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Research Article

Determinant Factors of "*Eucalyptus globulus*" (Labill.) Woodlot Production in Tach Gayint District, South Gondar Zone, Amhara Region, Ethiopia

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Eucalyptus is the most preferred exotic species in different parts of Ethiopia, particularly in the northern part of the country, including the study area. Socioeconomic, institutional, and endowment variables are an influence on the production of this species. The purpose of this study was to identify determinants of *Eucalyptus* woodlot production for producer farmers in the study area. Multistage sampling techniques were used in order to select the district, kebeles, and household heads to be interviewed. The district and the kebeles were selected purposefully based on their high potential for *Eucalyptus* production, whereas ninety-six (96) sampled respondent farmers were selected by using simple random sampling techniques. A multiple linear regression (OLS) model was used to run the determinants of *Eucalyptus* woodlot production, and descriptive statistics were used to describe the socioeconomic characteristics of smallholder *Eucalyptus* producers in the form of means, frequencies, and percentages. The respondents use *Eucalyptus* products for construction and fuel wood. Rural farmers produced about 70% of construction wood products and 30% of fuel wood products annually. Five variables (i.e., woodlot size, woodlot density, and market information) significantly affected woodlot production, whereas the age of farmers and market distance were negatively affected. In order to produce better income from *Eucalyptus* products, the collaboration efforts of all responsible groups (i.e., farmers, researchers, governments, and others) should be required.

1. Introduction

Eucalyptus comes from the Greek terms "Eu" and "Kalypta," which mean "well" and "cover," respectively, which in turn implies well cover. *Eucalyptus* has closed flower's green leaf color in all environments, phases, and seasons [1–3]. The *Eucalyptus* species was first found on the Australian continent, but after a few years, under various climatic circumstances, it spreads to other regions of the world [2, 4]. Farmers in Eastern Africa are growing *Eucalyptus* species over a long period of time in diverse land use types [5, 6].

Emperor Menelik II (1868–1907) brought various types of *Eucalyptus* and acacia seeds to Ethiopia in 1895 from Australia, while pine seeds traveled to Portugal, Italy, and Greece with the assistance of his French advisor Mondon-Vidaillet. He then set up nurseries near the imperial capital, Addis Ababa, and raised those seedlings for his subjects to lessen the scarcity of fuel wood and timber construction [7, 8]. Ethiopia now possesses fifteen different species from the Myrtaceae family, which flourish throughout the nation's rural and urban settings [9, 10]. Among those fifteen *Eucalyptus* species, some are known by different local names, such as *Bar Gammo* in Oromiffa and *Bahir Zaf* in Amharic, which signify a tree from beyond the ocean (an invasive species). The most common genera in Ethiopia are *Eucalyptus globulus* and *Eucalyptus camaldulensis,* which are commonly referred to as *Nech* (white eucalypts) and *key bahirzaf* (red eucalypts), respectively, in the official language of the nation, Amharic. *Bahir Zaf* means "tree comes from elsewhere" or "trees across a sea." While *Eucalyptus globulus*

and *Eucalyptus camaldulensis* may grow in any type of weather in Ethiopia, *Eucalyptus globulus* is primarily found in the country's highlands, while *Eucalyptus camaldulensis* is found in the country's lowlands in order to maximize its products and services [11, 12].

One-fourth of Ethiopian households' yearly monetary revenue comes from *Eucalyptus* [13–15]. As a result, *Eucalyptus* is a desirable species for Ethiopian rural communities because of its potential for economic growth and capacity to raise farmers' standard of living [12, 16–19]. Although *Eucalyptus* can be established in a variety of packages within a given land use type, woodlots are the most widely used package [20]. Thus, "woodlot" refers to a 0.1 ha plot of land that is 40 m by 25 m or larger and is sometimes referred to as a "Block." While many reasons may have contributed to the rapid spread of *Eucalyptus* woodlot planting in the study area and throughout Ethiopia, these factors fall into institutional, socioeconomic, and asset endowment factors [21–29].

Farmers in the study area expand the production of *Eucalyptus globulus* on various land uses within various packages. On the other hand, no concrete evidence exists about the driving forces behind *Eucalyptus* woodlot production or the variables that influence its income. Thus, the purpose of this study was to determine the factors that influence the production of *Eucalyptus* woodlots for producer farmers in Tach Gayint district. The aim of this study to provide solutions for the problems facing *Eucalyptus* planting, which are essential to the species' expansion by taking into account the determinants that affect smallholder farmers' woodlot production and the resulting annual income production for the farmers in the study area. In fact, this study will act as an opportunity for individuals who concerned about enhancing the standard of living for communities and forest producers in the study area.

2. Methodology

2.1. Description of the Study Area. The study area is located in the Tach Gayint district of South Gondar Zone, Amahra Regional State, Ethiopia. It is about 200 km from Bahir Dar, the regional capital city. The district lies within the geographical grid coordinates of 11°22 N Latitude and 38°43′ Longitude, with an altitude range of 1310–3407 m.a.s.l., as shown in the figure (Figure 1). According to the current administrative division, the district encompasses 18 rural and two urban kebeles. According to the information obtained in the 2018/19 data from the Office of Agriculture, the highest and lowest temperatures were 270°C and 130°C, respectively, and the mean annual rainfall ranged from 900 mm to 1000 mm. Based on the 2007 national census conducted by the CSA of Ethiopia, the district has a total population of 101,956, of which 51,041 are men and 50,915 are women, with an area of 825.30 square kilometres. The major land use patterns of the study district comprise cultivable land, grazing land, forest, infrastructure, and unproductive land.

2.2. Sampling Procedure and Sample Size. Three-stage sampling techniques were used in order to select the district, *kebele*, and household heads to be interviewed. In the first stage**,** Tach Gayint district was selected purposefully due to the high potential of *Eucalyptus* woodlot production. In the second stage, out of 18 rural *kebeles* in the district, two, known as Dajat and Anseta, were selected purposefully since they had relatively high potentials for *Eucalyptus* woodlot production compared to the remaining 16 rural kebeles in the district. In the third stage**,** farmers and households were selected by simple random sampling methods from the *Eucalyptus* producers. Among the total population of household farmers in the two *kebeles* (2350), i.e., 1200 households in Dajat and 1150 households in Anseta, sample farmers from each *kebele* were selected using a simple random sampling method, which can give each individual farmer an equal chance in the population of the study *kebele*. As indicated in Table 1, farmers in Dajat *kebele* had better participation in eucalyptus woodlot production than Anseta *kebele*.

The sampling size was calculated using the simplified formula provided by Israel [30]: minimum level of precision = 10% (0.1).

$$n = \frac{N}{1 + N(e)^2}, \tag{1}$$

$$n = \frac{N}{1 + N(e)^2} = \frac{2350}{1 + 2350(0.1)^2} = 96\text{hhs}, \tag{2}$$

where n is the sample size to be computed = 96 household heads, N is target population (total household heads size) in the study area = 2350 total household heads, and e is the level of precision = 0.1. hhs is household heads that is 96.

Then 96 household heads were selected using the simple random sampling technique.

2.3. Methods of Data Collection

2.3.1. Qualitative Data Collection Tools. Key informant interviews were conducted with different individuals (i.e., one Woreda agricultural office expert, two elders, and two extension agents). Checklists were developed and used to guide the interview.

Focus group discussions (FGDs) were conducted with each of the two selected groups having eight members in order to generate additional information. There were a total of eight FGDs (four in each kebele). To supervise and guide the discussion with the FGD members, checklists are prepared based on the research matter. The FGD members were selected based on their knowledge of the community and nominated by the kebele administration officers.

2.3.2. Quantitative Data Collection Tools. Household surveys through questionnaires: a household survey was conducted using semistructured questionnaires (open and closed-ended). Questions include the socioeconomic and demographic characteristics of respondents and determinant factors. A total of 96 farmers' took part in the household survey. The questionnaires were prepared in English, but they were translated into Amharic (the local

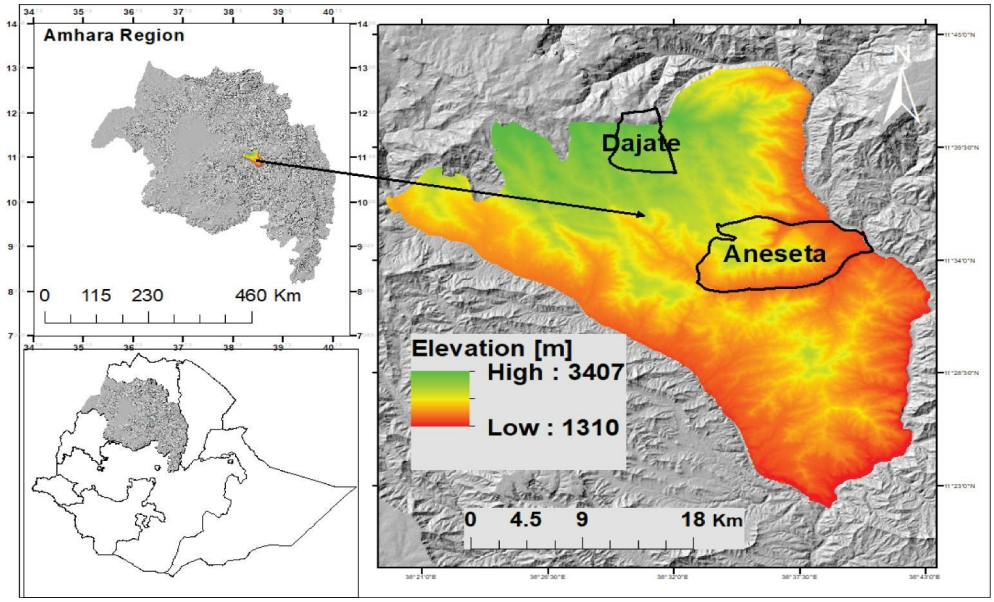

Figure 1: Map of the study area.

Table 1: Number of households interviewed per each kebele.

Kebele	HH number			Sample size per *kebele*		
	Male	Female	Total	Male	Female	Total
Dajat	976	224	1200	42	7	49
Anseta	903	247	1150	41	6	47
Total	1879	471	2350	83	13	96

language) to make the questions simple, readable, and understandable to the households. A household interview was conducted at home, at the market, and at the FTC (farmers training center) during meeting time between the farmers and the interviewer.

2.4. Data Analysis. The data were analyzed using descriptive and econometric analysis. Descriptive statistics such as means, frequencies, and percentages were used to describe and examine the socioeconomic characteristics of smallholder *Eucalyptus* producers and to identify motivation factors for farmers to plant *Eucalyptus* woodlots. Each of them was done in terms of tables and graphs. The collected data were encoded using the Package for Social Sciences (SPSS), where an econometric (multiple linear regression) model was run to identify significant variables determining the production of *Eucalyptus* woodlot products in the study area. The functional relationship is specified in the following equation:

$$y = f\left(x_1, x_2, x_3, x_4, x_5, x_6, x_7, \ldots, x_{n,}\varepsilon k\right). \quad (3)$$

The general form of the multiple linear regression models for this study is expressed in the following equation:

$$y = (\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \ldots + \beta k x n + \varepsilon k), \quad (4)$$

where y is the dependent variable explained by different explanatory variables, Xn is the independent variable used to explain the dependent variable, $\beta 0$ is the intercept of the regression model, βk is the parameter associated with the explanatory variable, and $\varepsilon\kappa$ is the stochastic error term. Prior to the regression analysis, multicollinearity tests, heteroscedasticity tests, and omitted variables were undertaken to sort out the variables that are highly dependent. As shown in Table 2, all dummy and continuous explanatory variables were already expected either negatively or/and positively in woodlot production.

3. Results and Discussion

3.1. Household Characteristics of Sample Households. From the total sampled households, the majority (86.5%) were males, whereas the remaining households were females. About 49% of the respondents were categorized as having a rich wealth status in Anseta *Kebele*, followed by a medium (10.6%) and poor (40.4%) wealth status. Similarly, the majority of the respondent farmers in Dajat *Kebele* were rich (49%) followed by medium (30.6%) and poor (20.4%) wealth status. With regard to educational status, the majority of the respondents in Anseta *Kebele* attended the first cycle (34%), whereas the majority of respondents in Dajat *Kebele* were unable to read or write (26.5%). The mean family size of the respondents in total was about 4.5, and the average age was about 52.5.

3.2. Socioeconomic Characteristics of the Respondents. The mean landholdings of respondent farmers were 0.98 and 1.02 ha in Anseta and Dajat *kebele,* respectively, which ranged from 0.5 to 1.75 ha in both kebele. Livestock is one of the socioeconomic characteristics of the respondent farmers. Therefore, the mean livestock size of the respondents in

Table 2: Description of the explanatory variables and the expected sign.

Variables	Description and type of variables	Expected sign
Woodlot products income	Dependent variable, production of eucalyptus woodlot products income: continuous variable (ETB)	
Sex	Sex of household head: dummy variable (0 = Female 1 = male)	+/−
Age	Age of household head: continuous (years)	+/−
Family size	Number of families of the household head: continuous (number)	—
Landholding	Size of land holding: continuous (ha)	+
Education	Formal education level of the household head: categorical (grades levels)	+/−
Wealth status	Wealth status of the household head: categorical (0 = poor, 1 = medium, 2 = rich)	+/−
Credit access	Credit access of the household head: dummy (0 = no, 1 = yes)	+/−
Extension services	Extension service of the household head: dummy (0 = no, 1 = yes)	+
Number of livestock	Number of livestock: continuous (TLU)	—
Woodlot size	Woodlot size of the household heads: continuous (ha)	+
Woodlot density	Density of the woodlot: dummy (0 = otherwise, 1 = dense)	+/−
Market distance	Distance of market from the home: continuous (Km)	—
Market information	Access to market information of the household: dummy (0 = no, 1 = yes)	+

Anseta *Kebele* was 2.20 TLU, which ranged from 0.00 to 20.25 TLU, whereas the mean livestock size of the respondents in Dajat *Kebele* was 2.7 TLU, which ranged from 0.00 to 6.40 TLU. The Eucalypts woodlot size of the respondents in Anseta Kebele ranged from 0.03 to 0.23 ha with a mean value of 0.06 ha, whereas in Dajat *Kebele*, the mean woodlot size was 0.07 ha, which ranged from 0.03 to 0.13 ha. Therefore, with respect to the mean landholding of the respondents in each *kebele*, the woodlots were proportionally allocated throughout the respondent farmers land in the study sites.

3.3. Local Market Selling Price of Eucalyptus Products. Currently, *Eucalyptus* plantations are becoming the main tree species for not only construction but also for fuel wood, furniture, and others in many parts of Ethiopia. Similarly, *Eucalyptus* planting in the backyard has been a long-term practice in the study area, but as a result of its great importance, smallholder farmers have expanded this species into a parcel of farm land as a woodlot. Therefore, woodlots are a common tree plantation package that could provide a lot of construction materials, fuel wood, and other product types in the study area.

During the focus group and key informant discussion, participants explained that *Eucalyptus*, especially *Eucalyptus globulus*, is gold gifted by God for us, which solved our ever-existing house construction problem once and forever. They also assured that, currently, life without Eucalypts would be very hard as other indigenous species have been wiped out by different factors. Mostly, farmers classified harvested or stand *Eucalyptus* woodlots as fuel wood, those with very small diameter and shorter length, and construction wood, those with bigger diameter and longer length woodlots. The construction wood is also classified as *mager, worage*, *filt,* and *pole* by their local names. As shown in Table 3, the selling price of all these products was determined by their diameter and length.

3.4. Household Annual Income from Eucalyptus globulus Woodlot Products. Household annual income from *Eucalyptus globulus* woodlot products has been growing continuously in the study area because farmers are increasingly shifting their crop land into *Eucalyptus* woodland. The participants during the focus group discussion justified that *Eucalyptus* species can grow better than other agricultural crops, even on fragile or unfertile land. In addition, compared to other income sources, *Eucalyptus* products provide better income with time savings, are less labour intensive for protection, harvesting, and postharvesting activities, and are more secure farming. The households' woodlot was sold either in the form of a stand or living tree or by cutting, which usually depends on the labour availability of the household, i.e., households that had enough families to carry woodlot products to the market, mostly harvested wood; otherwise, live trees were sold.

As shown in Table 4, the income obtained from construction wood in each *kebele* has a total mean income of more than 70%. Relatively, households in Dajat *kebele* have a better income than Anseta *kebele* from the main *Eucalyptus* products. This might be due to better market access for Dajat growers for their plantation products.

3.5. Factors Motivating Farmers in Eucalyptus Woodlot Production. As explained in Figure 2, respondents gave different reasons why they have been expanding *Eucalyptus* woodlots in their farm fields. For instance, the respondents explained that *Eucalyptus* plantations are becoming more attractive because they are unpalatable to animals, have a fast growth rate, and require fewer management activities, which in turn save time and money. In line with this result, Mekonnen et al. [18] reported that the fast-growing nature of the tree, the increased demand for fuel wood, the easy management requirements of the tree, and the unpalatable nature of the tree for animals were the prominent factors that enhanced *Eucalyptus* production. On top of these, the majority of respondents (33.3%) put the low return from agricultural crop production compared to *Eucalyptus* as the main pressing reason that made them engage more in *Eucalyptus* woodlots, as shown in Figure 2. Based on the information from focus group discussions, many farmers have been changing their crop land to *Eucalyptus* plantations.

Table 3: Eucalypts woodlot products and their market price.

Eucalyptus woodlot products	Diameter (cm)	Length (m)	Average selling price per product in ETB
Construction wood			
Worage	8–13	8–10	70
Mager	6–10	6–8	50
Pole for house building	13–15	9–10	100
Filt	—	5	32
Fuel wood			
Man bundle	—	—	80
Woman bundle	—	—	65
Child bundle	—	—	45
A quintal of charcoal			270

Source: local market survey result (2020).

Table 4: Mean annual income of respondents from each eucalyptus product type kebeles.

Kebeles	Product type	Frequency	Percent	Mean income in ETB	Proportion
Dajat	Fuel wood	24	25.00	3315.90	13.30
	Construction wood	25	26.04	9500.18	38.20
Anseta	Fuel wood	17	17.71	4082.10	16.40
	Construction wood	30	31.25	7957.50	32.00
Total		96	100	24855.72	100

Source: own survey result (2020).

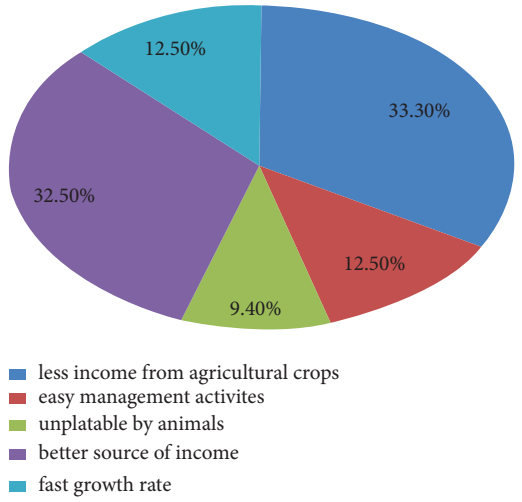

Figure 2: Motivation factors of farmers for *Eucalyptus* production.

3.6. Seedling Sources of Eucalyptus globulus. Finding the source of *Eucalyptus* seedlings is one of the prerequisite activities of respondents before planting. According to the survey result, the majority of farmers in both study *kebeles,* Anseta (46.8%) and Dajat (42.8%) got or bought commonly from other farmers' nurseries, and the remaining farmers got *Eucalyptus* seedlings by preparing their own nurseries in their farmland and they took from government nurseries by free access (Figure 3).

3.7. Determinant Factors of Eucalyptus Woodlot Production. The multiple linear regression (OLS) models were used to predict the effects of explanatory variables on woodlot production in the study district. As indicated in Table 5, the OLS analysis revealed that age of household head and market distance showed a significantly negative relationship with *Eucalyptus* plantation, whereas woodlot size, woodlot density, and market information were significant with a positive

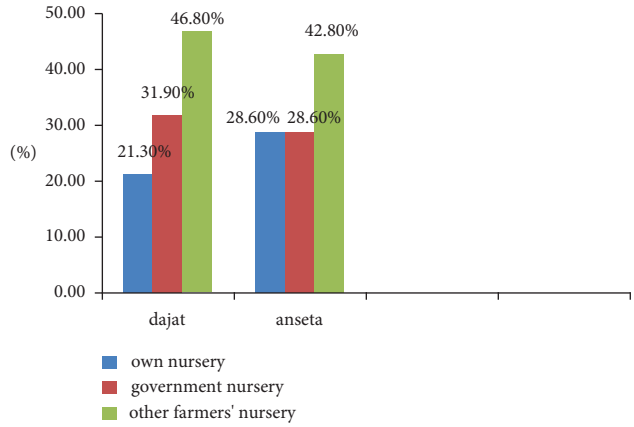

Figure 3: Seedling source.

Table 5: Model outputs on determinant factors influencing *Eucalyptus* woodlot production.

Variables	Robust Coef	Std. err	T	P
Sex (1 = male, 0 = female)	−306.973	254.760	−1.200	0.232
Age of respondent in year	−20.929	12.065	−1.730	0.087*
Family size in number	178.385	130.780	1.360	0.176
Landholding in ha	270.788	433.628	0.620	0.534
Educational status in grade category	−47.876	119.129	0.400	0.689
Wealth status (0 = poor, 1 = medium, 2 = rich)	−16.365	197.924	−0.080	0.934
Credit access (1 = yes, 0 = no)	620.210	426.006	1.460	0.149
Extension service (1 = yes, 0 = no)	372.218	399.135	0.930	0.354
Livestock in TLU unit	42.741	28.309	1.510	0.135
Woodlot density (1 = dense, 0 = otherwise)	561.162	316.792	1.770	0.080*
Woodlot size in ha	41205.730	3659.621	11.260	0.001***
Market distance in km	−151.110	61.994	−2.440	0.017**
Market information (1 = yes, 0 = no)	683.539	399.369	1.710	0.091*
Constant term	9305.873	984.307	9.450	0.000***
Number of obs = 96: f (13, 82) = 65.55, Prob > f (P = 0.0000), R-squared = 0.89				

Note. Significance level $^{**}P < 0.05$, $^{*}P < 0.1$, $^{***}P < 0.01$.

relationship, and sex of household head, educational status, and wealth of the household were not significant with negative relationships, whereas family size, landholding, livestock, credit access, and extension service were insignificant with a positive relationship regarding the income of *Eucalyptus* production in the study area.

The model in general was significant (P = 0.0000), with a higher value of R2 (0.8932) or 89.32%, indicating that a larger proportion of the variation in the income of the woodlot products is explained by the explanatory variables used in the model. Among the 13 variables included in the model, five, namely, the age of the household heads (P = 0.087), woodlot status (P = 0.080), woodlot size ($P \leq 0.001$), market distance (P = 0.017), and market information (P = 0.091), were found to be significant factors influencing the *Eucalyptus* woodlot production in the study area.

Age of household head was significant at a 10% level, but statistically negative relationship indicated that if the age of household head increased by a unit of years, the income obtained from woodlot products could decrease in the study area. The detailed explanation of this result means that when the age of the household head increased in a certain number of years, they could be more laggard or resistant to confirming new technology, and this result is also consistent with the finding studied by Kebebew [31] The other possible reason for this result could be that older farmers were weaker at cutting the wood and carrying the wood products to the market for sale and had longer planning horizons [32, 33]. However, this result is contrary to Abiyu et al. [16] and Coulibaly-Lingani et al. [34].

Woodlot size of the sampled households was highly significant at the 1% level, with a positive sign indicating that an increase in each unit of woodlot size will result in an increase with households' woodlot production. The brief explanation of this result implies that when the woodlot covers a large area, the amount of wood produced from it could be high, and similarly, the income obtained by selling the wood product could be high.

Woodlot density was significant at a 10% level, with statistically positive relationship with the households' woodlot production. This study indicated that the woodlot

was dense enough to result in a high level of income from the woodlot products. The detailed explanation for this result is straight-forward: as the woodlot density increases, the income obtained from the woodlot product also increases. The implication is that household heads with crowded trees in an occupied area of land produce and sell large amounts of *Eucalyptus* woodlot products to generate a high level of income. The result of this study is in line with Ketsela Hailemicael [15] which revealed that planting density has a positive effect on farmers' income, depending on the site conditions.

Market distance was significant at a 5% level, but there was a statistically negative relationship with the households' woodlot production. It was indicated that by increasing the distance between the market and woodlot production area by a unit of certain kilometres, the level of income obtained from the sale of woodlot products could be decreased in the study area. The implication is that household heads living far apart from the market centre could get low-quality products from the woodlot and provide low-level income obtained from the sale of *Eucalyptus* woodlot products. This result is consistent with Kebebew [14] revealed households that are located far away from accessible roads are less likely to establish and allocate land for eucalyptus woodlots.

Market information was significant at a 10% level and also had statistically positive relationship with the households' woodlot production. Further, the explanation of the result is parallel: as the household head is more informed about the market for woodlot products, the amount of production could be high and also increase income. The implication is that household heads with the closest information about the market for woodlot products produce and sell large amounts of *Eucalyptus* woodlot products to generate a high level of income. The result of this study is in line with Tassou [35], which revealed that access to market information often accelerates the collection or production of NTFPs that can be sold by households.

4. Conclusion and Recommendations

The study was aimed to identify determinants of *Eucalyptus* woodlot production in the study area. The finding of the study indicates that majority of farmers are encouraged to plant *Eucalyptus* because it offers a better source of income. The most popular and well-known *Eucalyptus* product in the study area is construction wood, which also offers a higher income in local markets. For this reason, *Eucalyptus* has long been regarded as a species of saving grace for smallholder farmers in the study area because it raises their standard of living.

To increase the income from *Eucalyptus globulus*, producer farmers should be linked with different wood industries and processing units. *Eucalyptus* products are bulky to transport over long distance by human and animal shoulders to the market. Therefore, any responsible bodies should do on road and market accessibilities not only to increase income of products but also can create new *Eucalyptus* woodlot producer farmers in the study area. In addition to this, government agents should also create short- and long-term training on *Eucalyptus* farming and its market opportunities to escape traditional way of farming woodlots (planting up to harvesting) and way to connect with the market chain.

Further research is required on contribution of food security, environmental impact, and management aspects of this species in the study area.

Data Availability

The data used to support the findings of this study are available from the author upon reasonable request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

Authors' Contributions

The author reads and approves the final manuscript.

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