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Estimation of Households Fuelwood Consumption and Its Carbon Dioxide Emission: A Case Study on Adaba District South East Ethiopia

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Abstract: Over 3 billion people throughout the world rely on traditional fuels such as fuelwood. In Ethiopia, 90 percent of energy consumption comes from biomass. Such heavy reliance on this form of energy is a threat to forest ecosystems and also contributes to greenhouse gas emission. However, empirical evidences on the amount of fuelwood consumption and emission of CO_2 are limited. This study was carried out to assess amount of fuelwood consumption, factors affecting fuel wood consumption rate and contribution of fuelwood consumption to carbon dioxide emission, in Adaba district South Eastern Ethiopia. The study was based on questionnaire survey from 317 randomly selected households, focus group discussion and market survey. Multiple regressions were used to determine factors that influence fuelwood consumption rate and the amount of fuelwood consumed was estimated from the market survey using descriptive statistics. The result showed that average weekly fuelwood consumption was 0.2 (±0.1) and 0.09 (±0.07) tons in Kiremit and Bega seasons respectively. During winter season pressure on forest for fuelwood is comparatively lesser since there are other alternative sources of income. The result also showed that an estimated percapita emission of 2.08 tCO_2e per year. The regression result reveals that, family size and total land size owned were found to be significant and positively correlated with the probability of fuel wood consumption rate. While total livestock unit was found to be significant and negatively correlated with the probability of fuel wood consumption rate. Furthermore, price of fuel wood and fuel wood availability were not found to be statistically significant. Focus group discussion and household survey revealed that, woody vegetation species like, Juniperus procera, Olea europaea and Erica arborea are the most preferred fuelwood species. In general distributing energy saving technology like ICS, family planning and using exotic tree species like, Eucalyptus for fuelwood is crucial to ensure sustainability and benefits of forest resources.

Keywords: Fuelwood, Carbon Dioxide Emission, Species Preference, Fuelwood Consumption

1. Introduction

1.1. Background

Over 3 billion people throughout the world rely on traditional fuels, such as wood, charcoal, dung, and agricultural residues, for cooking and heating [16]. The global total production of wood in 2000 reached approximately 3.9 billion cubic meters of which 2.3 billion cubic meters was used as wood fuels [25]. This indicates that approximately 60 percent of the world's total wood removals from forests and trees outside forests are used for energy purposes for heating and cooking. It is estimated that approximately about 2.5 billion people in developing countries depend on biomass energy such as wood fuel, charcoal, agricultural and forest residues and other plant matters for their daily needs [42]. FRA [24] estimated that the world's forests store 289 Gt of carbon in their biomass alone.

Almost all African countries still rely on wood to meet basic energy need [70]. Wood fuels account for 90-98% of the energy consumption in most Sub-Saharan Africa [21]. Firewood is the most important forest product and the main source of energy for most African households, accounting for

91 % of all wood consumption.

Ethiopia is a typical example, where nearly all its rural population depends on biomass energy sources for cooking and other energy requirements. Of the different biomass energy sources, fuel wood accounts for around 78 percent of the total energy demand, while animal dung and crop residue account for 12 percent and 9 percent, respectively [19]. Because these resources must be collected from common areas, such high dependence has a fundamentally negative impact on the availability of forest resources. Fuelwood in Ethiopia is primarily used for cooking, heating, and lighting. Baking *injera*, traditional pancake-like bread, is the most energy-consuming activity in both urban and rural areas of [2]. Usually wood with higher density better suited as fuel wood because it has higher calorific value. Species proffered for fuel wood depends mainly on quality like hot flame, long lasting flame, easy to split and ignite [49]. Fuel wood use, both for local needs and external markets, have negative environmental impacts.

1.2. Statement of the Problem

For long, Ethiopia had been losing its natural forests and woodlands for fuelwood, construction and expansion of agriculture. According to Ethiopia National Clean Cook Stoves Program, more than 99% of the rural households depend on firewood for cooking and heating purpose [27]. This heavy dependency on biomass fuel, leads to carbon dioxide emission, environmental degradation, and deforestation. In Adaba, about 25,000 urban and rural households freely utilize the forest resources such as firewood, and charcoal. Unsustainable forest resource utilization leads to deforestation, carbon dioxide emission and forest degradation..

Over 25,000-consumer households and from this 5000 Households are live in Adaba town (i.e., a population of about 100,000) of which5000 households reside in the forest depend on wood from the natural forest of Adaba- Dodola [39]. So far, no study has been conducted to investigate impact of household fuel wood consumption on the forest of Adaba, its contribution to carbon dioxide emission, factors that determine households fuelwood consumption rate and species preferred for fuelwood even though many other aspects of this forest has been thoroughly studied [65]. The purpose of this study is to provide empirically supported information that can contribute to a better understanding about households fuelwood consumption, factors determine fuel wood consumption rate, species proffered for fuel wood, impact of fuelwood extraction on forest of Adaba-and its contribution to carbon dioxide emission.

1.3. Objectives of the Study

1.3.1. General Objective

The general objective of the study was to assess the impact of fuelwood consumption on Adaba forest and estimate its contribution to carbon dioxide emission.

1.3.2. Specific Objective

The specific objectives of the study are;

(1) To estimate the quantity of fuel wood annually consumed for domestic purpose by households in the study area.
(2) To assess the factors that determine fuelwood consumption rate.
(3) To identify and rank the most preferred species for fuel wood in the study area.
(4) To estimate the contribution of fuel wood consumption to CO_2 emission in the study area.

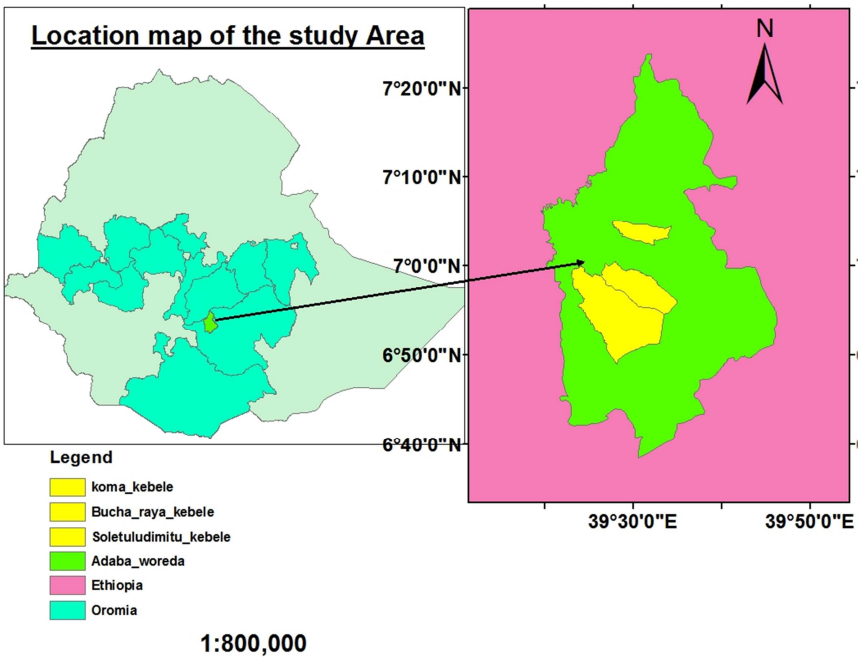

Figure 1. *Study map of the area.*

2. Methods and Materials

2.1. Description of the Study Area

The study was conducted in West Arsi zone Adaba district, Southeastern Ethiopia. Adaba district lies 330 km South East of Addis Ababa, the capital of Ethiopia. Adaba is one of the 180 *districts* (districts) in the Oromia regional state of Ethiopia located geographically at 6^0 40' - 7^0 20' North and 39^0 30' -39^0 50' East.

2.2. Sample Size and Sampling Method

2.2.1. Selection of Study Sites

The study was conducted in Adaba district of West Arsi Zone. Among the 11 district in the zone Adaba district was purposely selected for this study. Therefore, it would be convenient to examine how fuelwood consumption affects forest resources and contributes for carbon dioxide emission. The district comprises of 24 rural kebeles of which nine (9) kebeles are not forested and not included in selection. From the rest fifteen (15) kebeles three (3) of them Sole Tullu Dimtu, Koma Witch, and Bucha Raya were randomly selected for the study.

2.2.2. Sampling Strategy and Procedure

From the selected kebeles a total of 317household heads/respondents were taken for the study. The sample size was determined using 95% confidence level, and level of precision (5%).

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

Where "n'' is the sample size, ''N'' is total number of household heads, and ''e'' is the level of precision.

In the three selected kebeles, there are a total of *1550* household heads (Koma, Witicho 500, SoleTullu Dimtu, 430 and Bucha Raya, 620). Therefore, the sample size (n):

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

$$n = \frac{1550}{1+1550(.05)^2} = 317$$

To determine sample size in each Kebele, proportional sampling technique was employed. Therefore, from koma kebele 102 HHs, Sole kebele, 88HHs, and from Buchakebele127 HHs were selected for interview. Primary data was collected from sampled households/farmers through structured questionnaire. The information collected include amount of fuelwood consumed weekly, factors determining the consumption of fuelwood, and species preferred for fuel wood.

2.2.3. Methods of Data Collection

The data used in this study is mainly primary and secondary data. The study data was collected from heads of the households (male or female). Both household and market survey were used to collect data on information about amount of fuelwood consumed and species preferences. To get full data of urban fuelwood consumption in the study area market survey was conducted during summer and winter season.

i Household survey

The questionnaire was administered through face to face survey techniques. However, before undertaking formal survey, draft questionnaire was pre-tested on selected households in study area. On the basis of the pre-test result, the necessary modifications were made before the final questionnaire was prepared.

The first part of the questionnaire was pertinent to household characteristic and socio-economic information of the households. The second part of questioners contains general information about amount of fuel wood weekly consumed, source of fuel wood, species preference and other information important for the study.

To quantify fuel wood consumption we interviewed the selected HHs and most of obtained data were in load of donkey and load of women. Recorded data converted into kilograms using method suggested by EPA [30] and multiplied by 52 weeks to reach in yearly estimation of per household. To identify and rank species preference for fuelwood all mentioned species were ranked and weighed.

ii Focus group discussion

Interview is the most widely used as a means of collecting data in survey research methods. So to understand in detail about the impact of fuel wood consumption on forest resource and species preferred, the researcher is interested to carry out indepth interview with Kebele executives, kebele elders, and agricultural development agents. From each kebeles three focus group discussions were conducted separately. With this regard, a total of 27 people were participated on focus group discussions from different social groups. One focus group contains 9 people from different social group and accordingly about 3 focus group discussion was conducted in three selected kebeles. Woody species preferred for fuelwood, and impacts on forest resources in both Kiremit and Bega seasons were conducted during focus group discussion. According to focus group discussion Kiremit season starts from June to September and Bega season is from December to March.

iii Market Survey

In addition to household survey to get full data on urban and rural fuel wood consumption market survey was conducted in both summer and winter seasons. During Kiremit (summer) and Bega (winter) fuel wood demand is high because it is rainy and cold seasons and also summer is off season for students to collect fuel wood and sell to local market. So two market day selected and the counting was conducted from 08:00 a.m 9:00 pm during the week. All fuelwood that is supplied to town by using different mode of transportation from four major different routes were recorded. The most common measures concerning fuel wood at the study area was horse load, donkey load and horse drawn cart. One donkey load weighs an average of 49.82 kg

according to ministry of mining and energy [30] and one horse drawn cart corresponds to five donkey load. Marketing survey for fuel wood inflow rate was recorded, to estimate fuel wood supply to local urban market and estimate the amount of consumption in the study area.

2.3. Data Analysis

Data were analyzed using statistical techniques, (principally descriptive statistics, cross tabulations, frequency tables, and multiple regressions) with the support of the Statistical Package for Social Scientists (SPSSv17).

2.3.1. Descriptive Analysis

SPSS and Excel spread work sheet was used to analyze and summarize (into tables and graphs) the data obtained through households interviews, market count, and field observation. The investigation focused on to estimate annual fuel wood consumption, estimating carbon emission from fuel wood consumption, ranking and identifying tree species preferred for fuel wood. Annual carbon emission in the study area was calculated based on clean development mechanism and United Nation framework of Convention on Climate Change [67] default net calorific values, emission factors and carbon storage in forests.

$$E = FC \times f_{NRB,} \times NCV \times EF\text{- projected-fossil fuel} \quad (2)$$

where:

E, Is emission in tons of carbon dioxide equivalent (tCO_2e)

FC, Is the quantity of Fuel wood consumed in tones or kilo gram.

f_{NRB}, Is the fraction of non-renewable woody biomass

NCV, Is the net calorific value of fuel wood

$EF_{projected\text{-}fossil\ fuel}$, default emission factors

Table 1. *Parameters used for calculating carbon emission.*

Parameter	Value	Source
Annual fuel wood consumed	From HH & Market survey	Field survey
Net calorific value fuelwood (wet basis)	15MJ/KG	(IPCC, 2006)
Emission factor fuel wood	81.6 CO_2/TJ	(UNFCCC, 2013)
Conversion CO_2/C	3.667	Ratio molecular weight
Fraction of non-renewable fuel wood	88%	(UNFCCC, 2012)

2.3.2. Multiple Regression Analysis

Regression analysis is a statistical technique for studying linear relationships. It assumes a general form for the relationship, known as the regression model:

$$Y = \alpha + \beta 1X1 + ... + \beta kXk + \varepsilon \quad (3)$$

Y is the dependent variable, while X1,..., Xk are the explanatory variablesor the independent variables. α, β1,..., βk are partial regression slopes corresponding to respective Xi.

ε_i is the residual variance in Y after taking into consideration the effects of the Xi variables included in the model.

Regression analysis helps one understand how the typical value of the dependent variable changes when any one of the independent variables is varies, while the other independent variables are held fixed.

The estimators, however, end up with almost the same standardized (marginal) impacts of independent variables [53].

For this reason the study has used the multiple regression model to identify the determinants of fuel wood consumption.

$Yi=\beta_0+ +\beta_1 EDLVL+\beta_2 FAMSZE+\beta_3 LANDSZE+\beta_4 TLU+ \beta_5 FUELAVBLTY_i+\beta_6 FUELWDPRCE+ \varepsilon i$

If the error term (ε) is taken in to account the multiple regression model becomes:

$$y_i= \beta_0+ \beta_1 X_1 + \beta_2 X_2+... ++ \beta_n X_n+\varepsilon \quad (4)$$

Where β_0 is an intercept which tells us the of fuel wood consumption when the coefficients of all included explanatory variable are assumed to be zero, $\beta_1 \rightarrow n$are slope parameters to be estimated in the model, respectively. The slope tells how the factors affecting fuel wood consumption as each independent variable changes. *Yi* is also referred to as the factors that affect amount of fuel wood consumption.

Table 2. *Explanatory Variables and their Hypothesized effect.*

Variable code	Variable type Variable	definition and Measurements	Expected Sign
FAMSZE	Continuous	Household size (total number of people in household)	+
TLANDSZE	Continuous	Total area of land owned by household (in hectare)	+
TLU	Continuous	Total tropical Livestock holding by household	_
FUELAVBLTY	Dummy	Fuel availability (1, if access to open forest, otherwise, 0)	+
PRCE FUELWD	Continuous	Fuelwood price (1, if price increased, other wise, 0)	_

3. Result and Discussion

This section has three sub sections. The first sub section presents descriptive analysis, the second section present about household survey results and third section is market survey result. Under the last two section amount of fuel wood consumption and its contribution to carbon dioxide emission, factors affecting fuel wood consumption and species preferred for fuel wood consumption are discussed. The descriptive analysis and survey results have been made to

assess factors affecting the amount of fuel wood consumption and its contribution to carbon dioxide in the study area. Finally, preferred and ranked species that are frequently used fuel wood consumption are discussed.

3.1. Sources of Energy for Household Consumption

The result of the survey showed that firewood, leaves, charcoal, animal dung and electricity are sources of energy in the study area. Large proportions of the households in the study area are dependent on traditional fuels (biomass). The result shows that 88.3% and 91.3% of the households are dependent on firewood as source of energy for baking and cooking (boiling water, wot, soup, making tea and coffee) respectively followed by animal dung (8% for cooking and 4.6% for baking). The use of modern energy like electricity as a source of energy is at its infant stage showing that it is used by very few households. This high dependence on biomass source is mainly due to lack of access to modern energy sources and due to open access of natural forests.

The respondents revealed that fuel wood collection is mostly the responsibility of women. Accordingly, among the family members who regularly involved in fuel collection, 51% is shared by mother, 36% by girls, 8% by boys and 5% by father.

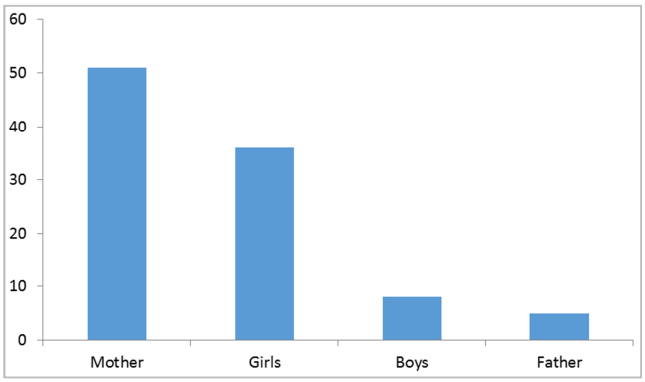

Figure 2. *Fuel collection by gender.*

3.2. Result of Household Survey

According to the respondents in the study area fuel wood is the common and major household energy source for home based activities (baking, cooking, heating and lighting).

The average fuelwood consumption per household in the study area is 4.4 tonnes (SD = 1.6) and ranges between 2.2 and 8.8 tonnes for Keramit season (June -September). For Bega season (December- March) average fuelwood consumption per household in the study area is 2.5 tonnes (SD=1.3) and ranges between 1.1 and 4.4 tons. Average annual household consumption was calculated as follows:

Average annual per household consumption in rural= (Keramit av. fuelwood consumption ×30 days×4months) + (Bega av. fuelwood consumption × 30 days×4 months)/365

=4.4t×120+2.5 t×120/365=2.3tonnes per year per household.

The average annual household consumption in the rural of study area is 2.3 metric tons. The result is comparable with study conducted [69] in Kaffa region which was1.6 tons.

In the study area Keramit fuel wood consumption is greater than Bega season, due to additional requirements of fuels to keep their houses warm. This is may be also during Keramit season schools are closed and children have time to collect more fuel wood for their family.

All kebele leaders and development workers agreed that, the main cause of forest destruction in Adaba district was extracting forest for fuel wood for domestic consumption and selling to local market. According to them, most households depend on fuel wood extracted from natural forest for consumption, sale and use as additional income generating activities. Also both kebele leaders and development agents, agreed that indigenous fuel wood species like *Juniperu sprocera*, *Olea europae*, *Erica arboria*, and *Hypericum revoltum* are highly preferred and consumed species. They also mentioned that, species like *Erica* and *Hypericum* are locally available bee flora plants and using such plants in unsustainable way may be threat to honey production in Adaba area.

(photo by Alemayehu Z)

Figure 3. *Firewood stored around the home & delivered to local market by donkey load.*

3.3. Result of Market Survey

Fuelwood selling in Adaba town is practiced throughout the year, but very high supply was observed in Kerami and Bega season. Fuel wood source for the town is neighbor village that have natural forest. This study revealed that on average 32 metric ton (28.5 tons of fire wood and 3.6tons of charcoal) is consumed in Adaba town per week in keramit season. And also on average 12.4 metric ton (9 tons of firewood and 3.4 tons of charcoal) is consumed in Adaba town per week during Bega season.

Avearge annual fuelwood consumption in Adaba town=(Ave. Keramit consumption ×30 days ×4 months) + (Ave. Bega consumption ×30days × 4 months)/365= (32t×120) +(12.4t×120)/365= 14.6 tons per year.

The average annual fuelwood consumed in Adaba town is 14.6 tons per household per year.

Average annual fuelwood consumption in Adaba district =(Ave. Rural feulwood consumption × Rural HH) +(Ave. Urban fuelwood consumption × Urban HH)/Total population

(2.3 t × 20,000HHs) + (14.6 t × 5,000HHs)/100,000 =1.2 tones

The average fuelwood consumption in Adaba district is 1.2 tones per household per year. The total domestic fuelwood consumption in Adaba district is 30,000 tones and average per capita fuelwood consumption was 0.2 ton. Fuelwood consumption in Adaba area is very high compared to Jogo-gudedo water shed Ethiopia 0.6 ton. Other rural regions in Sub-Saharan African regions such as, Uganda and Kenya, where mean annual consumption was estimated at 0.5 t/household, [55] and 0.6 t/household [56] respectively. But this result is smaller than fuelwood consumption in Arsi Negele 6.5 ton per household which was conducted by Nejib, [49]. This indicates that our finding result has difference or slight deviation with the national energy consumption estimation. And also smaller than annual fuelwood per capita consumption of Woina Dega Zone of Ethiopia 1.7 tones [45].

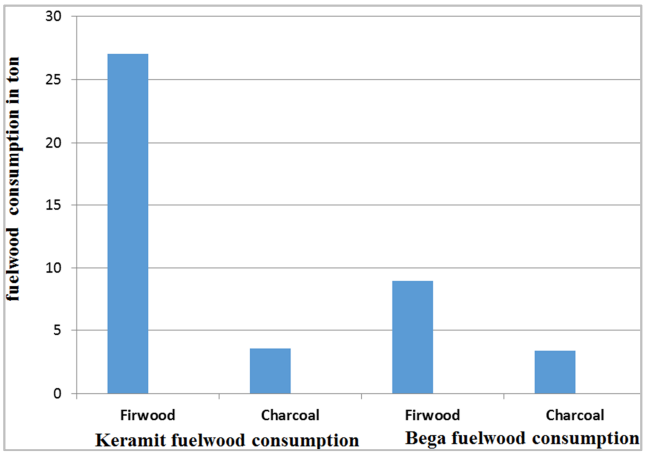

Figure 4. *Fuelwood supply to Adaba town.*

3.4. Fuel Wood Consumption and its Contribution to Carbon Emission

This study revealed that total fuel wood consumption in Adaba district is 30,000 tonnes. To estimate fuel wood consumption and its contribution to carbon emission, it is calculated for rural house hold fuel wood consumption and town fuelwood consumption and a net calorific value of 15 MJ/kg and an emission factor of 81.6tCO_2/TJ of woody biomass used [61] and this corresponds to emission of 1.3 tons of CO_2 per household per year with per capita emission of 2.08 ton of CO_2e. And the total carbon dioxide emission in Adaba district is estimated to 32,313 tCO_2e.

$$E = FC \times f_{NRB,} \times NCV \times EF\text{- projected-fossil fuel} \quad (5)$$

$$=30{,}000\ t \times 0.015TJ/Ton \times 0.88 \times 81.6tCO_2/TJ = 32{,}313.6\ t\ CO_2e$$

More than half of the fuelwood collected by households themselves also stems from forests, it is therefore justified to assume that 88% of total consumed fuelwood stems from forests for Ethiopian case UNFCC,[67]. Used an 88% non renewable bio-mass percentage, which is the CDM default value for Ethiopia UNFCC,[67] and it is estimated to 32,313 tons of CO_2e emitted annually from fuelwood consumption in Adaba district.

The estimated emission in Adaba corresponds to about 8,733 tons of carbon with the assumption of carbon density of 95 tons ha^{-1} for dry afromontane forest like that of Adaba area (IPCC, 2006) guidelines, the annual CO_2emission from use of firewood corresponds to removal/deforestation of about 92 ha of forest. The result of our study is very in line with national per capita emission of Ethiopia 1.8 tCO_2e [28].

(photo by Alemayehu Z)

Figure 5. *Firewood and charcoal sold at Adaba town.*

3.5. Determinants of Fuel Wood Consumption

Three of the six explanatory variables used in the model significantly affected the consumption of fuel wood by households in the study area (Table 3; $P < 0.01$). The independent variables explained 80% of the dependent variable. This regression result shows that fuel wood consumption is positively correlated with Family size, fuel wood availability and land size of house hold head. However, the result reveals that fuel wood consumption is negatively correlated with total livestock unit.

Table 3. *Regression coefficient estimates of socio economic factors influencing fuel wood consumption in Adaba district.*

	Unstandardized Coefficients	Standardized Coefficients		t	Sig
	B	Std. Error	Beta		
FUELWD AVBLTY	2.265	4.824	0.018	0.470	0.639
LANDSZE	7.662	2.326	0.191	3.294	0.001**
TLU	-1.257	0.517	-0.138	-2.431	0.016**
PRICEFWD	5.132	4.931	0.043	1.041	0.299
FAMSZE	7.173	0.611	0.417	11.742	0.000***
CONSTANT	13.478	7.446		2.179	0.03

Note: ** and *** indicate the level of significance at 5 %, and 1 %, respectively

R=0.899

R^2=0.809

Adjusted R^2=0.805

Family size: House hold family size significantly affect the probability of fuel wood consumption with p value and β coefficient of 0.000 and 0.417 respectively. Family size of household positively affects fuel wood consumption. This beta coefficient indicates that the probability of fuel wood consumption is 41% higher for household who has large family size than those who has small family size. This is may be, the number of members in a household increases, energy demand also increases for food preparation, lighting and for heating in most rural areas. And possibly more labor supply for fuel wood collection. The finding of this study is similar with result of [56, 3] found that family size is the most significant factors influences amount of fuel wood consumption level.

Tropical Livestock Unit: livestock ownership significantly affects amount fuel wood consumption with p value 0.016 and coefficient-0.14. The coefficient result indicate that the probability of consuming fuel wood for livestock ownership is 14% lower than non owner or small livestock ownership. This means that house hold with large number of livestock consume less fuel wood. This may be associated with using cow dung as a source of energy and reduce the probability of collecting fuel wood from open access forests. In addition households that own large livestock number has possibility of selling and purchasing other alternative energy sources like solar energy device, kerosene, and LPG for their domestic purposes. This is in agreement with previous studies which reported negative significant effect of TLU [1].

Land Size: As it was expected, land size owned by households significantly affects fuel wood consumption with p value of 0.001 and βcoefficient 0.191. This indicate that, the likely hood of household that have larger land size fuel wood consumption is 19% higher than those who has few land size. It suggest that, larger land size holders are to cover different agricultural activities like farm land ploughing, sowing, weeding, harvesting and threshing they need labors. Because of this additional food prepared with more fuel wood consumption. This is in agreement with finding conducted in Northern part of Ethiopia [22], which revealed that next to agricultural land expansion by farmers, the most leading factors for high deforestation is using fuel wood as source of energy in Ethiopia.

3.6. Species Preference for Fuel Wood

According to household survey, different species of trees and shrubs were identified to be collected from the nearby forest area as a source of energy. Accordingly, about fifteen fuel wood species were identified and out of this three species were ranked as the most preferred and used by the respondents.

Table 4. *Species preferred for fuel wood consumption by Households.*

Species name	Frequency	%	Rank	Reasons for species preference
Juniperus procera	297	94	1	Good quality and availability
Olea europaea. ssp	168	53	2	Good quality (burn slowly, long lasting flame, no spark,)
Erica arborea	24	24	3	Availability

As seen from table above, most of the households reported the three most plant species preferred for fuel wood use. *Juniperus procera* was found to be the most frequently preferred (by 94 % of the household) species followed by *Olea europea*, which was chosen by 53 % of the household and the third preferred species was *Erica arborea* by 24% of household. The respondents described a number of attributes or factors that they considered to be important for good fuelwood. The most important attributes were availability and quality of the species. According to respondents, if the fuelwood species have good quality, the fuel wood should have a hot flame, a flame that is long lasting, produce long lasting embers, and be easy to split and ignite. In addition the preferred species would have to burn without producing

much smoke, and have a flame that does not produce sparks. Availability is also one of the reasons for preference of species for fuel wood use. According to the households J. *procera, O. europaea and E. arborea* were highly preferred for energy consumption. In addition to fuelwood consumption those species are well known for high timber quality and construction. This situation was also proven by observing from the weekly supply of fuel wood from the forest for domestic consumption and to the market for sale. The dependence of the community on those species for fire wood was also a daily need of the community, so that it creates high pressure on degrading the status of the species in the forest. Their growth habit is very slow and the extraction of those species is also high. So, the community near and around the natural forest significantly affect the status of the species as the extraction of the species is greater than that of their renewal or growth habit of the species. This finding is in line with study conducted in Northern part of Ethiopia [35] which reported that *O. eropaea* and *J. procera* were the most preferred fuel wood species from the forest, based on species burning speed, calorific value, amount of irritating smoke released and charcoal production.

4. Conclusion

The most common source of energy by rural households in rural areas of the study area are firewood, leaves, charcoal, animal dung and electricity. The result of present study shows that 88% and 91% of the households depend on firewood as source of energy for baking and cooking (boiling water, wot, soup, making tea and coffee) respectively followed by animal dung (8% for cooking and4.6% for baking).

In assessing status of fuel wood consumption in the study area about 95% of households in the area use fuel wood from natural forest. This implies that use of fuel wood energy sources contributes to forest degradation in the study area. Furthermore, the study result revealed that estimated total annual fuelwood consumption in Adaba district was 30,000 tons and 2.08 tCO_2e is emitted per household per year. More fire wood is consumed in Kiremit season than Bega season this could possibly Kiremit is rainy and cold time that household needs more fuel woods to keep their houses warm. Total livestock unit is factor that could negatively influence fuelwood consumption, whereas land size owned and family size determine fuel wood consumption positively.

In general, the result of the finding indicates that, major of households dependent on firewood and charcoal for purposes of baking *injera, bread, making* porage and general cooking and heating while kerosene, crop residue and electricity are lowest energy consumption in Adaba district. This implies the consequences of uses of biomass energy sources may lead to forest degradation, deforestation, and lands degradation all are severe environmental and socio- economic problems. Moreover, market survey result shows that high amount of fuel wood extracted for supply to local market for sale. This large amount of fuel wood consumption contributes high emission of greenhouse gasses besides forest resources degradation.

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Statement of the Author

I, Alemayehu Zeleke, hereby declare that this thesis is my original work and has not been submitted for a degree in any other University.

Alemayehu Zeleke Urge,

This study was conducted in Oromia Regional state Bale Mountains, Adaba district, South East Ethiopia.

List of Acronomys and Abbrevation

PFM	Participatory Forest Management
FAO	Food and Agricultural Organization
CBO	Community Based Organization
IFMP	Integrated Forest Management Plan
Mt	Metric tone
T	Tone
ECRGE	Ethiopian Climate Resilient Green Economy
NFPAs	National Forest Priority Areas
EFAP	Ethiopian Forest Action Programme
NCCPSE	National Clean Cook Stove Programme
CO2e	Carbon dioxide equivalent
GTP	Growth Transformation Plan
GHG	Green House Gas
REDD	Reduce Emission Deforestation& Degradation
OFWE	Oromia Forest & Wildlife Enterprise
GTZ	German Agency for Technical Co-operation
FZS	Frankfurt Zoological Society
MEFCC	Ministry of Environment, Forest and Climate Change

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