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Research Article

Contribution of Fuel Wood Income from Natural Forests to Household Economy in Delanta District, Northeastern Ethiopia

Sintayehu Eshetu [1] and Yemiru Tesfaye [2]

[1] Mekdela Amba University, Department of Forestry, College of Agriculture and Natural Resources, Tulu Awuliya, Ethiopia
[2] Hawassa University, Wondo Genet College of Forestry and Natural Resources, Shashemene, Ethiopia

Correspondence should be addressed to Sintayehu Eshetu; sintayehue9@gmail.com

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For Ethiopia's rural homes, particularly those in the Delanta district, fuelwood is the primary energy source. This suggests that the impact of fuel wood from the forest to family energy use or income is significant. The goal of the current study was to estimate how much annual fuel wood harvested from forests contributes to household consumption and monetary income. 96% of the forest's income comes from fuelwood. In the study area, it contributes 2,013,539 Birr, or 33%, of all family income. 703,014 ETB, or 23.8% of the total subsistence income, and 1,310,525 ETB, or 40.65% of the total cash income of the tested households, are both covered by fuelwood from the forest. Both socioeconomic and physical characteristics close to the users influenced how dependent a household was on fuelwood income from the forest. The data obtained from randomly selected households by survey method have been subjected to multiple regression analysis and obtained that households' reliance on fuelwood income from the forest was significantly influenced by factors such as age, educational level, number of trees owned, distance to forest, distance to market, and nonforest income, all of which had a negative and significant impact. The only significant factor that significantly and positively influences reliance on fuelwood income from the forest is the number of family members. Therefore, preserving a natural forest through the use of alternative energy sources, such as electricity, or encouraging a plantation on one's own property is a potential discipline for mandating climate change prevention.

1. Introduction

1.1. Background. One of the fundamental requirements for maintaining human life is energy. However, the majority of residents in rural areas do not have sufficient access to cost-effective and efficient energy sources [1, 2]. The finding of Uhunamure et al. [1] shows around 2.5 billion people utilize charcoal and firewood as their primary sources of energy for cooking and home heating. According to Mhache [3], fuelwood makes up 60–95%, 25–60%, and 5% of the total energy utilized in poor, middle-income, and wealthy nations, respectively. Other conventional biomass, such as animal waste and agricultural waste, are a significant source of energy in developing nations [3]. Energy consumption in underdeveloped nations is defined by a complete reliance on fuel wood for domestic cooking, lighting, and heating due to its significantly lower cost accessibility than most alternative available forms of fuels [1, 4, 5].

In Africa, over 80% of the energy supply comes from wood [6]. Nevertheless, firewood and charcoal are still the main sources of energy from wood in many African countries.

According to Alemayehu Zeleke and Motuma Tolera [7], biomasses such as firewood, leaves, charcoal, animal dung, and electricity are the major sources of energy in rural Ethiopia. This leads 88% and 91% of the households in Ethiopia to depend on firewood as a source of energy for baking and cooking, respectively. Only very few households have access to electricity mainly due to lack of access to modern energy sources and open access to natural forests [8].

Energy consumption patterns of households normally represent status and welfare as well as the stage of economic development [1]. The livelihood of rural people depends entirely or in part on products made from nearby woods, and among all forest resources, fuelwood generates the most income for rural livelihoods [9].

According to Hussain et al. [9], sales of fuelwood and timber account for 52% and 46%, respectively, of the income from wood forest products in rural areas. To reduce forest degradation and fight poverty, it is crucial to understand the economic impact of fuelwood in rural families [6]. However, previous research in Ethiopia has not sufficiently investigated the role that fuel wood plays in the family economy and its consumption habits.

In the Delanta district, there is no numerical value of the area covered by a forest, but the district is surrounded by hilly topographical futures covered by degraded forests, woodland, scrubland, and the scattered trees in pasture and agricultural lands.

The ownership of these areas is government, but most of these areas are open access and naturally regenerated. The forest has different uses for the local households such as fuelwood, fodder, farm machinery, building materials, and other benefits [10]. Even though forest contributes fuelwood for total household energy use, most countries have no clear and reliable assessments on the amount of fuelwood collected from forest [11]. In rural areas of Ethiopia, fuelwood collection from open-access natural forest is a common activity for domestic energy consumption and income generation for households [7, 8]. Therefore, the study's main goal was to look at how fuelwood affects household economics in dry Afromontane forests in the Delanta district in northeastern Ethiopia.

2. Research Methodology

2.1. Description of the Study Area

2.1.1. Location of the Study Area. Delanta district is located in South Wollo Zone, Eastern part of the Amhara region of Ethiopia (Figure 1). Specifically, it is located at 38°40′39″N and 11°20′11″E. The main town and large market destination of this district is Wogeltena located about 98 km away from Dessie (the main town of South Wollo Zone) and 499 km away from Addis Ababa in the northeast direction. Currently, the district has 30 rural kebeles and 3 urban kebeles, totally 33 kebeles (Delanta District Communication Affairs Office, 2021).

2.1.2. Topography. Delanta district lies on 106,017 hectares of land, which is composed of 30% plains, 36.5% rugged terrain, 30.5% rocky land, and 3.5% mountainous land. The northern part of the Delanta district is more of a rugged surface, while the western part is an expanse. The elevation point of the district ranges from 1900–3800 meters above the mean sea level (m.s.l). Delanta district is circumvented by the Bashilo River, which delimits Delanta from the Tenta district and finally flows into the Abay River (Delanta District Communication Affairs Office, 2021).

2.1.3. Climate. Delanta district mainly consists of moist Dega (highland and cold temperate), Woyna Dega (midland and warm to cool semi-humid or warm temperature), and Kolla (lowland and warm-to-hot semiarid) agroclimatic zones and, within a limited area, are Wurch (alpine) climatic zone. The agroclimatic zone of the Delanta district expressed as 26.4% Dega (cool temperature), 41.3% Woyna Dega (mid-altitude), 28.5% Kolla (tropics), and 3.8% Wurch (alpine) climatic conditions. The annual rainfall varies from 614.80–968.7 mm, and the average annual rainfall is 803 mm.

The average annual temperature of Delanta district ranges between 5.9° and 19.11°C. Records obtained show that the maximum temperatures are between 21.2°C and 28°C from January to June and the minimum amount of temperature is 1.6°C–7.1°C from October to December (coldest month) (Delanta District Communication Affairs Office, 2021).

2.1.4. Natural Vegetation. The spatial distribution of natural vegetation depends on many factors. Among these factors are topography, climate, drainage pattern, and soil types are the most ones. Vegetation cover is low in Delanta district because of the long history of agriculture and high population. Woody vegetation in the district constitutes degraded forests, woodland, scrubland, and scattered trees on agricultural lands. The degraded forests are found in the northern part of the district where the forest has now dwindled to small patches of less than 1500 hectares. The commonly observed remaining tree species in the forest are *Acacia*, *Juniper*, Hagenia, *Eucalyptus*, and *Cordia* [10].

The scrubland consists of low shrubs mixed with grasses and herbs. Moreover, remnant trees are observed throughout the district, mostly scattered in the cultivated landscape of low altitude [10]. The resources have no scientific plan. Even if there is a requirement to study the area covered by the forest, there is no forest resource assessment in the randomly selected three sample kebeles. Also, I was never sure about the area of the forest in the study kebeles due to lack of budget and time to accomplish this project.

2.1.5. Demographic Features. According to CSA [12], the total population of the district is 149,882, of which 72,701 (50.5%) are males and 71,181 (49.5%) are females. Delanta has a high rate of population growth that has caused crowded populations to settle over scarce land [10].

2.1.6. Economic Activities. Agriculture is the dominant economic activity in the study area. About 97% of the total district population is engaged in the agriculture sector. Delanta district is a producer of various highland legumes and oil seeds. The district is a surplus producer and supplier of lentils, peas, chickpeas, beans, and the like. Major growing crops are barley, wheat, beans, lentils, Teff, wheat, maize, oats, and sorghum.

The most important livestock of the district include cattle, sheep, goats, equines (horses, mules, and donkeys), chickens, and honey bees. The livestock resource of the district is mainly indigenous, and they serve for the sources of power for plowing, transportation, milk and meat production, hide and skin production, and fuel manure

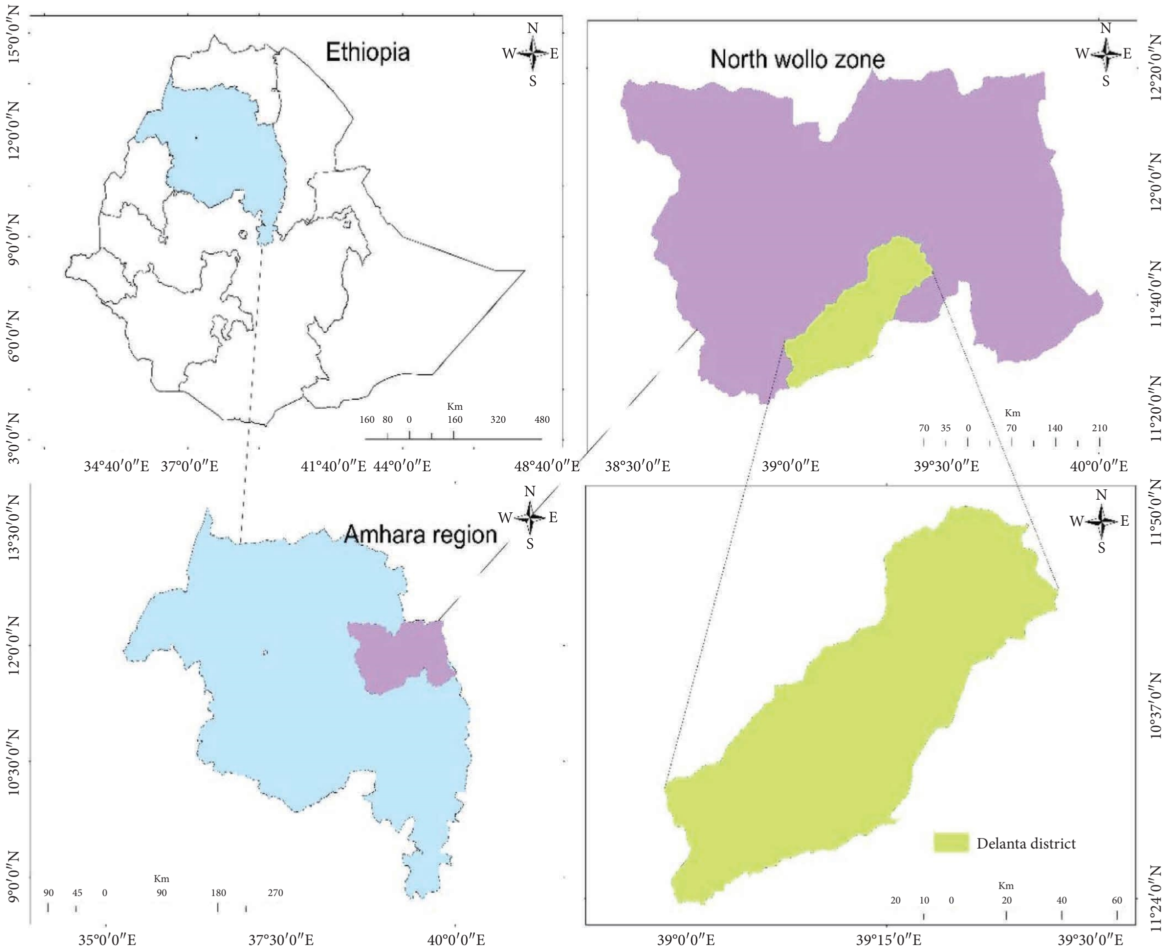

Figure 1: Map of the study area.

production (Delanta District Communication Affairs Office, 2021).

Moreover, a considerable amount of cash income is also generated from other activities, such as fuelwood production, traditional opal mining, daily wage labor, and trading. Selling fuelwood is also a widespread and relatively common activity in the study area.

2.1.7. Energy Sources. In the district, traditional biomasses such as fuelwood and animal dung are the major sources of energy for both rural and urban households. Modern sources of energy such as electricity are still insufficient in both availability and affordability. Only four kebeles and three kebeles from rural and urban kebeles of the district, respectively, have electricity for a total of 33 kebeles. This leads the community to use traditional biomass such as fuelwood and animal dung for domestic energy in the district. This indicates that it is important to explore the country's potential energy sources to avail an adequate supply of energy to the society.

Connecting all kebeles to the electricity grid generated from hydropower has been difficult because of the geographical topography of the country, making it extremely costly to distribute to remote areas. Based on this situation, the extraction of firewood and the production of charcoal from montane forests to fulfill the energy requirement have a direct implication on land degradation.

2.2. Sampling Technique and Sample Size. Delanta district was selected for the study as it is identified as one of the areas with forest resources in the zone where there is significant forest and land degradation. The sampling procedure followed for this study was multistage sampling. Accordingly, first, out of 33 total kebeles in Delanta district, three kebeles, namely, Mesnoamba (01), Goshmeda (019), and Mistinkir kebeles (018), were randomly selected.

The respondents of this study were rural households who extracted fuel wood for energy availability from the surrounding forest. Therefore, sample households in each village were randomly selected. The total sample size was determined by using formula [13] (equation (1)). The reason to use this formula is the total number of households is finite, and the budget required to accomplish the direct field measurement for fuel consumption and sale was none. So, this formula was attempted to take a small sample size from a large finite population. The required sample from each kebele was determined proportionally and described in Table 1.

Table 1: Number of households sampled from kebeles.

Study kebele	Number of households	Required sample size	Sample proportion (%)
01	461	38	30
018	553	48	38
019	438	40	32
Total	1452	126	100

Source: own survey 2021.

$$\mathbf{n} = \frac{\mathbf{Z^2 pqN}}{\mathbf{e^2 (N-1) + Z^2 pq}}, \quad (1)$$

where n = the required sample size, $p = 0.1$ that is 10% population reliability (for frequency estimated for a sample size of n); $q = 1 - p\ (1 - 0.1) = 0.9$; $N = 1452$, which is the total number of households in targeted kebeles; Z = standard error corresponding to 95% confidence interval, which is 1.96; and e = the margin of error that the researcher tolerates, which is (0.05) or the degree of accuracy desired.

So, $n = (1.96)^2 * 0.1 * 0.9 * 1452/((0.05)^2 * (1452 - 1)) + ((1.96)^2 * 0.9 * 0.1) = 126$ households.

2.3. Sources of Data. To achieve the objective of the study, the researchers used both primary and secondary sources of data. Primary data were collected from household surveys, key informant interviews, focus group discussions, and direct measurements. Secondary data were collected from other sources such as books and journals from the Internet, Delanta district government documents, and Delanta District Communication Affairs Office.

2.3.1. Household Survey. To gather information on the fuel sources that are available, the economic activities that take place in households, and the value that each activity adds to the household economy, a structured questionnaire was created. A total of 26 closed-ended (single response) and open-ended (many responses) questionnaires were created. The household heads who were chosen at random received orientations prior to the administration of the surveys. For the respondents, questionnaires were written in English and translated into Amharic.

A questionnaire with three sections—household characteristics, income from agricultural operations, and income from the nearby forest—was created with the study's goal in mind.

The questionnaire's part on household characteristics assisted in gathering information on the distribution of sexes and ages in the family, the educational attainment of family heads, the size of the home, the status of the household's members in terms of their education, and other topics.

To determine the sources of income for each individual household, many procedures, including agricultural ones, have been devised. At the time of the field survey, details about the household's collection of forest products from the forest were listed.

In this situation, we might evaluate the family economy's income contribution from the sale of fuel woods harvested from forests. Additionally, we determined how much fuel wood each home sells each year to generate income.

2.3.2. Key Informant Interview. In this study, key informants are considered as persons who are knowledgeable about fuelwood extraction from the forest, who know the economic contribution of fuelwood to the household economy, and who continuously lived for a long period of time in the community. They were selected by the snowball method [14]. Those who participated in the interview were developmental agencies (DAs), special women, and household heads that harvest fuelwood mainly from open-access forests to understand the person's insights, feelings, thoughts, and opinions. Thirteen structured interviews were prepared to gather data from interviewees.

2.3.3. Focus Group Discussion. Focus group discussions (FGDs) were conducted with interested group members in each kebele. The purpose of FGD was to get detailed evidence from different groups of people about the reliance on fuelwood income from the wooded area. The major focus group discussion members were the Agricultural Development Agency (DA), kebele administrative, and the households that commonly produce charcoal and firewood to get detailed information from different groups of communities about the fuelwood production in the study area. The participants in the focus group discussions comprised 4-5 HHs in each kebele. The focus group discussion was handled using the prepared checklist, which holds around six questions.

2.3.4. Direct Measurement of Available Fuels. The amount of fuel consumed and sold during a seven-day period was calculated using the weight survey method [15–17]. This measurement was taken by an instrument called spring balance employed by the authors of [15, 17].

The respondents selected readily available fuels as being utilized every day, and each fuel type (wood, crop residues, dung, charcoal, and kerosene) was measured physically and recorded separately. Weighed and left at each sample home were the rough estimates of the daily fuelwood needs for each household made by the respondents. Households were instructed throughout this exercise to only consume or burn fuelwood from the weighted bundles and sacks according to their separate sources of fuelwood (their own, the forest, and the market). The weight of the bundles or sacks delivered by various sources was subtracted from the weight of the residual fuelwood the next day to determine the amount of fuelwood used [11, 18].

Respondents were requested to arrange fuelwood for dimensions comparable to those utilized on the preceding day of sale to estimate the daily sale of fuelwood per household within a week. As a result, the identified bundle of wood was weighed or measured using a spring balance before being recorded on the datasheet. Other fuels, such as animal dung for consumption and selling, were also weighted and recorded individually according to the same methodology as above and as indicated by the respondents during the interview. Kerosene usage was calculated in liters for each household. Typically, the weight of fuelwood used for one week was multiplied by 52, the number of weeks in a year [19], to determine the yearly fuelwood consumption.

2.4. Methods of Data Analysis

2.4.1. Household Survey Data Analysis. Data gathered for the study were analyzed through qualitative and quantitative methods. The data obtained from the household surveys and direct measurements were organized and analyzed by descriptive statistics, such as frequency, percentages, mean, and standard deviation, which is used to analyze different socioeconomic situations. Qualitative data obtained through interviews, personal observations, and via focus group discussions were analyzed and described in the form of narration by sorting grouping views and concepts. The data were analyzed by using [20] and STATA version 14.2.

2.4.2. Income of Fuel for Consumption and Sale. In February, March, and April 2021, measurements of fuels for sale and consumption were made. Weighing solid fuels is a crucial factor to take into account when measuring fuel because it allows for an accurate calculation of consumption [21, 22]. Weight measurement was a more practical way to determine the solid volume because it is quicker and easier to calculate the weight of a bundle of crop residue, animal dung, or wood using a spring balance than it is to calculate the gross weight of a headload of irregularly shaped fuelwood [23].

The annual amount of each energy source (fuels) and the reported price of each energy source (fuels) by household and market survey were multiplied to determine the income of each energy source available to the households. The average of the mean value of the reported prices by the respondents and market survey was taken as the price of all forest and nonforest products.

2.4.3. Household Income Sources. In this research, the relative fuelwood income from the forest means the income, which was contributed by fuelwood like firewood and charcoal extracted from the forest. Also, the income from forest products comprises the sale of farm equipment, forage, and timber for houses. This technique is comparable to that of [24]. Crops, woodlots, and fruits made up agricultural products, which were sources of agricultural income. The value of domestically consumed livestock products and the sale of animals are both included in the income from livestock. In the current study, we calculated the proportion of products sold in marketplaces and consumed by households. Products used at home were valued at what they would have cost in the local town at retail. We used the price of replacements in cases where the market price was unavailable [25].

2.4.4. Income Computation. According to Pokhriyal et al. [26]'s methodology, all sources of income were included in the computation of income (equation (2)). All incomes were converted into Ethiopian Birr to account for it. The calculations made to determine the annual household income are as follows:

$$(\text{Forest income} + \text{agricultural crop income} + \text{livestock income} + \text{off-farm income}) = \text{total annual family income}. \tag{2}$$

Total annual household income was determined by the following equation:

$$\mathrm{A}_{\mathrm{tincome}} = \sum_{t=1}^{n} \mathrm{Xi}, \tag{3}$$

where A_{tincome} is the annualized total household income, and Xi is the source-specific income. We took into account the existence of loans from each responder when calculating total annual income. This reduces the loan's impact on the household's overall income. This approach is based on the approach used by Hlaing et al. [27].

The research area's collected forest resources included fuelwood, wood for buildings, construction, feed, and tools for farming. By multiplying the amounts with the current market values for each product and adding them up, the income from forest goods (firewood per kilogram, wood for dwellings, buildings, and feed per human load, and agricultural implements per number) is calculated by the following equation:

$$\text{Total forest income} = \sum (\text{fuelwood income} + \text{income of other forest product}). \tag{4}$$

According to weight survey methodologies, the annual amount of fuelwood is used to compute the fuelwood income from the forest [15]. For the purpose of determining fuelwood income for sustaining life and generating money, the measured amounts and reported prices of fuelwood used and sold by each household were used. Therefore, the annual amount of fuelwood, which includes firewood and charcoal, and the reported price of the fuelwood were simply multiplied by the households to determine the fuelwood income.

As long as the household could remember, all non-fuelwood product categories that were gathered and consumed in each HH were observed, and their quantities were noted. The research of [9, 25, 28, 29] and [27] used a methodology similar to this one. The physical quantities and value estimates provided by the household itself, along with the current local market values, were utilized. The amount of each product that was annually harvested, gathered, utilized, and sold, as well as the cash proceeds from sales, was reported by respondents (equation (5)).

The majority of current techniques for calculating a household's reliance on fuelwood income from the forest rely on translating the measured fuelwood into monetary values and comparing them to the total household income.

$$\begin{aligned}\text{Agricultural crop income} = \sum(&\text{wheat income} + \text{barley income} + \text{teff income} + \text{beans income}\\ &+ \text{lentils income} + \text{sorghum income} + \text{onion income} + \text{income from own plantation}\\ &+ \text{maize income} + \text{income from own plantation} + \text{income from grass}).\end{aligned} \tag{5}$$

It contains farming of crops for both household consumption and sale. A household survey was used to gather information on agricultural yields from the relevant households, and the local market was used to determine crop prices. To be included in this component, the income from private plantations and woodlots is also gathered and measured.

When households were recalled for a year, the total income generated from consumed and sold cattle and their products was added up (equation (6)). While the income from sold livestock was also computed as cash income by adding all sold livestock in a year's time using the recall method, the livestock that was consumed in the family was calculated as a subsistence income by adding its proportionate estimated price. The annual income of livestock earned from sold and utilized animal feces, including hired labor, feed, and veterinary bills, was also taken into account in this example.

$$\begin{aligned}\text{Livestock income} = \sum(&\text{goat's income} + \text{sheep income} + \text{bull's income} + \text{cow's income} + \text{hen's income}\\ &+ \text{honey income} + \text{horse's income} + \text{income of animal dung} + \text{income from dairy production}),\end{aligned} \tag{6}$$

$$Off-farm\,income = \sum(\text{businessman income} + \text{government servant income} + \text{daily wage labor income}). \tag{7}$$

Salaries from private employment and pensions for the elderly are included in daily wage labor. Interviews with the interviewees also yielded information about company income and salaried government employment.

2.4.5. Contribution of Fuel Wood from the Forest to the Household Economy. Data on the price of selling fuelwood should be obtained from key informants within a week since the amount of income from selling fuelwood was approximated in this study by adding up each participant's daily income over the course of a week. The income from the amount of fuelwood consumed by each household was added up to determine the subsistence income from fuelwood. Therefore, the amount of the cash and fuelwood used for subsistence is the total income from the forest in terms of fuelwood.

2.4.6. Determinants of Households' Dependence on Fuelwood Income from Forest. Dependency on fuelwood income from the forest is expressed as a proportion of total annual household income (equation (8)) or as a percentage of it. This demonstrates how heavily households rely on the sale of fuelwood obtained from the forest.

$$\text{Dependency on fuelwood income} = \text{income of fuelwood from forest} \div \text{total household income} * 100, \tag{8}$$

where the whole earnings from fuelwood harvested from the forest are referred to as fuelwood income.

As a set of tools for analyzing the linear relationships between two or more variables, multiple regression analysis was chosen. In this study, dependence fuelwood income from the forest serves as the dependent variable, and the independent variables are sex, age, education, household head status, family size, land size, proximity to the forest, number of trees owned, proximity to the market, and household income derived from sources other than the forest.

A statistical method for examining the factors that influence a household's reliance on fuel wood from forested areas is regression analysis. The relationship is assumed to take on a broad shape known as the multiple regression model [30].

$$Y = \alpha + \beta 1X1 +, \ldots, + \beta kXk + \varepsilon. \tag{9}$$

Equation of multiple regression α is the intercept, $\beta 1$ is the vector of the estimated coefficient of the explanatory variable, and Y is the dependent variable (households' dependence on fuelwood that takes from the percentage of fuelwood income from the forest to the total household income), while $X1, \ldots, Xk$ are the explanatory variables or the independent variables (sex, age, education level, land size, family size, distances from the forest, number of tree owned, distance from the market, and nonforest income). There is no wealth classification in this study because each criterion used for deciding the wealth status of a community such as land size and nonforest income (agriculture income, off-farm income, and livestock income) has different influences on dependency on fuel wood income from open-access natural forest.

2.4.7. Variable Selection Rationale. Major factors that determine the households' dependency on fuelwood income from the forest include age, sex, educational status, household size, land size owned, distances to market, distances to forest, number of tree owned, and nonforest income (Table 2).

3. Results and Discussion

3.1. Demographic and Socioeconomic Characteristics of Sample Households

3.1.1. Household Characteristics. According to Table 3, approximately 23.81% of the 126 household heads that were sampled were females. The minimum, maximum, and average compositions of the respondents were 22, 85, and 47 years old, respectively. Of the homes, 5.56 percent were single, and 66.67% were married; the remaining 15.08 percent were divorced, and 12.70 percent were widowed. Additionally, one-third of the families have a single head that is single, divorced, or widowed. There were two family members as the lowest, eight as the maximum, and four as the average. 59% of the sampled families were illiterate, indicating a low level of education in the area. The majority of respondents (59.52%) were illiterate. In the sample, women head about 25% of the families. The entire demographical features of households subjected to categorical variable are summarized in Table 3.

3.1.2. Landholding Size. There are not many land assets in the research area. A total of 122 respondents (96.86%) have their own land, ranging in size from 0 to 2.5 ha. Four (3.14%) of the farmers share rents with people who own land to carry out their farming activities.

3.1.3. Number of Own Trees. Even though land size is scarce in the study area, trees from private lands, woodlots, roadsides, and gardens are also income sources of households. That 92.86% of the respondents have a private plantation used for house construction, fuelwood sales, and agroforestry practices. The mean, standard deviation, minimum, and maximum value of continuous variable concerning the sampled households including landholding size and number of tree owned are shortly described in Table 4.

3.1.4. Family Members Involved in Fuelwood Collection. The respondents revealed that both male and female household members are responsible for collecting fuelwood. As a result, 35% of respondents said that mothers and daughters are the main people that regularly get firewood from forests.

However, according to 32% of respondents, dads and boys are also the main producers and transporters of charcoal and firewood in order to generate monetary income. The remaining 33% of respondents said that both male and female respondents, regardless of income level, were in charge of producing income by gathering and selling fuelwood from the forest in addition to providing the household's energy needs. However, cooking and making energy-saving decisions are regarded as feminine domains.

3.2. Cash and Subsistence Income of Different Energy Sources.

Figure 2 also explains how to calculate the total annual income of the quantified energy sources. Knowing the income contribution of each distinct energy source as a cash income and a means of subsistence is necessary to calculate the income of each energy source. Because the cost of energy sources per unit varies depending on quality, income comparison is a fundamental metric for evaluating the effectiveness and quality of the energy sources that are now accessible. This study compares the income from various fuels (energy sources) for both subsistence use and cash when they are accessible in the study location.

For the households in the sample, the total annual cash income from firewood and charcoal from the forest is 985,135 Birr and 325,390 Birr, respectively. In contrast, the biggest annual cash income per household from nonforest sources comes from charcoal (77,480 Birr), which is followed by firewood (22,854 Birr) and animal dung (17,056 Birr). In case of subsistence income, the biggest value of energy sources is firewood from the forest with a total annual income of 686,712 Birr. This is followed by animal dung (290,149.6 Birr), nonforest firewood (141,258 Birr), and forest-derived charcoal (16,302 Birr). This indicates that charcoal is produced mainly for cash income generation. Therefore, firewood from the forest is the largest contributor of income as a cash and subsistence use.

3.3. Economic Activity of Households

3.3.1. Annual Income from Different Forest Products. Here, we examine how these fundamental requirements are met by each of the forest products through field research,

Table 2: Description of explanatory variables included in the regression model.

Variable	Type of variable	Measurement	Sign of expectation	Citation
Age	Continuous	Year	−	[31]
Sex	Dummy	1 = male & 0 = female	+	[32]
Educational status	Dummy	1 = unable to read and write 2 = able to read and write 3 = primary school 4 = high school and preparatory	−	[33]
Household size	Continuous	Number	+	[9, 34]
Land size own	Continuous	Hectare (ha)	−	[9]
Distance to forest	Continuous	Kilometer (km)	−	[9, 28]
Distance to market	Continuous	Kilometer (km)	−	[7]
Number of tree owned	Continuous	Number	−	[35]
Nonforest income	Continuous	Ethiopian Birr (ETB)	−	[28, 32, 34]

Table 3: Summary statistics of categorical variables.

Variable	Frequency	Percent (%)
Sex		
Male	95	76.19
Female	31	23.81
Educational status		
Unable to read and write	75	59.52
Able to read and write	23	18.25
Primary school	22	17.46
High school	6	4.76

Source: own survey, 2021.

Table 4: Summary statistics of continuous variables.

Variable	Obs.	Mean	Std. dev.	Minimum	Maximum
Age	126	47.75	13.08	22	85
Number of family members	126	4	1.45	1	8
Land size owned (ha)	126	0.72	0.64	0	2.5
Number of tree owned	126	42	48.65	0	320
Distance to forest (km)	126	4.83	2.17	1.5	10
Distance to market (km)	126	7.41	2.23	1.5	13
Annual income of agriculture (ETB)	126	17924.23	14272.07	0	105650
Annual forest income	126	16592.77	10810.88	225	46865
Annual income of livestock	126	12868	6265	1528.6	34943.4
Annual income of off-farm	126	1408.333	2435	0	10000

Source: own survey 2021.

HH interviews, and key informant interviews. The study's findings demonstrate the vital significance that the natural forest in the Delanta area plays in the livelihood of rural communities by providing the primary source of income for rural households. To varying degrees, the local populations in the Delanta district rely on the extraction of forest resources for their subsistence.

Households in the study region gather and use forest goods, such as farm implements, fuelwood, feed, and building materials. While forests produce a variety of nontimber forest products, such as fuelwood, fodder, building materials, traditional medicine, honey, fruit, food, and farm instruments, the northeastern region of Ethiopia is primarily covered by the dry Afromontane ecosystem, these species include *Eucalyptus globulus*, *E. camaldulensis*, *Carissa spinarum*, *Olea europaea* ssp., *Cuspidata Rhu*, *glutinosa* ssp., *Ficus palmate*, *Ficus vasta*, *Rubus apetalus*, *Croton macrostachyus*, *Juniperus procera*, and *Olea europaea* ssp. *cuspidate* [36], which only contributes to the products that we have studied in this research [32, 37].

The order of percentages of forest income derived from agricultural instruments, charcoal, fence and building materials, and firewood is 3%, 0.05%, 80%, and 16%. Due to its easy access from the study area's natural forest, firewood accounts for the largest portion of the forest's income and serves as the community's major source of energy for cooking and heating. The findings show that firewood, which accounts for 80% of the forest's overall income, is by far the most significant product removed from it. This result is in line with that of Adanech Asfaw et al. [32], who demonstrate that fuelwood is a key product that accounts for 80% of forest income.

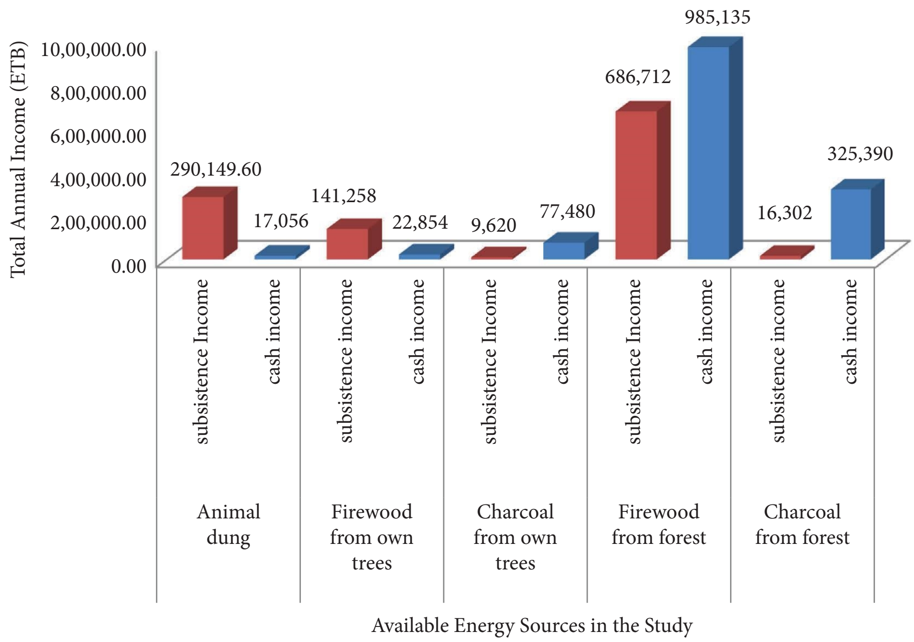

Figure 2: Comparison between incomes of energy sources.

Table 5 shows the variety of forest products that HHs gather and how much each one contributes to the annual income needed for various daily necessities. The findings indicate that the aggregate yearly earnings from farm equipment, feed, fence, and fuelwood—that is, firewood and charcoal—were 15950, 58175, 2025, 1671847, and 341692 Birr, in that order. Charcoal and firewood are the two forest resources that give rural livelihoods the most income.

These findings demonstrate that fuelwood extraction dominates rural lifestyles compared to other forest products since fuelwood is the most lucrative, cash-contributing, and subsistence-useful forest commodity.

3.3.2. Cash Income and Subsistence Use of Forest. Trees and shrubs are utilized as various building materials and fences in the study area. The floor, walls, poles, rafters, beams, roofing, and other components of the homes were made of these materials. Because they are only somewhat functional, fences and thatch only generate a subsistence income. The majority of the forest is mountainous and slopes steeply, making it challenging to transport poles and timber. For traditional dwellings, woodland thatches were employed as building materials.

When taken out of the natural forest, fodder provides the community with both monetary and subsistence income. Additionally, little wood is gathered for the purpose of constructing or fixing agricultural cultivation implements, including plows, harrows, yokes, and handles (Figure 3).

This outcome is consistent with research by Ali et al. [28], Hussain et al. [9], and Zeb et al. [38], demonstrating that forests are a significant source of agricultural instruments. Because of the economic worth of forest products, people relied more on the fuel wood from them to generate income than on direct consumption. The results of this investigation are consistent with those of Babulo et al. [37].

3.3.3. Major Sources of Income for the Household. The annual average income of households from all major sources of rural livelihood in the district is presented in Table 6. The annual income from forests, resources, agricultural products, livestock, and off-farm activities contributed 34%, 37%, 26%, and 3%, respectively. The mean annual income per household from agriculture products and forest products was 17924.23 and 16584.45 Birr, respectively. According to the study, kebeles, the income from these sources is significantly higher than that from other sources. Additionally, the overall mean annual income from livestock was 12868 Birr, or 26% of the total household income, and the mean annual income from off-farm activities was 1,408.333 Birr.

In general, the total annual income was 6,147,960 Birr, with an average household income of 47,674.6 Birr.

3.3.4. Relative Contribution of Fuelwood from Forest for Household Economy. The forest produced 2,013,539 Birr in fuelwood, which accounted for 33% of the household's total income. When compared to other income sources discovered in this study, which revealed that the NTFPs contributed significantly to the total household income in Ethiopia, the total income of fuelwood, or firewood and charcoal, was relatively high [39]. All kebele leaders, respondents, experts, developmental agencies, and key informants concurred that HHs in the low-income category had the largest fuelwood from forest income contribution to total income (Figure 4). The following authors [9, 37, 40] have also validated these findings.

As a result, low-income households rely increasingly on forest resources. This is mostly due to the HHs' lack of access

Table 5: Summary of statistics for income of forest products.

Variable	Obs.	Mean	Std. dev.	Min	Max	Relative contribution (%)
Income of farm instrument	126	126.5873	141.1618	0	730	1
Income from fodder	126	461.7063	539.7007	0	2600	3
Income from fence and thatch	126	16.07143	30.72203	0	225	0
Income from firewood	126	13268.63	9746.898	0	45760	80
Income from charcoal	126	2711.841	3504.625	0	17680	16

Source: own survey 2021.

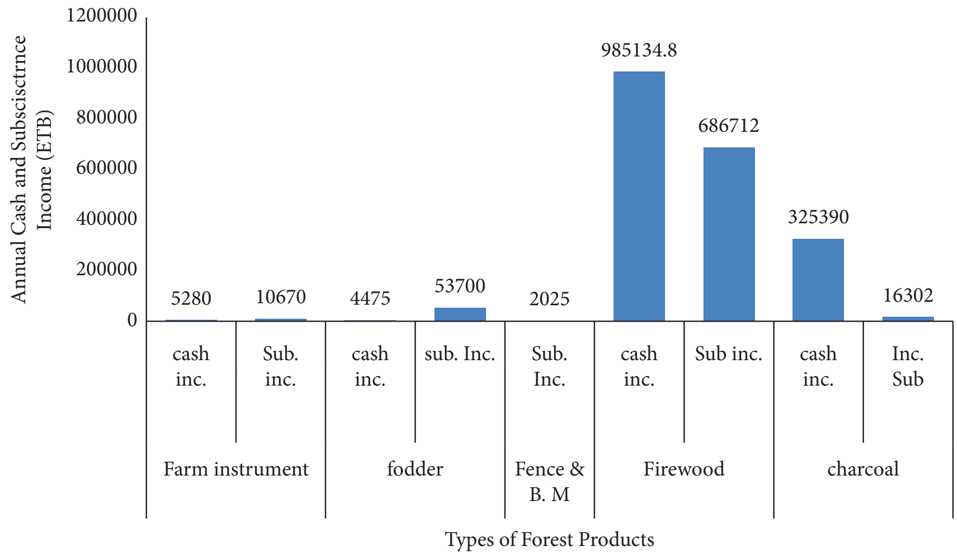

Figure 3: Cash and subsistence income of the forest.

Table 6: Summary of sources of income for the household.

Variable	Obs	Mean	Std. dev.	Min	Max
Forest income	126	16584.83	10819.45	225	46865
Income of agriculture	126	17924.23	14272.07	0	105650
Income of livestock	126	12868	6265.036	1528.6	34943.38
Income of farm	126	1408.333	2435.034	0	10000
Total income of HH	126	47674.6	19606.54	12331.56	138243.5

Source: own survey 2021.

to alternate sources of income, which exacerbates their poverty and may play a significant role in the communities' heavy reliance on forest goods.

3.3.5. Contribution of Fuelwood from Forest to the Subsistence and Cash Income of HHs. Because they gather all biomass fuels from both forested and nonforest sources, every survey participant stated that they have never bought the energy sources used for cooking and heating. Table 7 shows how fuelwood from the forest helps households generate financial income in addition to sustaining themselves. For both monetary and subsistence use, the forest produced a total of 703,014 and 1,310,524.8 ETB of fuelwood annually, respectively. Based on the monetary worth of fuelwood from the forest, people relied on it more than 0.86 times for their cash generation than for their direct use.

3.4. Determinants of Households' Dependence on Fuelwood Income from Forest. The definition and measurement of dependency on fuelwood income from the forest are based on overlapping categories, such as the production and extraction of fuelwood from the forest for the provision of cash and subsistence income to the household. The fuelwood (firewood and charcoal) net income (cash income) and the fuelwood (firewood and charcoal) collected by households, which are typically used to meet their basic needs like subsistence income, are the two main sources of fuelwood dependence on income in this study.

Regression analysis reveals that households' reliance on fuelwood income from forests is determined by a number of underlying factors, including age, sex, educational attainment, family size, distance to the market, distance to the

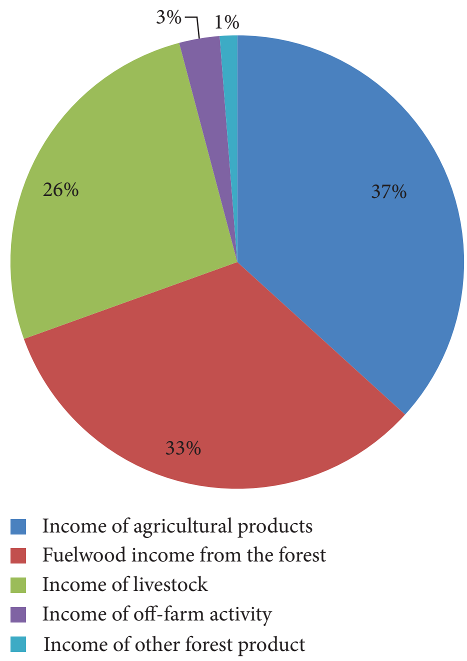

Figure 4: Relative contribution of fuel wood for household economy.

Table 7: Household activities and their annual contribution to subsistence use and cash generation.

Sources of income	Annual amount of subsistence income/ETB	Relative contribution for subsistence income (%)	Annual amount of cash income/ETB	Relative contribution for cash income (%)
Forest fuelwood	703014	23.80	1310524.8	40.65
Other forest product	66395	2.25	9755	0.30
Livestock	896403	30.35	754905	23.42
Agricultural product	1287457	43.59	970996	30.12
Off-farm activity	0	0	177450	5.50
Total	2953268.843	100	3223631.04	100

Source: own survey (2021).

forest, land size owned, number of trees owned, and non-forest income.

The findings of the multiple linear regression analysis (Table 8) indicated that the following factors were found to be significant predictors of dependence on fuelwood income from the forest: age, family size, educational attainment, and distance to the market, number of trees owned, and income from sources other than the forest. Positively correlated estimated regression coefficients with the dependent variable suggest a direct positive relationship between them. Conversely, it was suggested by the predicted regression coefficients with negative signs that they had a tangential relationship with the dependent variable. The coefficient of multiple determinations was strong, as indicated by the double-log total result (0.7469). A greater R^2 indicates a better fit between the model and the collected data. The formula goes on to show that 74.69% of the variables that have been examined have an impact on the reliance on fuelwood income from the forest.

There is no multicollinearity issue with the independent variable, according to the multicollinearity test for continuous and dummy variables using the variance of the inflating factor (VIF) and the contingency coefficient. The results of the Breusch-Pagan/Cook-Weisberg heteroscedasticity test show that the model is heteroscedasticity-free.

3.4.1. Age. At $p < 0.01$, age showed a statistically significant and adverse correlation with reliance on fuelwood income from the forest. The oldest respondents appear to be less reliant on forest fuelwood, based on the age-related negative coefficient. The following authors [6, 9, 34, 41, 42] have also corroborated these findings. Because they are willing to explore economic opportunities in cities to secure a bright future, younger household heads are therefore more reliant on forest resources than their older counterparts. In a similar vein, the research conducted in 2013 by Fonta and Ayuk outlines the necessity of significant physical power and a large workforce for forest extraction activities.

3.4.2. Educational Status. At $p < 0.05$, the household head's educational background has a statistically significant negative relationship with their reliance on fuelwood income from the forest. Similar studies conducted in 2017 by Hlaing

Table 8: Results of regression model for dependency on fuelwood income from the forest.

Independent factors	Coefficient	Standard error	T	Significance
Constant	86.87571	5.842047	14.87	0.000
Age	−0.23173	0.089644	−2.58	0.011**
Sex	0.77981	2.37242	0.33	0.743
Educational status	−3.59055	1.050582	−3.42	0.001***
Number of family members	1.57467	0.65253	2.41	0.017**
Land size owned	0.439922	1.949995	0.23	0.822
Distance to forest	−1.66472	0.518441	−3.21	0.002***
Distance to market	−2.68794	0.508229	−5.29	0.000***
Number of trees owned	−0.10047	0.024053	−4.18	0.000***
Nonforest income	−0.00036	$6.45E^{-5}$	−5.58	0.000***

Number of obs = 126, Prob > F = 0.0000, R-squared = 0.7469, Adj R-squared = 0.7272, F = 38.03, ** and *** the level of significance at 5% and 1%, respectively.

et al. and 2014 by Baiyegunhi and Hassan explain why this is the case: Educated people are less likely to engage in activities that rely on the forest because they can afford more modern lifestyles, such as cooking with electricity or gas stoves or solar energy. They also take their attention away from farming and other subsistence pursuits.

Because of their greater future chances outside of the forest, persons with advanced formal education prioritize using fewer forest resources than people with informal education [2, 5, 9]. Additionally, they possess a solid awareness of indoor air pollution and the health risks associated with fuel wood consumption in homes.

3.4.3. Number of Family Members. The number of family members was statistically significant and had a positive connection at $p < 0.01$. This is consistent with a previous prediction. Household size is substantially connected with dependency on fuel wood income from the forest since larger families use and sell more forest biomass for domestic energy sources [9, 34, 39, 43].

Because there are more home workers available, a greater number of family members undoubtedly take more fuelwood from the forest resources. The following authors [3, 28, 31] have also validated these findings. Large families thus depend increasingly on forest goods to meet their basic needs due to the increase in the unemployment rate and increased subsistence needs in areas bordering on forests.

3.4.4. Distance to Forest. Distance to the forest has a negative and significant association with dependency on fuelwood income from the forest resource at $p < 0.01$. Nearer households to the forest have a chance more likely to collect fuelwood from the forest, while they have a lower probability of purchasing or obtaining biomass fuels from their farmlands. This is consistent with the study by Rahut et al. [31] and Hussain et al. [9] where fuelwood production and consumption patterns depend on the ease of fuelwood collection.

Women are mostly in charge of gathering firewood, and thus, it is challenging for them to go large distances to the forest because it takes a lot of time and energy away from their extensive to-do list of other home duties. Therefore, to meet their energy needs, people who lived further away from the forest used firewood mixed with cattle dung more often than people who lived in or close to the forest. This is consistent with research by [44]. In this case, there is no consideration of cost for the people that goes a large distance to meet the fuel woods because all households can cover the trip towards and forwards of the forest area with a time of less than one day, and there is no extra cost.

3.4.5. Distance to Market. At $p < 0.01$, market distance significantly and negatively correlates with reliance on fuelwood income from the forest resource. Alemayehu Zeleke and Motuma Tolera [7] assert that the cost and availability of fuelwood have a big impact on how much fuelwood is used in each household. Thus, the primary factor reducing fuel wood income and consumption is distance from the market. In addition, homes located far from markets tend to extract only what they require for personal use. However, every rural region in this research area is separated from the district center by a distinct distance and is encircled by a steep topographical feature with open-access forests.

3.4.6. Number of Trees Owned. The number of trees possessed is significantly and negatively correlated with reliance on fuelwood income from the forest resource ($p < 0.05$). When the number of trees owned on private property increases by one, the household's reliance on fuelwood income from the forest declines by 0.10047%, according to the coefficient −0.10047. Every important respondent, development facilitator, and agricultural specialist concurs that homes with more trees in their home gardens, woodlots, and roadside plantings are better equipped to gather fuelwood from their own property to meet their firewood requirements. These include *Eucalyptus globules*, *Eucalyptus camaldulensis*, *Cordia africana*, *Olea africana*, *Cupressus lusitanica*, and other types of species. Also, free is this firewood. It is true that the amount of consumption is influenced by the availability of energy sources. That being said, not every home will necessarily experience this.

Furthermore, significant factors are the types of tree, age, and production [43, 45, 46]. A natural reaction to the increasing scarcity of fuel wood is to plant trees that grow quickly [23].

3.4.7. Nonforest Income. This aligns with an earlier hypothesis that the research demonstrated a statistically significant negative correlation between nonforest income and $p < 0.01$. The money received from livestock, agricultural crops, and off-farm pursuits is categorized as nonforest income. The coefficient of −0.00036 indicates that for every one Birr rise in nonforest income, the household's reliance on fuelwood income from the forest declines by 0.00036. Income from agriculture has a detrimental impact on a household's reliance on fuel wood from the forest because, as income rises, the household uses less contemporary energy sources. Refs. [9, 34, 42] have also validated these findings.

According to Baral et al. [34], respondents with higher livestock incomes are less reliant on fuelwood income from forest resources. This is because livestock income reduces reliance on fuelwood income from the forest. A rise in off-farm income reduces reliance on fuelwood income from the forest because individuals with more successful off-farm ventures rely less on fuelwood income from the forest because they make more money from other sources, which may divert the neighborhood from forest collection operations [9].

4. Conclusion

According to the results of a study on the reliance on fuelwood income from the forest, fuelwood is the most significant and largest product of open-access natural forests, used to raise household living standards through subsistence and financial use. We also looked at how, to varied degrees, all income groups in rural regions rely on fuel wood from the forest because it is a more desirable energy source than other conventional energy sources. The income from fuelwood is essential to the daily lives of the local households, accounting for 96% of the forest's income.

With 34% of total household income, forest income is the second-largest income share. Fuelwood from the forest covers a relative contribution of 33% of the total income and 40.65% of the total annual cash income of the sampled households. This study also examined the determinants of dependency on fuelwood income from forest for the rural community through the OLS regression model. Based on the model, age, educational status, distance to forest, distance to market, number of trees owned, and nonforest income have a statistically significant negative relationship with dependency on fuelwood income from the forest, whereas family size is the only factor that has a statistically positive relationship with dependency on fuelwood from forest.

The increasing trend in forest degradation for household fuel consumption will ultimately accelerate future emissions of greenhouse gases, which will lead to changes in global climate. Thus, opposing strategies are required to achieve the twin objectives of preserving forest carbon and meeting regional demands.

These strategies include expanding agricultural production on previously cleared land, implementing agroforestry, and creating alternative energy sources in addition to biodiversity conservation measures. Additionally, it is necessary to create protected areas, integrate enough law enforcement and monitoring into the current management regimes, and combine conservation and community-based management.

The selection of fast-growing tree species for fuelwood production with the identification of appropriate provenance to match specific conditions is also necessary [47–52].

Data Availability

The data used to support the findings of this study are found in household questionnaire and direct field measurement and are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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