45	19	21.1
	46–64	48	53.3
	>65	23	25.6
Education status	Literate	24	26.7
	Illiterate	66	73.3
Access to electronic media	Yes	50	55.6
	No	40	44.4
Access to training on tree conservation	Yes	29	32.2
	No	61	67.8
Access to the land certification book	Yes	83	92.2
	No	7	7.8
	Total	90	100.0

Source: own survey, 2023.

Table 3: Farmers' preferences for agroforestry practices from socioeconomic and ecological perspectives.

Preference questions	Agroforestry types	Response (%)
Which agroforestry type is better for you from an economic benefit perspective?	Home garden	38.9
	Parkland	3.3
	Wood lot	57.8
Which agroforestry type is better for you from a management perspective?	Home garden	81.11
	Parkland	12.22
	Wood lot	6.66
Which agroforestry type is better for increasing soil fertility and crop production?	Home garden	37.77
	Parkland	62.23
	Wood lot	0.00

Source: own survey, 2023.

farming experience were highly significant predictors of farmers' perceptions of planting or retaining trees in agroforestry practices that cause pests and diseases ($p < 0.05$). Similarly, whether the farmers received training in tree conservation or not significantly affected their perceptions of agroforestry practices causing pests and diseases ($p = 0.03$, Table 5).

The results of the redundancy analysis indicated that the first axis explained 96% of the variations in the responses to the socioecological benefits of agroforestry, whereas the second axis explained only 24% of the variation. Wealthy households either disagreed or strongly disagreed with the socioecological benefits of agroforestry. The households that had lived in the area for a longer number of years strongly agreed with the socioecological benefits of agroforestry. Similarly, educated households also agreed with them (Figure 3).

5. Discussion

This study revealed that most of the respondents were older in the study area. This implies that older farmers are more likely to perceive the benefits of agroforestry practices because they may have different experiences and perspectives. This understanding is crucial for effective agroforestry promotion and adoption strategies [18]. The study revealed that most farmers in the study area were illiterate, with only a quarter being literate. This low level of education affects their understanding of agroforestry concepts and associated benefits, suggesting the need for education and training programs [34]. Most farmers (55.6%) had access to electronic media, including radio, which showed that they could effectively disseminate information about agroforestry practices and their benefits. Limited access may affect farmers' perceptions and knowledge of agroforestry [58]. The study also revealed that 32.2% of the farmers had access to tree conservation training, whereas 67.8% did not. This suggests the need for training initiatives for farmers [34]. Most farmers in the study area had land certification (92.2%), indicating secure tenure and willingness to adopt long-term agricultural practices such as agroforestry, despite a small portion lacking legal recognition [53].

This study revealed that farmers have diverse preferences for agroforestry practices, which are influenced by factors such as economic benefits, management, and soil fertility. Accordingly, most respondents preferred wood lots for their economic benefit, indicating that they perceived wood lots as the most significant option compared with other options such as home gardens and parkland. This preference for wood lots may be driven by the potential for higher-income

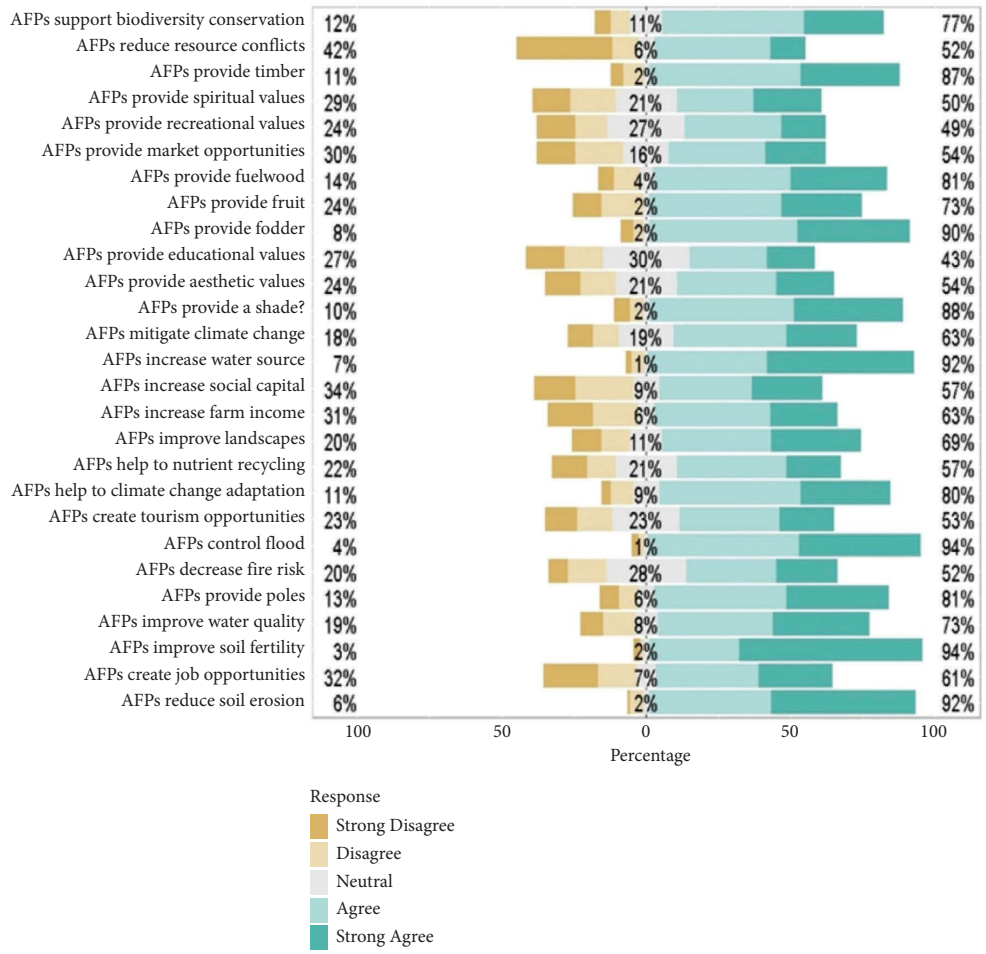

Figure 2: Farmers' perceptions of the ecological and socioeconomic benefits of agroforestry practices in the study area (source: own survey, 2023). Note. AFPs = Agroforestry practices; 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree.

Table 4: Chi-square analyses of the frequency of distributions of respondents' perceptions of various socioecological benefits of agroforestry.

No.	Perceptional statement	Factors	*X*-squared	df	*P* value
1	Income generation	Household head age	29.81	8	<0.001
		Farming experiences	21.44	8	0.006
2	Reducing conflicts on resources	Length of residence	15.78	8	0.045
		Household head age	19.20	8	0.013
3	Spiritual values	Length of residence	16.25	8	0.038
		Household head age	22.29	8	0.004
4	Educational values	Farming experiences	17.00	8	0.030
5	Climate adaptation	Farming experiences	18.59	8	0.017
		Length of residence	18.35	8	0.018

Source: own survey, 2023.

generation and the perceived market value of timber products [59]. From the management perspective, most participants preferred home garden agroforestry because of its accessibility and convenience, as it is located near residences, making it easier for daily monitoring, management, and harvesting activities. In contrast, parkland and woodlot agroforestry may require farmers to travel longer distances, which can be time-consuming and less practical for regular maintenance [60, 61]. This study suggested that preferences for agroforestry practices vary among farmers in the study area. This was corroborated by a study by Agúndez et al. [62], who found that farmers' preferences for agroforestry were context-specific in terms of the growth of agroforestry in Niger.

This study showed that most farmers strongly agreed that agroforestry practices are essential for the farming

Table 5: Generalized linear probit models on the determinants of the farmers' perceptions of the socioecological benefits of agroforestry practices.

Models	Factors	Estimate	Std. error	P values
1	Land certification	1.539	0.623	0.013
	Access to tree conservation training	0.505	0.719	0.036
2	Year of residence	−0.047	0.019	0.014
	Farming experience	0.042	0.018	0.020
	Access to training in tree conservation	0.680	0.315	0.028

Source: own survey, 2023.

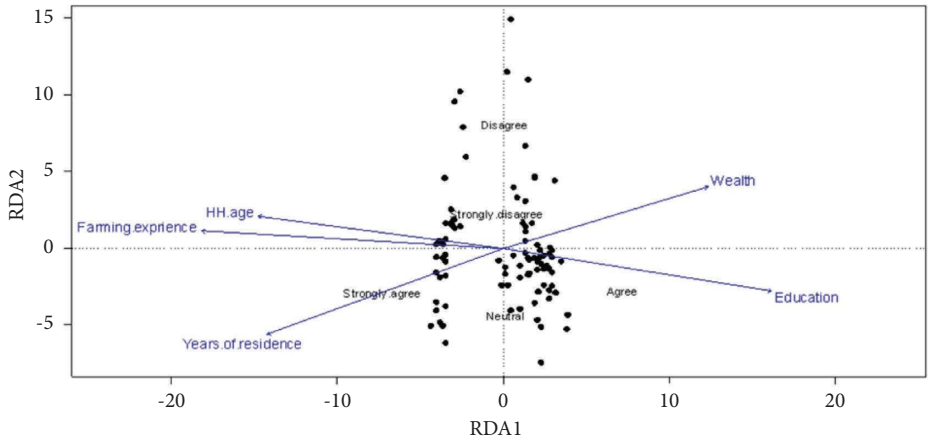

Figure 3: Redundancy analysis (RDA) shows the association of the responses of the farmers with explanatory variables in the ordination space (source: own survey, 2023).

community to boost farm income. These results were confirmed by Abdella et al. [63], Diriba et al. [64], and Saha et al. [65], who stated that agroforestry practices helped to increase farmers' incomes in Ethiopia and Bangladesh. Similarly, most farmers had a positive perception (strongly agreed and agreed) towards the benefits of agroforestry practices in terms of creating fuelwood for household consumption and sales. This is supported by the study by Saha et al. [65], who found that farmers in Bangladesh had favorable opinions of agroforestry practices as a way to satisfy their fundamental needs for fuel wood. A study by Abdella et al. [63] also indicated that 74% of households in Ethiopia had a positive perception of how agroforestry practices helped to produce fuelwood. The study also revealed that most of the respondents strongly agreed (had a positive perception) that employing agroforestry practices is crucial for the agricultural community to reduce soil erosion and increase soil formation. This finding was supported by Atangana et al. [1], Bekele [66], Drechsel et al. [67], and Tega and Bojago [18], who stated that the perennial roots of trees stabilize the soil and reduce soil erosion. According to a key informant, the use of different leguminous trees such as *Vachellia albida* in agroforestry practices reduces soil erosion, increases soil fertility by fixing nitrogen, and improves yields without the use of chemical fertilizers in the study area, which is also confirmed by a study by [68].

In general, the findings of this study are congruent with our hypothesis that most respondents have a positive perception of all perceptional questions about the socioeconomic and ecological benefits of agroforestry practices. In contrast to expectations, 42% of the respondents had a negative perception that agroforestry practices help reduce resource conflicts. This showed that farmers believed that agroforestry practices were the root of their conflicts with neighbors because they affected other people's crops close to their own. For instance, if a wood lot is located close to a crop field, it will impact the neighboring crop fields. The main agricultural activity for most households is crop farming, even though trees compete with crops for nutrients in this situation, reducing crop production. House devastation, land encroachment, and fouling neighboring complexes were the other harmful effects of trees that led to conflict. Therefore, there were disputes between the crop and tree growers. Some respondents, expressing their unhappiness, said that canopy shade would hinder the growth of beans, teff, maize, and other crops. This demonstrates that the respondents' understanding of various agroforestry management techniques was insufficient. This study is supported by Kebede and Chen [69], who found that farmers had a negative perception of wood lot agroforestry in northeastern Ethiopia.

The present study shows that the frequencies of the distributions of farmers' perceptions regarding the benefits of agroforestry are significantly dependent on age, farming experience, and the length of the respondents' years of residence. The respondents' ages had significant relationships with the frequencies of the distributions of farmers'

perceptions ($p < 0.05$). This indicated that different age groups have varying perspectives and priorities regarding the benefits of agroforestry, resulting in differences in perception among different age categories [18]. The study also indicated that farmers with diverse farming experiences have distinct perceptions about income generation, conflict resolution, spiritual values, education, and climate change adaptation through agroforestry. This implies that farmers with greater farming experience may have a deeper understanding of the potential benefits and are more likely to appreciate the positive impacts of agroforestry. The results of this study conform to those of a study by Kebede and Chen [69], who found that the farming experience significantly impacts farmers' perceptions of the benefits of agroforestry in northeastern Ethiopia. Furthermore, respondents' length of residence in the area was significantly associated with farmers' perceptions of agroforestry benefits. This suggests that the duration of residence influenced farmers' awareness and understanding of the potential advantages offered by agroforestry practices in their specific context. This agreed with the findings of Ahmad et al. [47], who claimed that the participants' years of residence had a significant and favorable link with the farmers' perceptions of the ecological benefits of agroforestry in Pakistan.

The results of the generalized linear models provide insights into the determinants of farmers' perceptions of the socioecological benefits of agroforestry practices. According to the first model, land certification had a statistically significant positive impact on farmers' perceptions of the benefits of agroforestry practices ($p < 0.05$). This implies that farmers who have their land certified are more likely to perceive these benefits positively than those without land certification. This study is consistent with a study by Mehmood et al. [53], who found that in Pakistan, the status of land ownership was directly related to farmers' perceptions of climate change. Similarly, access to tree conservation training had a statistically significant positive impact on farmers' perceptions of agroforestry benefits ($p < 0.05$). This indicates that farmers who receive training in tree conservation are more likely to recognize and appreciate the benefits associated with agroforestry practices. This finding agrees with the results of Moges and Taye [56], who claimed that farmers who had access to soil conservation and management training were more aware of conservation technologies and their advantages than those who did not. The findings of this study were also supported by a study by Pratiwi and Suzuki [70], who found that access to training increased participants' knowledge of agroforestry in Indonesia.

According to the second model, farming experience had a statistically significant positive impact on farmers' perceptions that agroforestry practices cause pests and diseases ($p < 0.05$). This implies that farmers with more farming experience are more likely to have positive perceptions of agroforestry practices. This study is consistent with a study by Mehmood et al. [53], who reported that farmers' perceptions were directly related to their experiences with agriculture in Pakistan. Similarly, access to tree conservation training had a statistically significant and positive impact on farmers' perceptions. This indicated that farmers who have received training in tree conservation are more likely to have positive perceptions regarding planting or retaining trees in agroforestry systems that cause pests and diseases. The findings of this study are in line with those of [70].

Unfortunately, our results contradicted our hypothesis that the year of residency was a negative and significant predictor of farmers' perceptions of planting or retaining trees in agroforestry practices that cause pests and diseases ($p < 0.05$). This suggests that as the number of years of residence increases, farmers' perceptions of agroforestry practices tend to decrease. This study is supported by a study by Fagerholm et al. [71], who claimed that respondents' perceptions of ecosystem services in Europe are also negatively and significantly influenced by the respondents' length of residence.

Redundancy analysis revealed that wealthier households often disagreed or strongly disagreed with the socioecological benefits of agroforestry, suggesting that socioeconomic factors may influence perceptions due to alternative income sources or resource access [72]. However, households with more years of residence in the area strongly agreed with the benefits of agroforestry, likely because of their familiarity with the local environment and experience with agroforestry practices, which may have had positive impacts. This result suggested that households that had lived in the area for longer strongly agreed with the benefits of agroforestry. This is supported by Fagerholm et al. [71]. The study also showed that educated households generally agreed with the benefits of agroforestry, indicating a better understanding of its ecological, economic, and social benefits. This research is in line with the studies of Solomon [52], Ahmad et al. [47], and Buyinza et al. [10].

The findings of this study have significant implications for the promotion and adoption of agroforestry practices in Northwestern Ethiopia. By elucidating the farmers' preferences and factors affecting their perceptions of agroforestry benefits, this study provides a robust foundation for policymakers, extension services, and agricultural practitioners to design targeted interventions that leverage the strengths of different agroforestry techniques. The documented preferences of farmers shed light on the diverse needs and priorities within the community. This understanding is crucial for tailoring agroforestry promotion strategies that resonate with local contexts, ensuring increased acceptance and sustainable adoption. The findings of this study also offer insights into the determinants of farmers' perceptions of the multiple benefits of agroforestry practices. This is essential for promoting sustainable agroforestry management, driving adoption, empowering farmers, and designing effective policies and interventions. By addressing these determinants and promoting positive perceptions, stakeholders can foster a shift towards more sustainable and environmentally friendly agricultural practices.

Despite its valuable insights, this study had several limitations. This research focused specifically on the Gondar Zuria District, but variations in sociocultural and ecological contexts in other regions may influence the applicability of

the results. The study's reliance on self-reported data introduces the potential for respondent bias. Future research could consider incorporating diverse data collection methods, such as observational studies or third-party assessments, to validate the self-reported findings. In addition, the study primarily focused on farmers' perceptions and preferences, leaving room for exploring the perspectives of other stakeholders, such as local authorities, environmental agencies, and nongovernmental organizations. A more comprehensive examination of the broader implications of agroforestry practices involving multiple stakeholders could provide a holistic understanding. Despite these limitations, this study serves as a valuable contribution to the existing literature on agroforestry practices in Ethiopia, offering nuanced insights that can inform future research directions and policy implementations.

6. Conclusions

In conclusion, this study confirms that farmers have various preferences for agroforestry practices from different perspectives. In the Gondar Zuria District, most farmers had positive perceptions of the ecological and socioeconomic benefits of agroforestry practices. This finding implied that farmers knew the benefits of agroforestry practices very well and had a good knowledge of agroforestry. Therefore, when developing policies and strategies to scale up and promote sustainable management of agroforests, it is crucial to consider farmers' knowledge of their perceptions of and preferences for the benefits of agroforestry at the grassroots level. The study also revealed that a significant proportion of respondents had neutral or disagreeing opinions regarding the benefits of agroforestry practices. To promote sustainable agroforestry management, it is crucial to conduct awareness campaigns targeting farmers and local communities. These campaigns should focus on highlighting the socioecological benefits of agroforestry, such as reducing resource conflicts, improving educational and cultural values, and mitigating climate change. By raising awareness and addressing misconceptions, farmers may be more inclined to adopt agroforestry practices. Furthermore, the findings showed that sociodemographic and institutional factors, such as length of residence, age, level of farming experience, access to land certification books, and training on tree conservation, significantly influenced farmers' perceptions of the benefits of agroforestry practices. These findings suggest that targeted strategies and policies aimed at promoting agroforestry practices should consider the diverse sociodemographic and institutional factors that shape farmers' perceptions and adoption of these practices. This study assessed the perceived benefits of agroforestry practices; future studies should be conducted on the actual benefits of agroforestry practices. Moreover, to fully understand the complex factors that affect farmers' perceptions, future studies should examine other variables that affect farmers' perceptions of the ecological and socioeconomic benefits of agroforestry, such as access to markets and extension contact. Future studies of agroforestry practices should focus on exploring environmental conditions through a sociocultural approach.

Data Availability

The authors declare that the data supporting the findings of this study are available within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Mequannt Marie conceptualized the research idea. Mr. Mequannt Marie, Debissa Lemessa, Ebrahim Esa, and Behailu Tadesse formulated the design and methodology; Mequannt Marie performed the formal analysis, investigated the data, and prepared the original draft. Mequannt Marie, Debissa Lemessa, Ebrahim Esa, Behailu Tadesse, and Hossein Azadi made revisions. All authors reviewed and revised the manuscript and approved the final manuscript.

Acknowledgments

The authors thank the Ethiopian Ministry of Education for financial support with the host of the University of Gondar. The authors are grateful to the farmers of the study sites for allowing us to provide relevant information during data collection. The authors are especially grateful to Oda Bultum University for providing a postgraduate study opportunity for the first author. The authors also thank all those experts, especially Setegn Mengesha, who fully devoted their time during the whole data collection process. The authors extend our heartfelt appreciation to Fikadu Yirga (Ph.D. candidate), Dr. Solomon Mulu, and Dr. Mebrahtu Haile for their invaluable contributions, expertise, and insights in reviewing, editing, and enhancing the quality of our manuscript's first draft. The reviewer and editor are highly thankful for their constructive comments on this paper.

Supplementary Materials

Appendix 1. Description of sample household selection. This appendix provides information on the selection of sample households in the study area. It presents data on the number of sample households chosen from different *kebeles* (administrative subdivisions) within the study area, along with the corresponding agroecological zones. The table includes the total number of households per *kebele* and the number of sample households selected from each kebele. The total number of sample households selected for the study is also provided. Appendix 2. Major local criteria for household wealth classification. This appendix outlines the major local criteria used to classify households into different wealth categories. It presents key informants' criteria for distinguishing between rich, medium, and poor households.

The table includes various indicators such as the status of the house (number of tin), land holding (in hectares), oxen and cow numbers, goat and sheep numbers, donkey ownership, and crop production per year. The criteria for each wealth class are provided, indicating the thresholds or ranges for each indicator used to classify households into rich, medium, and poor categories. (*Supplementary Materials*)

References

[1] A. Atangana, D. Khasa, S. Chang, and A. Degrande, "Definitions and classification of agroforestry systems," *Tropical Agroforestry*, Springer, Berlin, Germany, 2014.

[2] S. Ahmad, H. Xu, and E. Ekanayake, "Socioeconomic determinants and perceptions of smallholder farmers towards agroforestry adoption in northern irrigated plain, Pakistan," *Land*, vol. 12, no. 4, p. 813, 2023.

[3] G. A. Bogale and S. E. Bekele, "Sustainability of agroforestry practices and their resilience to climate change adaptation and mitigation in sub-saharan africa: a review," *Ekológia*, vol. 42, no. 2, pp. 179–192, 2023.

[4] M. Elbakidze, D. Surová, J. Muñoz-Rojas et al., "Perceived benefits from agroforestry landscapes across North-Eastern Europe: what matters and for whom?" *Landscape and Urban Planning*, vol. 209, Article ID 104044, 2021.

[5] I. Mukhlis, M. S. Rizaludin, and I. Hidayah, "Understanding socio-economic and environmental impacts of agroforestry on rural communities," *Forests*, vol. 13, no. 4, p. 556, 2022.

[6] A. Pantera, M. Mosquera-Losada, F. Herzog, and M. Den Herder, "Agroforestry and the environment," *Agroforestry Systems*, vol. 95, no. 5, pp. 767–774, 2021.

[7] R. Akter, M. K. Hasan, K. H. Kabir, D. Darr, and N. A. Roshni, "Agroforestry systems and their impact on livelihood improvement of tribal farmers in a tropical moist deciduous forest in Bangladesh," *Trees, Forests and People*, vol. 9, Article ID 100315, 2022.

[8] M. Zerihun, "Agroforestry practices in livelihood improvement in the Eastern Cape province of South Africa," *Sustainability*, vol. 13, no. 15, p. 8477, 2021.

[9] S. Kuyah, G. Sileshi, E. Luedeling et al., "Potential of agroforestry to enhance livelihood security in Africa," *Agroforestry for Degraded Landscapes*, vol. 1, pp. 135–167, 2020.

[10] J. Buyinza, I. K. Nuberg, C. W. Muthuri, and M. D. Denton, "Psychological factors influencing farmers' intention to adopt agroforestry: a structural equation modeling approach," *Journal of Sustainable Forestry*, vol. 39, no. 8, pp. 854–865, 2020.

[11] B. M. Gebru, S. W. Wang, S. J. Kim, and W.-K. Lee, "Socio-ecological niche and factors affecting agroforestry practice adoption in different agroecologies of southern Tigray, Ethiopia," *Sustainability*, vol. 11, no. 13, p. 3729, 2019.

[12] S. Jha, H. Kaechele, and S. Sieber, "Factors influencing the adoption of agroforestry by smallholder farmer households in Tanzania: case studies from Morogoro and Dodoma," *Land Use Policy*, vol. 103, Article ID 105308, 2021.

[13] N. M. Syano, M. M. Nyangito, O. V. Wasonga, and G. Kironchi, "Agroforestry practices and factors influencing their adoption by communities in the drylands of Eastern Kenya," *Agroforestry Systems*, vol. 96, no. 8, pp. 1225–1235, 2022.

[14] B. Bekele, E. Yeshiwas, and A. Zewde, *Determinants of the Agroforestry Practices in Mana Districts*, Oromyia Region, Ethiopia, 2023.

[15] A. D. Beyene, A. Mekonnen, B. Randall, and R. Deribe, "Household level determinants of agroforestry practices adoption in rural Ethiopia," *Forests, Trees and Livelihoods*, vol. 28, no. 3, pp. 194–213, 2019.

[16] S. M. Tafere and Z. A. Nigussie, "The adoption of introduced agroforestry innovations: determinants of a high adoption rate–a case-study from Ethiopia," *Forests, Trees and Livelihoods*, vol. 27, no. 3, pp. 175–194, 2018.

[17] M. Tega and E. Bojago, "Determinants of smallholder farmers' adoption of agroforestry practices: sodo Zuriya District, southern Ethiopia," *Agroforestry Systems*, vol. 98, pp. 1–20, 2023.

[18] M. Tega and E. Bojago, "Farmer's perceptions of agroforestry practices, contributions to rural household farm income, and their determinants in sodo Zuria district, southern Ethiopia," *International Journal of Financial Research*, vol. 2023, Article ID 5439171, 19 pages, 2023.

[19] T. Ibrahim, E. Feleke, M. Genete, and T. Bekele, "Determinants and perceptions of farmers towards tree planting on farmland in northeastern Ethiopia," *Trees, Forests and People*, vol. 10, Article ID 100350, 2022.

[20] A. Adedayo and S. Oluronke, "Farmers' perception and adoption of agroforestry practices in Osun State, Nigeria," *Forest Research*, vol. 3, no. 127, p. 2, 2014.

[21] C. Valdivia, C. Barbieri, and M. A. Gold, "Between forestry and farming: policy and environmental implications of the barriers to agroforestry adoption," *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*, vol. 60, no. 2, pp. 155–175, 2012.

[22] E. Zossou, A. Arouna, A. Diagne, and R. A. Agboh-Noameshie, "Learning agriculture in rural areas: the drivers of knowledge acquisition and farming practices by rice farmers in West Africa," *The Journal of Agricultural Education and Extension*, vol. 26, no. 3, pp. 291–306, 2020.

[23] S. S. Meijer, D. Catacutan, O. C. Ajayi, G. W. Sileshi, and M. Nieuwenhuis, "The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa," *International Journal of Agricultural Sustainability*, vol. 13, no. 1, pp. 40–54, 2015.

[24] G. Mather, *Foundations of Sensation and Perception*, Psychology Press, London, UK, 2016.

[25] A. Nes, K. Sundberg, and S. Watzl, "The perception/cognition distinction," *Inquiry*, vol. 66, no. 2, pp. 165–195, 2023.

[26] R. T. Shackleton, D. M. Richardson, C. M. Shackleton et al., "Explaining people's perceptions of invasive alien species: a conceptual framework," *Journal of Environmental Management*, vol. 229, pp. 10–26, 2019.

[27] S. Larweh and A. Abukari, "Small-scale farmers' perception of the adoption of agroforestry practices in tolon district, Ghana," *Turkish Journal of Agriculture-Food Science and Technology*, vol. 10, no. 2, pp. 2899–2902, 2022.

[28] A. Fleming, A. P. O'grady, D. Mendham et al., "Understanding the values behind farmer perceptions of trees on farms to increase adoption of agroforestry in Australia," *Agronomy for Sustainable Development*, vol. 39, no. 1, p. 9, 2019.

[29] A. Sharmin and S. Rabbi, "Assessment of farmers' perception of agroforestry practices in Jhenaidah district of Bangladesh," *Journal of Agriculture and Ecology Research International*, vol. 6, no. 4, pp. 1–10, 2016.

[30] A. Anjulo and A. Mezgebu, "Determinants of agroforestry practicing at fogera district, northwestern Ethiopia," *Journal*

of Agriculture and Ecology Research International, vol. 9, no. 4, pp. 1–14, 2016.

[31] L. Ayichew, "Determinants of apple based agroforestry technology adoption in lay gayint district northwestern Ethiopia," *International Journal of Research in Agriculture and Forestry*, vol. 6, pp. 38–48, 2019.

[32] B. Asfaw, "Agroforestry practices in gondar Zuria District,Central gondar zone, Amhara region, Ethiopia," *Mathesis*, vol. 12, 2018.

[33] G. Dereje and A. Melkamu, "On-farm tree management practices in gondar Zuria district, northwestern Ethiopia," *Journal of Scientific and Engineering Research*, vol. 7, no. 8, pp. 105–113, 2020.

[34] S. Lei, Q. Qiao, X. Gao, J. Feng, Y. Wen, and Y. Han, "Ecological awareness, policy perception, and green production behaviors of farmers living in or near protected areas," *Forests*, vol. 14, no. 7, p. 1339, 2023.

[35] K. Wienhold and L. F. Goulao, "The embedded agroecology of coffee agroforestry: a contextualized review of smallholder farmers' adoption and resistance," *Sustainability*, vol. 15, no. 8, p. 6827, 2023.

[36] A. Willmott, M. Willmott, I. Grass, B. Lusiana, and M. Cotter, "Harnessing the socio-ecological benefits of agroforestry diversification in social forestry with functional and phylogenetic tools," *Environmental Development*, vol. 47, Article ID 100881, 2023.

[37] M. Marie, F. Yirga, G. Alemu, and H. Azadi, "Status of energy utilization and factors affecting rural households' adoption of biogas technology in north-western Ethiopia," *Heliyon*, vol. 7, no. 3, Article ID e06487, 2021.

[38] M. Marie, F. Yirga, M. Haile, S. Ehteshammajd, H. Azadi, and J. Scheffran, "Time-series trend analysis and farmer perceptions of rainfall and temperature in northwestern Ethiopia," *Environment, Development and Sustainability*, vol. 23, no. 9, pp. 12904–12924, 2021.

[39] A. Bekele-Tesemma and B. Tengnäs, *Useful Trees and Shrubs of Ethiopia: Identification, Propagation, and Management for 17 Agroclimatic Zones*, World Agroforestry Centre, Eastern Africa Region Nirobi, Nairobi, Kenya, 2007.

[40] J. Tarekegn Asmare, T. Bosena, and B. Daregot, "Factors determining market supply of chickpea in gondar Zuria woreda, ANRS, Ethiopia," *Science Journal of Business and Management*, vol. 7, pp. 1–7, 2019.

[41] M. Marie, F. Yirga, M. Haile, and F. Tquabo, "Farmers' choices and factors affecting adoption of climate change adaptation strategies: evidence from northwestern Ethiopia," *Heliyon*, vol. 6, no. 4, 2020.

[42] S. A. Tadesse and D. Teketay, "Perceptions and attitudes of local people towards participatory forest management in tarmaber district of north shewa administrative zone, Ethiopia: the case of wof-washa forests," *Ecological Processes*, vol. 6, pp. 17–16, 2017.

[43] Ess, "Ethiopian statistical service (ESS)," 2022, https://www.statsethiopia.gov.et/wp-content/uploads/2023/08/Population-of-Zones-and-Weredas-Projected-as-of-July-2023.pdf.

[44] G. Mulugeta and A. Achenef, "Socio-economic challenges of area exclosure practices: a case of Gonder Zuria Woreda, Amhara region, Ethiopia," *Journal of Natural Sciences Research*, vol. 5, no. 13, pp. 123–132, 2015.

[45] W. Yonas, B. Asmamaw, A. Solomon et al., "A participatory agricultural production systems analysis of AGP-I1 districts in north gondar zone: implications for research and development," *Amhara Agricultural Research Institute*, vol. 1, 2018.

[46] B. Asfaw, *Assessment of Agroforestry Practice in Gondar Zuria Wereda, Central Gondar Zone*, Amhara region, Amhara, Ethiopia, 2018.

[47] S. Ahmad, C. Zhang, and E. Ekanayake, "Smallholder farmers' perception on ecological impacts of agroforestry: evidence from northern irrigated plain, Pakistan," *Polish Journal of Environmental Studies*, vol. 30, no. 4, pp. 2969–2979, 2021.

[48] S. Chisika, J. Park, H. Park, and C. Yeom, "Farmers' perception of ecosystem services from agroforestry practices in Kenya: the case of kakamega county," *Journal of Sustainability Research*, vol. 4, no. 1, 2022.

[49] F. Camilli, "Stakeholder's perceptions of the environmental and socio-economic benefits of agroforestry systems: an online survey in Italy," in *Proceedings of the European Agroforestry Conference-Agroforestry as Sustainable Land Use*, EURAF, Europe, UK, May 2018.

[50] J. Salinas Ruíz, O. A. Montesinos López, G. Hernández Ramírez, and J. Crossa Hiriart, *Generalized Linear Mixed Models with Applications in Agriculture and Biology*, Springer Nature, Berlin, Germany, 2023.

[51] M. Delporte, S. Fieuws, G. Molenberghs et al., "A joint normal binary (probit) model," *International Statistical Review*, vol. 90, no. 1, pp. S37–S51, 2022.

[52] A. Solomon, "Views and attitudes of local farmers towards planting," *Growing and Managing Trees in Agroforestry System in Basona Worena District*, vol. 10, p. 258, 2019.

[53] M. S. Mehmood, G. Li, A. R. Khan et al., "An evaluation of farmers' perception, awareness, and adaptation towards climate change: a study from Punjab province Pakistan," *Ciência Rural*, vol. 52, no. 3, 2022.

[54] J. S. Bento-Silva, W. Martins de Andrade, M. A. Ramos et al., "Students' perception of urban and rural environmental protection areas in Pernambuco, Brazil," *Tropical Conservation Science*, vol. 8, no. 3, pp. 813–827, 2015.

[55] A. A. R. Kobbail, "Local people attitudes towards community forestry practices: a case study of Kosti Province-Central Sudan," *International Journal of Financial Research*, vol. 2012, Article ID 652693, 7 pages, 2012.

[56] D. M. Moges and A. A. Taye, "Determinants of farmers' perception to invest in soil and water conservation technologies in the North-Western Highlands of Ethiopia," *International Soil and Water Conservation Research*, vol. 5, no. 1, pp. 56–61, 2017.

[57] E. Melaku Addis, M. Muche Amera, and G. Birhane Biru, "Land certification and farmers' decision on long term investment in Jimma Zone, Southwest Ethiopia," *Journal of Degraded and Mining Lands Management*, vol. 7, no. 4, pp. 2269–2278, 2020.

[58] S. Guntukogula Pattabhi, P. Prashanth, M. Sreenivasulu, and A. Madavilata, "Effectiveness of social media agricultural information on farmer's knowledge," *Environment Conservation Journal*, vol. 24, no. 1, pp. 123–129, 2023.

[59] R. Chen and C. Dong, "The study of the relationship between natural forests and modern wooden dwellings," *Advances in Urban Engineering and Management Science Volume 1*, vol. 1, pp. 357–362, 2022.

[60] D. Pauletto, L. Guerreiro Martorano, L. S. de Sousa Lopes et al., "Plant composition and species use in agroforestry homegardens in the Eastern Amazon, Brazil," *Sustainability*, vol. 15, no. 14, p. 11269, Article ID 11269, 2023.

[61] G. T. Fida and E. E. Chala, "Assessment of homegarden agroforestry practices: case study of horticultural crop production trends, and contribution towards biodiversity

conservation and local livelihoods," *Assessment*, vol. 13, no. 3, 2023.

[62] D. Agúndez, S. Lawali, A. Mahamane, R. Alía, and M. Soliño, "Development of agroforestry food resources in Niger: are farmers' preferences context specific?" *World Development*, vol. 157, Article ID 105951, 2022.

[63] M. Abdella, B. Cheneke, and R. Elema, "Assessment of existing agroforestry practices in east hararghe zone oromia, Ethiopia," *Developing Country Studies www.iiste.org*, vol. 12, no. 3, pp. 20–34, 2022.

[64] A. Diriba, S. Dekeba, and W. Gizaw, "Assessment of Existing Agroforestry Practices in West Hararghe Zone of Oromia Region, Ethiopia," *International Journal of Research-GRANTHAALAYAH*, vol. 9, no. 12, pp. 286–302, 2021.

[65] S. Saha, A. Sharmin, R. Biswas, and M. Ashaduzzaman, "Farmers' perception and adoption of agroforestry practices in Faridpur district of Bangladesh," *International Journal of Environment, Agriculture and Biotechnology*, vol. 3, no. 6, pp. 1987–1994, Article ID 268280, 2018.

[66] S. E. Bekele, "Parkland agroforestry of Ethiopia; key to production, productivity, biodiversity conservation and climate change mitigation: a review," *Open Journal of Forestry*, vol. 08, no. 04, pp. 472–488, 2018.

[67] P. Drechsel, P. Heffer, H. Magen, R. Mikkelsen, and D. Wichelns, *Managing Water and Fertilizer for Sustainable Agricultural Intensification*, International Plant Nutrition Institute (IPNI)), Paris, France, 2015.

[68] G. W. Kassie, "Agroforestry and farm income diversification: synergy or trade-off? The case of Ethiopia," *Environmental Systems Research*, vol. 6, pp. 8–14, 2018.

[69] T. A. Kebede and X. Chen, "Local farmers' perception towards Eucalyptus woodlot: lesson drawn from the jamma district, northeastern Ethiopia," *East African Journal of Agriculture and Biotechnology*, vol. 6, no. 1, pp. 257–270, 2023.

[70] A. Pratiwi and A. Suzuki, "Reducing agricultural income vulnerabilities through agroforestry training: evidence from a randomised field experiment in Indonesia," *Bulletin of Indonesian Economic Studies*, vol. 55, no. 1, pp. 83–116, 2019.

[71] N. Fagerholm, M. Torralba, G. Moreno et al., "Cross-site analysis of perceived ecosystem service benefits in multifunctional landscapes," *Global Environmental Change*, vol. 56, pp. 134–147, 2019.

[72] S. Tsvuura, M. Mudhara, and T. Mabhaudhi, "An analysis of the perceived societal benefits of and threats from trees for the delivery of livelihoods and community development," *Plants, People, Planet*, vol. 5, no. 3, pp. 424–436, 2023.