



Assessment of Fuel Wood Energy Demand of Arba Minch Town, Gamo Gofa Zone, Southern Ethiopia

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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Abstract

The current rate of deforestation in Ethiopia is exacerbated by number of factors including increased rate of population, increased fuel wood consumption, urbanization, infrastructure development, etc. However, fuel wood energy requirement is one of the major problems causing deforestation. The current study was conducted during 2017 with the objective to estimate the fuel wood consumption of Arba Minch Town. To achieve this objective a household survey was conducted in the town. Out of 11 kebeles of the town four were selected purposely. 58 household respondents were selected for the study. People of the area using fuel wood for various purposes such as cooking, for lighting and for selling as source of income. Arba Minch forest is the source of fuel wood for majority of the households. On average basis, single house hold is using 4.01 kg of fuel wood day⁻¹. The fuel wood consumption of other user such as hotels, govt. institutions were also recorded by conducting survey in four sub cities. Among different user group of fuel wood in the town fuel wood consumption by individual HHs were maximum (66 t day⁻¹ or 24090 t year⁻¹) followed by hotels (2.65 t day⁻¹ or 969.08 t year⁻¹) and lowest by government institutes (110 t day⁻¹ or 40.15 t year⁻¹). Thus, total consumption of fuel wood in Arba Minch town is 68.78 t day⁻¹ or 25,099.23 t year⁻¹. The demand for fuel wood consumption is in increasing trend. This growing demand of fuel wood from household is posing a threat to the remaining natural forest and associated wildlife and resources. Therefore, it is recommended that there is a need of adoption of alternative sources of energy which can replace fuel wood energy. Thus community participation in forest protection should be encouraged and illegal consumption of fuel wood in the study area should be checked.

Keywords: Consumption, demand, fuel wood, households, kebeles

1. Introduction

Energy constitutes one of the most important aspects of human life and is vital existence of modern life (Owusu and Asumadu-Sarkodie, 2016). Bio-energy is currently the primary energy source for almost 2.7 billion people worldwide (Birka et al., 2011; Stecker et al., 2013). Traditionally, energy in the form of firewood, twigs, and charcoal has been the major source of renewable energy for many developing countries (Akowuah et al., 2012). For many of these countries, more than 90% of total household fuel is biomass (Bamiro and Ogunjobi, 2015). In developing countries >75% of wood harvested from forest is used as domestic fuel wood (Bearer et al., 2008) and about 2.5 billion people rely on biomass fuels to meet their cooking, heating, and lighting needs. According to Bonjour et al.

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(2013). It is estimated that over 40% of the world's population is currently relying on solid-fuels for cooking and heating. Biomass is the predominant source of energy in Ethiopia and its consumption estimated to be 84% to 94% (Teka, 2006; Haile, 2009; Mekonnen and Kohlin, 2009; Anonymous, 2016; Gurmessa, 2010) which is one of the highest in the world (Haile, 2009). Fuel wood is used significantly in both rural and urban communities for cooking and many other heating applications (Tucho and Nonhebel, 2017).

Most of Ethiopian households depend overwhelmingly on biomass for cooking in rural areas and even in most urban areas households have upgraded their biomass use (Damte et al., 2012). To meet out this huge energy demand people heavily depend on deforestation. Fuel wood and charcoal is one of the main causes of deforestation in Africa (Gebbru, 2016). Globally about 55% of the wood extracted from forests, which responsible for 5% of global deforestation (Miles and Dickson, 2010). The energy production through traditional system is discouraged because of its negative impact on environment, economy and health at local as well as at world level besides increased use of agricultural residues and animal dung deprives of the land for essential nutrients necessary for soil fertility (Geissler et al., 2013; Amare et al., 2015). During last fifty years charcoal production increased from a million tonnes to more than three million tonnes annum⁻¹ and fuel wood consumption from forty million to one hundred million m³ per annum (Asfaw and Demissie, 2012). About 4 tonnes of air-dried wood would produce about 1 tonne of charcoal (Prasad and Tiwari, 2016). The biomass consumption from 2000 to 2013 was more than 105172465 t yr⁻¹ while charcoal demand of the country increased from 48,581 to 4,132,873 t year⁻¹ (Geissler et al., 2013). However, fuel wood consumption rate of developing countries is slowing down due to urbanization as being replaced by other energy sources such as charcoal, kerosene and electricity with increase in their income. Despite that, the total wood fuel consumption in some regions, particularly in Africa, is projected to continue increasing at least until 2030 (Broadhead et al., 2001). Currently, over 2.5 billion people depend on biomass fuels for cooking and heating (Sampson, 2005; Anonymous, 2006; Anonymous, 2008; Haile et al., 2009). Although all people have a legitimate right to and need for energy services which are affordable, healthy, reliable and sustainable, energy issues are particularly challenging for developing countries where high energy costs exert tremendous pressure on fragile economies that have little capacity to adapt to change (IUCN, 2007).

The use of fuel wood is in full swing at local and institutional level. Gamo Gofa zone is not an exceptional. The study area is heavily dependent on fuel wood and they met most of their fuel wood demand from nearby national park illegally. Fuel wood collection is also being considered as the major source of livelihood for many inhabitants of the town. The heavy dependence of people on this park is a threat to its existence. So its necessary to have some data regarding fuel wood

consumption of the inhabitants not only for policy makers regarding park management but also for to make arrangement of alternative sources of fuel wood energy. By keeping in view this present research work was undertaken with the specific objective to quantify the volume of fuel wood consumed by the people in and around Arba Minch town.

2. Materials and Methods

2.1. Description of the study area

Current study was conducted in Arba Minch town which has four sub-cities and eleven kebeles (smallest administrative unit). It is located in Gamo gofa zone of the southern nations, nationalities, and people's region and found at the distance of 505 kilometers south of Addis Ababa, the capital of Ethiopia. It is surrounded by Arba Minch Zuria Woredas and provides as center of economy, politics and society of the zone. The elevation of the town above the sea level is 1300-1500 meters. Geographically, Arba Minch town is located between 5°42' and 6°13' north of latitude and 37°19' and 37°41' east longitudes. The area of Arba Minch town is 557 ha. (55.57 Km²). Based on the 2007 Census conducted by the CSA, this town has a total population of 74,879, of whom 39,208 are men and 35,671 women; and the yearly growth of the population number is projected by 4.8% thus expected to reach 119,666 (62,658 men and 57,008 women) during study year. The average annual temperature is 24°C and the annual average rain fall is 900 mm. The higher rainy seasons of the town are: May, June, September and October. (Arba Minch town socio economic information office, 2007) (Figure 1).

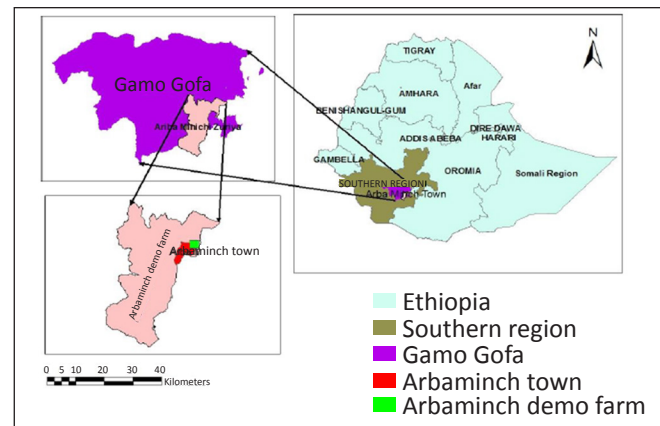


Figure 1: Location map of the study area. Courtesy: Gebreselassie et al., 2015

2.2. Methods of data collection

2.2.1. Preliminary survey

A preliminary field survey was conducted in Arba Minch town to get detailed information for setting research design, determine sample size, and identify fuel wood user groups across the town. Data on socio-economic conditions (low, middle and high) of target population was also collected so as to correlate fuel wood consumption with respect to economic status of Arba Minch town dwellers.

2.2.2. Sampling method and sample size

The study was conducted by using both purposive and systematic sampling procedures to collect data. The Arba Minch town includes four sub-cities and eleven kebeles. Specific kebeles within each sub city were selected purposely. These Kebele were Chamo, Idget ber, Dulfana and Kulfo with population of 1857, 2076, 1465 and 609 households respectively. From each of selected kebeles, 1% of total households were selected. In total, 58 householders were selected as a sample for interviews. By means of systematic selection, households were selected based on their economy, age, sex and work. Similarly, data was collected for fuel wood consumption in hotels and govt. Institutes. Total 9 hotels were selected out of 4 sub cities under survey for fuel wood consumption depending upon the number of hotels available in the sub-city.

2.2.3. Data collection

A cross-sectional survey of sample households was carried out by using semi structured questionnaires, which were administered through a face-to-face interview. Several considerations were taken care to ensure the reliability and representativeness while designing questionnaire. Some of these most important considerations include involvement of socio-economic classes in the population, use of local language, use of multiple questions (cross-validating), balancing of both closed and open-ended type of questionnaires. In-depth interviews and focus group discussions were also held with the householder to obtain more information and for cross

checking. Personnel communication was also set up with officials of Nechsar National Park to get information regarding fuel wood energy consumption of the households. The data were collected by using both primary and secondary sources. The primary data was obtained through structured questionnaire administer to various respondents, focus groups discussions with local elders. Secondary data was obtained from various sources such as report of bureaus of agriculture, administrative office, previous research findings, internet and other published and unpublished materials.

2.2.4. Data analysis

The qualitative and quantitative data that were generated from the survey was analyzed through descriptive statics. The results were presented by table, graphs and figures to enable easy interpretation and quick visual comparisons of variables.

3. Results and Discussion

3.1. Total fuel wood consumption

Current study witnesses the consumption of 4.01 kg of fuel wood/day by the inhabitants of the Arba Minch town. Results revealed that lowest fuel wood consumption (2.64±0.11 kg day⁻¹ HHS⁻¹) was recorded for Chamo Kebele while the highest (5.20±0.41 kg) was recorded for Idget Ber kebele (Table 1). According to one way ANOVA, statistical analysis of fuel wood consumption shows a significant difference at 0.05 level of significance among different households in each kebele as well as among different kebeles (Table 1).

Table 1: Average fuel wood consumption in Arba Minch town by HHS

Name of kebele	Total HHS	Sampled HHS	Consumption day ⁻¹ HHS ⁻¹ (kg)	Consumption day ⁻¹ kebele ⁻¹ (t)	Expected consumption of Arba Minch town day ⁻¹ and yr ⁻¹
Chamo	1857	18	2.64±0.11*	4.90	@ 6 t day ⁻¹ for 11 kebeles = 66 t day ⁻¹ or 24,090 t yr ⁻¹
Idget Ber	2076	20	5.20±0.41*	10.8	
Dulfana	1465	14	3.82±0.31*	5.6	
Kulfo	609	6	4.38±0.33*	2.7	
Total	6007	58	4.01	6.00	
				6±2.91*	

*: significant at statistical level of (p=0.05)

It was observed that the quantity of fuel wood used by different town dwellers vary with their economic level. Idget ber kebele which was economically poorest kebele, consuming fuel wood more than any other kebele in the study area and make use of fire wood and charcoal for enhancing their income by selling them. So, electricity used by them is mostly for lightening as they cannot afford its utilisation for heating and cooking. Comparatively better economic condition of the Chamo kebele is reflected in comparatively more use of electricity for lightening and cooking.

On an average basis fuel wood consumption of 6 t day⁻¹ was

recorded from a single kebele from the study area. Thus, it is estimated that Arbaminch town which consists of 11 kebele can consume fuel wood @ 66 t day⁻¹ or 24,090 t yr⁻¹ (Table 1).

The survey conducted in 4 sub city revealed that average fuel wood consumption in the city vary from lowest (30 kg day⁻¹) for sub city 4 and highest for sub city 2 (100 kg day⁻¹) with the average Consumption of 56.25 kg day⁻¹ to these hotels. There was significant variation in per day fuel wood consumption in these hotels attributed to the availability of alternate sources of energy with them. Thus these hotels consumes appx. 969.08 tonne of fuel wood annually (Table 2).

Table 2: Average fuel wood consumption in Arba Minch hotels

Name of kebele	Total Hotels (appx)	Sampled Hotels	Avg. consumption day ⁻¹ hotel ⁻¹ (kg)	Consumption day ⁻¹ sub-city ⁻¹ (kg)	Consumption yr ⁻¹ (t)
Sub city-1	15	3	45±5*	675	246.38
Sub city-2	10	2	100±7*	1000	365.00
Sub city-3	16	3	50±4.5*	800	292.00
Sub city-4	6	1	30±3.5*	180	65.70
Total	47	9	56.25	2655	969.08

*: significant at statistical level of (p=0.05)

Different governmental institutions use fuel wood in various amounts. As a sample two governmental institutions were taken. The two big institutes in the sub city include Arba Minch university and Govt. Hospital. The total fuel wood consumption for these two institutes were 90 t and 20 t day⁻¹ respectively with annual consumption of 32.85 t and 7.30 t respectively. The higher fuel wood consumption of Arba Minch University as compared to Govt. Hospital is because of more number (5) of campuses of the university and mostly use fire wood for cooking purposes. The use of electricity was used for baking enjera (personal communication). In contrast, Arba Minch general hospital use stove rather than using fire wood. They specially use wood chip from wood processing industries. The fuel wood consumed by those two governmental institutions is represented by the following table (Table 3).

Table 3: Average fuel wood consumption in institutes

Name of the institute	Avg. consumption day ⁻¹ (kg)	Consumption yr ⁻¹ (kg)
Arba Minch University (AMU)	90 ±10	32,850
Govt. hospitals	20±4	7,300
Total	110	40150 (40.15 T)

Among different user group the maximum fuel wood consumption was recorded for HHs (66 t day⁻¹) or 24090 t year⁻¹ followed by hotels (2.65 t day⁻¹ or 969.08 t year⁻¹), Govt. Institutes 110 kg day⁻¹ or 40.15 t year⁻¹. In this way total fuel wood consumption of the users' group were 68.8 t day⁻¹ or 25099.23 t year⁻¹ (Table 4).

Table 4: Amount of fuel wood consumed day⁻¹ (kg) by different user groups (appx)

User group	Avg. consumption day ⁻¹ (kg)	Consumption yr ⁻¹ (t)
All HHS	66000	24090
Hotels	2655	969.08
Govt. Institutes	110	40.15
Total	68,776	25099.23

3.2. Sources of energy

The sources of energy used by Arba Minch town vary from Kebele to Kebele significantly. Wood, charcoal and electricity (Table 4) are the main sources of energy that peoples are using in these kebeles. It was observed that out of total 58 respondents coal and fire wood was used by 22 respondents (38%) each as a source of energy followed by 10 HHs using both coal and fire wood (17%) and 4 HHs (7%) as electricity (Table 5 and Figure 2). Electricity is mainly used for lighting

Table 5: Source of energy for the four kebeles for Arba Minch town

Kebeles	No. of HHs	Types of energies used			
		Charcoal	Fire wood	Elec- tricity	All
Chamo	18	6	6	2	4
Dilfana	14	4	6	2	2
Idget ber	20	10	8	0	2
Kulfo	6	2	2	0	2
Total	58	22	22	4	10
		5.5±2.90*	5.5±2.14*	1±0.98*	2.5±0.85*

*: significant at statistical level of (p=0.05)

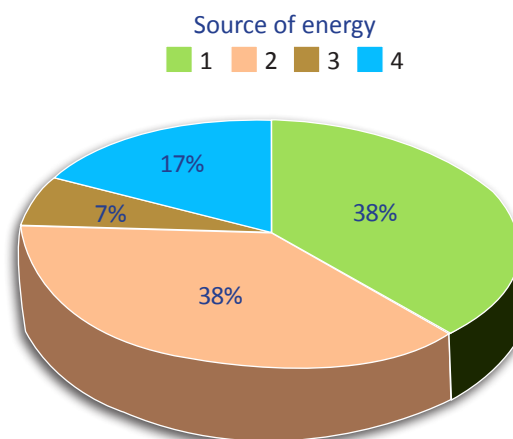


Figure 2: Source of energy (%) of Arba Minch town

and some other household items like television and charging mobile phones. The energy sources of four kebeles from Arba Minch town kebeles were illustrated in the table below.

3.3. Purposes of energy sources

The results revealed that there was significant variation for using different sources of energy for different purposes. It was observed that 37.93% of the HHs use charcoal only for

cooking while 44.83% use both charcoal and firewood for cooking. Similarly, 72.41% were using charcoal for cooking as well as selling whereas 27.24% of HHs do selling and cooking of both firewood and charcoal. It is clear from the table that only 17.24% of the population use electricity as source for cooking while 96.55% of the respondent get agree that electricity is the only source for lightening (Table 6).

Table 6: Purpose of different energy source for Arba Minch town dwellers

Purpose	HHs use charcoal	HHs use firewood and charcoal	HHs use electricity	Mean±SD
Cooking	37.93	44.83	17.24	33.33 ±13.27*
Selling and cooking	72.41	27.24	0	33.22±33.22*
Lighting	0	3.45	96.55	33.33±50.61*

3.4. Sources of fuel wood for Arba Minch town dwellers

Arba Minch forest is the major source of fuel for Arba Minch town where people used to get fuel wood from government owned Nechsar national park. Thus if the situation prevails longer it will lead to degradation of Arba Minch forest and will results in migration of wildlife from Nechsar national park. Because park is loosing appx. 24,090 t fuel wood yr⁻¹.

In similar study Desse (2015) reported that about 98% of Arba Minch inhabitants are reliant on fuel wood as their major source to meet their household energy demand, Nech Sar National Park being the prime source for it. 94% of the respondents mentioned that the fuel wood comes totally from the Park while the rest of the respondents mentioned that the neighboring mountains are additional sources for the fuel-wood supply of the city (Alemu, 2017).

As par Nechsar National Park official, the communities is collecting fuel wood illegally from the park daily. To control this patrolling by shifting guard is practised, community awareness also given, by associating the local people in work and by insuring participatory forest and wildlife management (personal communication). Alemu (2017) also reported that trees (both live and dead), and branches are being cut from the Ground Water Vegetation of the park in an illegal way. Though the Park is exerting its capacity for the protection of the forest and its associated resources, the fuel-wood collectors will always find their way to do their regular duty. The trends of fuel wood consumed were increased from time to time but the organization does not have official data regarding. According to park official around 30-40 people's daily take away fuel wood from this park which not only affecting park management but due to sound made by them also results in change in habitat by some wild life animals/birds. Alemu (2017) reported that the intensity of fuel collector increased after 5 pm onwards as Park Ranger will be off from their duty and the patrolling activities will be minimal to none.

The present study survey showed that if the current trend continues, a huge number of trees will be sacrificed daily by the inhabitants and will be continued if protection efforts are not intensified and will lead to vanishing of Ground

Water Vegetation of local and economic importance. Thus, there is some issues which needs to be addressed like law enforcement, creation of alternative livelihood opportunities and provision of alternative sources. Alemu (2017) also felt similar need to release pressure from Nechsar national ark.

4. Conclusion

Fuel wood is the major source of energy for the people of Arba Minch town with daily consumption of 4.01 kg and 66 t at family and town level respectively. Nechsar National Park (NNP) is the major source of fuel wood collection for them. Annual consumption of fuel wood by different user is 25,099 t year⁻¹ where NNP is the major source and causing severe threat to park by affecting biodiversity and associated wild life resources. Thus, adoption of alternative sources of energy is highly recommended.

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