Assessing The Impacts Of Utilization Of Traditional Cook Stove In Comparison With Improved Cook Stove On Rural Livelihood In Adiyo Woreda, Kaffa Zone, Snnprs. (The Case Of Selected Kebeles)

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ABSTRACT: Over 94 percent of energy consumption in Ethiopia comes from biomass fuels along with traditional cooking technologies and this pattern has major effect on livelihood in the country. To overcome these problems the government of Ethiopia and International development organizations, have recently ramped up efforts to promote the use of improved cook stoves (ICS) in the country, aiming to reduce impacts of the burning of biomass for cooking and heating. Thus, the purpose of this study was to evaluate the effects of traditional cook stove in comparison with ICS utilization on rural livelihood in the case of Adiyo Woreda, Kaffa Zone. Among 28 kebeles in Adiyo Woreda, Boka and Mera Kebeles were selected using purposive sampling. Sample size between ICS and traditional CS users, was determined using proportionality principle and more proportion of sample was given to those ICS user households. Then, 298 sample households were selected using systematic random sampling technique. The household surveys, focus group discussion, personal observations and key-informants interview were used for primary data collection. Data were analyzed using descriptive and inferential statistical techniques. The study revealed that traditional CS user household spending more than five hours additional cooking time per day; more likely to suffer from eye disease, lung cancer, respiratory disease, cough, headache and phlegm than the user groups. Women and children contributed over 98.95% and 80% of the domestic cooking and fuel wood collecting responsibility in the household of the study area respectively.

Keywords: Biomass energy source, Improved cook stove, Rural livelihood, Traditional cooking stove, Utilization.

1. INTRODUCTION

Ethiopia is one of the developing countries with more than 80% of the country's population is engaged in the small-scale agricultural sector and live in rural areas, traditional energy sources represent the principal sources of energy in the country. Domestic energy requirements in rural and urban areas are mostly met from wood, animal dung and agricultural residues. At the national level, it is estimated that biomass fuels meet over 94% of total energy consumed in the country (Zenebe, 2007). The Ethiopia energy policy promotes ICS as an appropriate technology to reduce emissions from deforestation and forest degradation as well as to improve the livelihood of rural people. As the result of this in 1970s, the Ethiopian Rural Energy Development and Promotion Centre (EREDPC), has been engaged in the business of improving household cooking efficiency, resulting in three improved cook stoves, namely: “Laketch” charcoal stove, “Mirt” fuel wood stove, and the “*Gonzie*” multi-purpose wood stove used for baking, cooking and boiling (Zenebe, 2007). Since *Adiyo Woreda* is one of the rural areas in Ethiopia, it also shares similar problem. According to *Adiyo Woreda* Water, Mine and Energy Office (AWWMEO) annual report 2016; more than 97% of the *Woreda* households use traditional stove, which has a number of drawbacks. First, in most of the households of the *Woreda*, food cooking and *Injera* baking is carried out using an open fire /three stone/ system, which is inefficient at converting energy into heat for cooking. Because of this, the amount of biomass cooking fuel required each year could reach up to 2 tons per family (Ezzati & Kammen, 2002). To obtain this amount of fuel, women and children have to travel further distances to collect wood fuel, thus causing loss of human availability for productive work. In addition to this, it also takes long cooking times. Since, traditional stoves consumes large amount of wood fuel, Moreover, indoor pollution problem due to smoke emission using traditional biomass stoves produces significant amounts of smoke, which can pose a health threat including acute respiratory illnesses and even cancer, with women and young children affected disproportionately. In addition to this, Greenhouse gas emission concern burning of biomass significantly contributes to CO2 as well as black carbon emissions, which intensify greenhouse gas in the atmosphere (George, 2002). Most available studies related to impacts of ICS, such as Kai, (2003) and Zenebe et al. (2006) have generally focused on urban area, such that the rural sector is under-represented. However, the high dependence of rural dwellers on biomass resources has greatly contributed to the current livelihood in the study area. Therefore, focusing on rural households is useful, from the viewpoint of improving rural livelihood as well as reducing the ill effects of biomass fuel use on health. Furthermore, this study aims at comparing the difference between effects of traditional and ICS utilization on rural livelihood and forest coverage, which have not shown in previous study. Therefore, this study has filled these knowledge gaps and added onto the existing knowledge. By having the aim at analyzing the effects of improved cook stove utilization on the local livelihood in *Adiyo Woreda*, *Kaffa* Zone, and SNNPRS.

2. Materials and Methods

2.1. Study site

This study was carried out in two selected *kebeles*, namely *Boka* and *Mera Kebeles* of *Adiyo Woreda*, in *Kaffa* Zone. *Adiyo Woreda* is one of the ten *Woredas* of *Kaffa* Zone. The study area lies between 7° 8' to 7° 26'N latitude and 36° 15' to 36° 50'E longitude. It shares boundaries with Oromia region of Jimma Zone in the North and North east, TelloWoreda in the South, GimboWoreda in the West, Decha Woreda in the Southwest and Konta special Woreda in the South East (KaZoFED, 2013). According to the ZoFED, Adiyo Woreda covers a total area of about 94,992.3 km^2 which comprised 9.45% of the Zone. In order to facilitate the socio economic development of the *Woreda*, it was structured in to 27 rural and 01 urban *kebeles* .The highest political decision body is the *Woreda* council, which has 81 (seats) council members. All political, economic, social as well as governance duties are carried out by the *Woreda* cabinet members and council of the *Woreda*. *Adiyo Woreda* is a predominantly highland area with undulating landscape, mountains and rivers, forests, wide vegetation cover and wildlife. As AWADO (2010), about one third of *Adiyo* and the surrounding area is covered by forest comprising a rich mixture of species. *Adiyo Woreda* has the mean annual rainfall ranging between 1400 and 2000 mm and average annual temperature varying from 12 ºC to 26 ºC. It has three traditional agro-ecological zones such as cold zone (*Dega*) 2500-3000 meters above sea level (masl), semi cold zone (*Woina Dega*) 1500-2500 masl, and hot zone (*Kolla*) 500-1500 masl. Thus, cold zone, semi-cold and hot zones comprised for 56%, 38% and 6% of the *Woreda* respectively (KaZoFED, 2013).

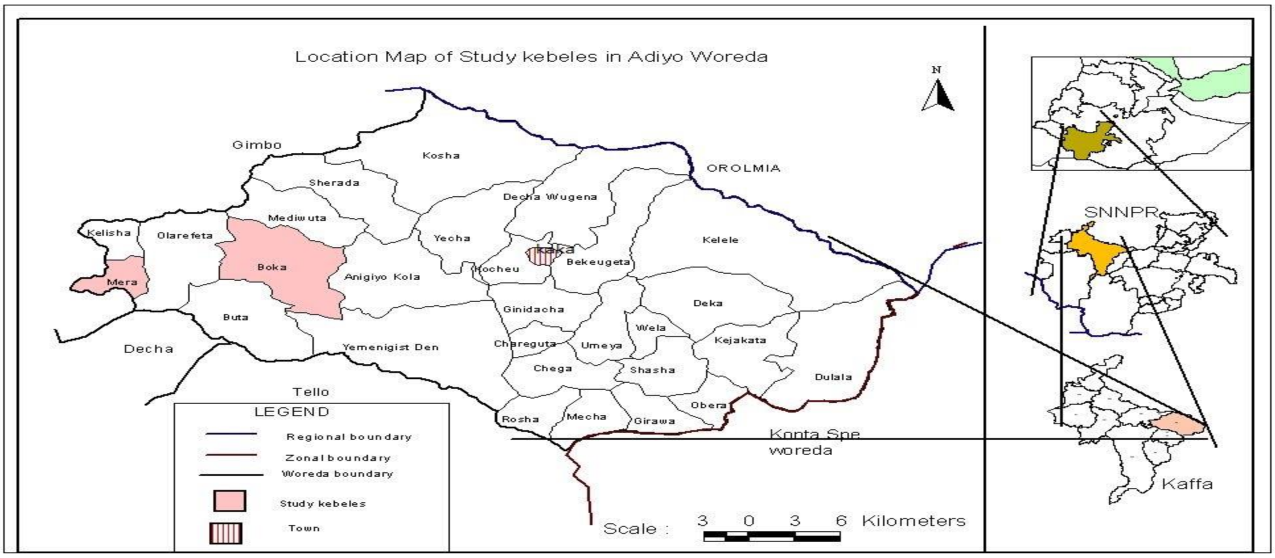

Figure 1. *Location map of Addiyo Woreda*

Source: SNNPRS Finance and Economy Development Bureau, 2016

2.2. Research Design

A mixed approach of both qualitative and quantitative methods was used in the analysis of the study. Therefore, qualitative as well as quantitative data were collected in the form of opinions, semi-structured interviews, focus group discussion and observation. For this reason, it was necessary to use a mixed methods approach coding the data in two ways: qualitative and quantitative.

2.3. Sampling Techniques

Multi stage sampling technique was used to this study. In the first stage, Purposive sampling was used to select *AdiyoWoreda* among 10 rural *Woredas* and 1 City administration that were found in *Kaffa* Zone because of the researcher's deep work experience in the study area. In the second stage, for the selection of sample *Kebeles* among 28 *kebeles* that exist in the study area, purposive sampling was also used based on the distribution of ICS services made by the *Woreda* energy office. To this end, ICS distribution has been made only in 8 *kebeles* while, in the remaining of 20 *kebeles* there was no distribution. According to the report of *Adiyo Woreda* Water Energy and Mine Office (AWWEMO) (2016), the priority given for those 8 *kebeles* was because they are residing near to the *Buta* forest, which is included under Biosphere reserved region. From those of 8 accessed *kebeles*, two of them with the highest number of stove distribution were selected using purposive sampling because the number distributed stoves is few in all 8 *kebeles* as compared to the number of households in those *kebeles* (AWWEMO, 2016). In addition to this, researcher's main aim was to investigate the contribution of ICS utilization on rural livelihood improvement. To do so, representative sample was taken from the population. Moreover, this method allowed the researcher to examine factors that determine the utilization of ICS technology. The sampling frame was included all the households in these two *kebeles* including both household groups that are user and non-user of the improved cooking stoves. The total number of the households in these two *kebeles* was 1,162 and the sample size was determined using Yamane (1967) formula as follows:

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

This formula was employed to calculate the sample sizes at 95% confidence level and P =0.5. Where n is the sample size, N is the population size, and e is the level of precision. When this formula is applied to the above sample, we get

$$\frac{1162}{3.905} = 298$$

Therefore, the researcher believed that a total of 298-sample size was a representative of the population. The sample size for each *kebele* was determined using the proportionality principle. Moreover, the sample size between the two strata (ICS users and traditional CS users) was further determined by giving more proportion of sample (60% of proportionate sample size) to those ICS user households. This was because of their being few in number. Then the sample households were selected using systematic random sampling technique.

Table 1: *sample size Determination*

Kebeles	Clusters of Samples		Total No. of HH	proportionate sample	60% of Proportionate sample (from ICS users cluster)	40% of Proportionate sample (from the non-user cluster)
	No. of user households	No. of non-user households				
Boka	209	621	830	213	128	85
Mera	175	157	332	85	51	34
Total	384	778	1162	298	179	119

Source: *Adiyo Woreda* Water, Mine and Energy office, 2016.

The population for this study was both traditional and improved cook stove users. Moreover, both male and female households were included to the study. Sample household respondents were selected through simple random sampling technique using the sampling frame of the list of the households obtained from the *Woreda* Water and Mineral Office for the ICS users of ICS and the list from the *Woreda* Finance and Economic development Office for non-ICS users of the ICS.

2.4. Tools and Techniques for Data Collection

Large and representative household sample survey was collected in order to obtain the information that was needed to conduct the research. To carry out this, different tools were used for this study. Data was collected from different sources through structured questionnaires, interview, personal observation and focus group discussion.

2.5. Methods of Data Analysis

The survey generated both qualitative and quantitative data was summarized, categorized and coded some qualitative responses into numeric values and then entered in to statistical program (StataIc11) and Microsoft window (2007). Information obtained from unstructured interviews and informal interviews with key informants and with focus group discussion in the study area was narrative and qualitative in nature and used to support the coded qualitative and quantitative data. Descriptive statistics; sum, mean, standard deviation, cross tabulation and percentages was presented in tables, graphs to enable easy interpretation and quick visual comparisons of variables within the study area. T-test test was also used to make comparative analysis between the user households of ICS and traditional cook stove in order to understand the effect of both stoves more clearly. To do so, two-group mean comparison test was used for the analysis of the study, since the emphasis is on comparing the means from two groups (ICS users and traditional CS users).

3. RESULTS AND DISCUSSION

The Effects of Traditional Cook Stove in Comparison with ICS Utilization on Rural Livelihood Different literatures have pointed out that utilization of traditional cook stove causes various effects on rural livelihood and the forest resources such as effects on the amount of fuel wood consumed; time and budget utilized; workload in the household and forest coverage. Therefore, in order to see the effects of traditional cook stove on the livelihood and forest resources, comparative analysis between the user households of ICS and non-user households enable us to understand the effect more clearly. To do so, two-group mean comparison test was used for the analysis of the study, since the emphasis is on comparing the means from two groups (ICS users and traditional CS users). The null hypothesis for this test states that there is no mean difference in between two groups depending on the type of cook stove utilization. Here the inferential statistics focus on the difference between the two groups.

3.1. The Effects of Traditional Cook Stove Utilization on Frequency of Fuel Wood Collection

Before analyzing the frequency of fuel wood collection, let us see about the number of fuel wood collectors engaged in fuel wood collecting activity. Therefore, the results of the t-test for two group means comparison indicated that during dry seasons there was significant difference in the number of fuel wood collectors among non-ICS users ($N=117$, $M=2.42$, $SD=0.96$) and the user ($N=167$, $M=1.41$, $SD=0.68$), $t(282)=10.35$, $d=1.00$, $p > 0.001$ (see Appendix 1) per one round collection. This indicates that the null hypothesis which states that there is no mean difference between two groups (non ICS users and ICS users) was rejected in favor of alternative hypothesis that states there is a mean difference in the number of fuel wood collectors between groups is accepted. Moreover, the mean difference of fuel collector between non-ICS users and user household groups per one round collection time was approximately about one collector. This implies that the number of fuel wood collector engaged in fuel wood collection was more in number in traditional CS users group than the ICS users of ICS (see Appendix 2). This is probably; due to the high fuel consumptions of traditional cook stoves that were used in non-user of ICS households, forced them to meet their fuel demand by sending many collectors in fuel wood collecting activity than the user groups. In this study, frequency of fuel wood collection is the numbers of trips that household member go to fuel wood collecting area in order to collect the fuel wood. Two group mean comparison test showed that during dry season the difference in frequency of fuel wood collection per week between non-user households (*N = 117, M = 2.83, SD = 0.90*) and the user households (*N = 167, M = 2.25, SD = 0.66*) were statistically significant at $p < 0.01$, $t(282) = 6.21$, $d = 0.58$ (see Appendix 1). The result of t-test suggests that the null hypothesis which states that there is no difference between the means between the two groups was rejected in favor of alternative hypothesis states that there is a mean difference between the mean frequency between user and non-user of ICS utilization is accepted. This implies that traditional CS users more frequently accessing the fuel wood from different sources than the ICS users of ICS groups per week. Moreover, the difference in mean frequency of fuel wood collection between non user and user group ranges up to 0.92 in rainy seasons (see Appendix 2). This was due to an increasing demand for domestic energy purpose during rainy season especially more consumption for heating purpose. The probable reason for this frequent collection of fuel wood by traditional CS users was due to inefficient cook stoves that were used in their home that consumes a lot of fuel wood for cooking, lighting, boiling and space heating activities as compared to improved stoves. However, the fuel wood collection frequency also depends on the family size and the distance to fuel wood collection sources. It was found that households near the forest, collected fuel wood more frequently per week than those household who were very far away from the forest. It was also recorded that households whose family size was larger than the mean size of family, which is 4.36 collected fuel wood less frequently than those who have less than the mean family size (Figure 2).

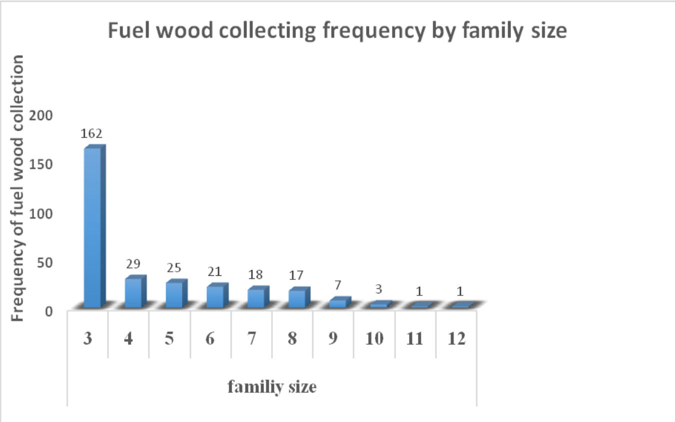

Figure 2: *Frequency of fuel wood collection by Family Size*

Therefore, we can also say that the fuel wood collection frequency decreases with an increase of family size and vice versa. One may expect that larger family size could consume more energy and hence it requires frequent collection of fuel wood to meet their demand. The results suggest that this is not the case. This might be because; from the larger family member, many fuel wood collectors can go for fuel wood collection at a time (per one round fuel wood collection), that can be consumed for many times. The other factor could be age of the family members who are involving in collecting the firewood. That means the more the children involved, the lesser amount (weight) of fire wood collected per one collection time and the more adults involved, the more amount can be collected at once and can be stored for long time, so that reduce the frequency of going to the forest. However, the finding of this study is not in accord with a study conducted in Pakistan by Mohsin (2011) that the large household families required more fuel wood to fulfill their domestic energy needs, so they collected more than one time per week than the one who contained smaller size household members.

3.2. The Effects of Traditional Cook Stove on Time Utilization

The effect of traditional cooking stove was analyzed on fuel wood collecting and cooking time activities.

3.2.1. Effects of traditional cook stove on fuel wood collecting time.

A Two sample t-test revealed that the mean difference in fuel wood collecting time between non-user (*N=117, M=3.45, SD=1.08*) and user groups (*N=167, M=3.56, SD=0.72*) was statistically insignificant at $P<0.1$, $t(282) = -1$, $d = -0.11$ (see Appendix 3) per one round of collection. This suggests that the null hypothesis, which states that there is no mean difference in fuel wood collecting time between the two groups, was accepted. This implies that non-user and user households of ICS were spending almost equal time on fuel wood collection. This might be because of the two groups were sharing similar sources of fuel wood collecting area as which is government forest

3.2.2. Effects of traditional cook stove on cooking time.

Another time consuming household activity are cooking and cooking related activities, which are mainly carried out by females. T-test for two group mean comparison revealed that the mean difference in cooking time between non-user (*N=119, M=8.41, SD=1.32*) and user groups (*N=179, M=3.25, SD=0.76*) was statistically significant at $P<0.001$, $t(296) = 42.74$, d= 5.16 (see Appendix 3) per a day. This suggests that the null hypothesis, which states that there is no mean difference between the two groups, was rejected in favor of alternative hypothesis stating there is a mean difference between non-user and user groups is accepted. This implies that non-user households of ICS were spending an additional of more than 5 hours per a day on cooking and cooking related activities than the user household groups. This might be because of traditional or inefficient three stone cooking stoves which were used in non-user households that take more time to cook the meal. This was similar to a study conducted in South Africa by Restio Eenergy pty Ltd (2009) that the overall time respondents spent in preparing food with the stoves was significantly reduced (between 2 to 4 times) when compared to the time it takes to prepare the same meals over conventional open fires. Moreover, most sources cited that traditional stoves took long time for cooking the meal (Foley & Moss, 1983).

3.3. Effects of Traditional Cook Stove on Household's Health

From Two groups mean comparison test, non-user of ICS (*N= 119, M= 3.06, SD=1.98*) were more likely to suffer from eye diseases than user of ICS (*N=179, M=1.10, SD=1.18*) was statistically significant at *P<0.001, t (296) = 10.75, d= 1.97(see* Appendix 4*)*. This suggests that the null hypothesis which states that there is no mean difference in the occurrence of eye diseases symptom within month duration between the two groups was rejected in favor of the alternative hypothesis that states, there is a mean difference in the number of occurrence of eye diseases symptom between the two groups is accepted. This implies that non-user households of ICS were more likely to suffer from eye disease. Similarly it was also appeared from Two groups mean comparison test, non-user of ICS (*N=119, M= 2.48, SD= 1.57*) were more likely to suffer from respiratory disease than user of ICS (*N=179, M=0.98, SD= 1.01*) was statistically significant at *P<0.001, t (296) = 10.00, d= 1.49*, per a month duration (see Appendix 4). This suggests that the null hypothesis which states that there is no mean difference in the occurrence of respiratory diseases symptom frequency per a month between the two groups was rejected in favor of the alternative hypothesis that states, there is difference in the number of occurrence of respiratory diseases symptoms between the two groups is accepted. This implies that non-user households of ICS were more likely to suffer from respiratory disease. Finally, the Two group mean comparison test was also indicated that (*N=119, M= 1.95, SD= 1.18*) were more likely to suffer from headache and cough disease than user of ICS (*N=179, M=0.97, SD= .94*) was statistically significant at *P<0.001, t (296) = 7.89, d= 0.97*, per month duration (see Appendix 4). This suggests that the null hypothesis which states that there is no mean difference in the occurrence of headache and cough symptom frequency within a month duration between the two groups was rejected in favor of the alternative hypothesis that states, there is difference in the number of occurrence of headache and cough symptom among the two groups is accepted. This implies that non-user households of ICS were more likely to suffer from headache and cough disease. These, more number of occurrences on the above diseases could be due to the fact that traditional (three stone) stove used for cooking in non-user households emitted high smoke that in turn causes the rural family to be more likely suffer from particular diseases due to indoor air pollution (IAP) than ICS user households. Moreover, most of the respondents 96(49.48%) were also identified both wives and children of the households were more likely to suffer from the above diseases. As it was also appeared from focus group discussion, especially non-user of ICS households heads, young fuel wood collectors and cookers claimed that they were facing indoor smoke related health problems such as eye disease, lung cancer, cough, headache and phlegm due to indoor smoke and back pain due to the frequent collection of fuel wood. This is perhaps because traditional cook stoves emit high smoke in pollution content, which affects ICS users' health. The smoke exposure is particularly harmful for cooks closest to the fire and others such as children who spend more time in the kitchen. WHO (2006) provides similar information on aforementioned health problems due to the use of traditional cooking technology.

3.4. The Work load due to the Use of Traditional Cook Stove

The cumulative impacts of the daily practices with traditional cook stoves make immeasurable effect to the livelihoods and surrounding environment of the community in the study area. The survey result indicated that almost more than 41% of the fuel wood collection was carried out by wives; 28.52% by children; 16.2% by husbands and the remaining 13.38% was collected by the combination of household members (see Table 2). this indicated that women particularly, wives were the main responsible for fuel wood collection, processing and using traditional fuel for cooking activity followed by children and husbands.

***Table 2:** Fuel Wood Collecting Responsibility among Household Members*

Responsible person for fuel wood collection	Frequency	Percent
Husband	46	16.2
Wife	119	41.9
Children	81	28.52
Wife and Children	25	8.8
Husband and children	4	1.41
Husband and wife	9	3.17
Total	284	100

Source: Own survey data, 2016

Even though, there was difficult route of forests, which was not safe for the children to collect fire wood in the study area, they were collecting fuel wood at their age of 12 to 14 years. Women and children alone contributed generally, over 80 % of the domestic fuel wood collection while, husband in combination with the other household members did less than 20% of fuel wood collecting responsibility. This might be due to the local culture, which allows them for only all cooking and domestic related activities other than field works. The finding of this study was in accord with the study conducted in Pakistan by Barnes et al. (2011) that 90% of fuel wood was collected and transported by women. The other workload which women are facing is related to cooking activity. To check this assertion, respondents were asked to respond the responsible person in cooking activities. Based on this, 161(54.03%), 2(0.67%) and 135(44.4%) were wives, husbands and the combination of household members (Table 3)

Table 3: *Cooking Responsibility among Household Members*

Responsible person for cooking	frequency	percent
Husband	2	0.67
Wife	161	54.03
Children	18	6.04
Wife and Children	116	38.93
Husband and wife	1	0.34
Total	298	100

Source: compiled from field survey, 2016

Women and children contributed almost over 98.95% of the domestic cooking responsibility while, less than 1% of cooking responsibility was contributed by husband in combination with the other family members in household. Questions like, "what was the main time consuming activity in your house that are hindering you not to be effective on your concerned work?" was raised for focus group discussion participants. To this question, almost all girls who participated in focus group discussion replied that cooking is the main time consuming task that hinders them not to focus more on their educational activities. Among these respondents, one (young girl) quickly blamed about her responsibility in their household was that "no one understands my problem among my household members. They always make me busy in cooking food three up to four times per day. In addition to this, I boil coffee three up to four times, per day, so I don't have any time to study my education". Unfortunately, she was from the traditional CS users' family. From the above analysis of effects of traditional cooking stove (see section 3.2.2), traditional CS users spent an additional cooking time of more than 5 hours per day as compared to ICS users of ICS. This might be due to the aggravating role of traditional cooking stove that were used in traditional CS users that requires more cooking time and fuel wood collecting time as compared to the user households. These activities were also identified in this study as the main responsibility of women and hence it has created more loads to women in the traditional CS users than the ICS users.

3.5. Opportunity Cost due to Fuel Wood Collection among Household Members

Almost all respondents have mentioned that fuel wood collection detracted them from productive activities. For the purpose of clarity, these activities were categorized into 5 general activity groups. These were domestic, agricultural, income generating, educational and recreational activities. The finding of the study indicated that domestic, agricultural, income generating, educational and recreational activities were agreed by 265(93.3%), 147(51.76%), 138(48.6%), 190(66.9%) and 70(24.64%) of household respondents as the principal activity which was mostly affected by fuel wood collection respectively (Table 4).

Table 4: *Level of Agreement on the Affected Activities due to Fuel Wood Collection*

Activities	level of agreement on the affection of the activity					Agreed + strongly agree	% Agreed + strongly agree
	strongly disagree	Disagree	Undecided	Agree	strongly agree		
Domestic activities	8	11	0	152	113	265	93.3
Agricultural activities	0	137	0	88	59	147	51.76
Income generating activities	0	146	0	79	59	138	48.6
Recreation	48	166	0	59	11	70	24.64
educational activity	8	74	12	120	70	190	66.9

Source: own survey data, 2016

This indicated that domestic and educational activities featured as first and the second most affected activities while agricultural, income generating and recreational activities comes third, fourth and last respectively. Among those who, mentioned agricultural and income generating activity as a principal activity affected, majority of them were male respondents. So, overall male responses emphasized on agriculture and business activities while female responses emphasized domestic activities. The result described in section 3.5 above, indicated that, female household members did over 80 % of the domestic fuel wood collection. Among them, there were females students and hence their educational activities were affected by wood collection. The young girls alone or accompanied by mothers or most of the time young girls were being asked to collect fuel wood for cooking. This affects their schooling and ultimately affects their education. The female respondents from focus group discussion stated that their household work burden become doubled due to fuel wood collection. Their cooking, house cleaning, washing and water collection activities were really detracted and most of the times they do not able to manage all the activities. Due to more work burden female had less time for recreational as well as educational activities. According to the data obtained from FDG regarding the constraints collector faced during fire wood collection, women and girls were facing a risk of violence and rape by some peoples in the forest area. Moreover, children were less concentrated on their academic issue, collectors were highly isolated from other productive activities and carrying heavy load by itself is creating immense health problems as well.

3.6. Amount of Fuel Wood and Charcoal Consumption

The amount of fuel wood collected by households is difficult to measure directly because majority of respondents were of no formal education and hence cannot estimate the amount of fuel wood directly using kilogram measurement. To overcome this problem, simplest and indirect measurements such as analysis of frequency of fuel wood collection and the number of fuel wood collector engaged in fuel wood collecting activity were employed by the researcher. The researcher used the mean of frequency of fuel wood collection and the number of fuel wood collectors from section 3.1, to calculate the average amount of fuel wood needed to cook the meal in a household per a week. Later; this figures were converted in to kilogram by taking an estimated average load carried by one collector in the study area. The estimation was conducted by visiting some peoples who were bringing the firewood to their home while they were carrying it. For this purpose, collectors composed of male, female and different age group were randomly selected. Based on this, the average weight of these different groups was found to be 22 kg in dry season while 18 kg in rainy season. This is because of unfamiliarity of rural people to respond the amount of fuel wood collected in terms of kilogram measurement; rather they easily respond the frequency of fuel wood collection and the number of collectors involved in fuel wood collection. Therefore, the average amount of fuel wood additionally collected by non-ICS users households of ICS as compared to user households per a week was calculated to be (the mean number of fuel wood collector) * (the mean frequency of fuel wood collection) * (22 kilogram) for dry season. It was also calculated for rainy season as (the mean number of fuel wood collector) * (the mean frequency of fuel wood collection) * (18 kilogram). Based on this, additional amount of fuel wood collected by an individual non-user of ICS household per week than that of user was 80.87 kilogram during dry season. However, this amount varies from season to season. The survey result was also indicated that the amount of fuel wood additionally collected by an individual non-user of ICS households per week than that of user during rainy season was 77.62 kg (Table 5).

Table 5: *Comparison of Fuel Wood Consumption between User and Traditional CS users Stove HHs*

Data	During dry season		During rainy season	
	Non user groups	User Groups	Non user groups	User Groups
Mean number of fuel wood collectors	2.42	1.41	2.1	1.10
Mean Frequency of fuel wood collection	2.83	2.25	3.3	2.38
Average weight carried by one collector	22	22	18	18
Total amount per week	150.63	69.79	124.74	47.12
The difference per week	80.87		77.62	
The average difference per week				79.24
Average difference per year				3804

Source, own survey data, 2016

This variation in amount, during dry and rainy seasons is due to the fact that the amount of wood collected and carried by the collector was declined in fear of hardship during the rainy season. Moreover, they also store firewood for this specific hard time earlier than the rain time. As the information obtained from FGD, the reason for this decreasing of the amount of fuel wood was duet inconveniency and away route of forests, which was considered unsafe for fuel wood collectors especially, for children and older to be engaged in fuel wood collection and to carry heavy load in rainy seasons. Therefore, by considering the unique weather condition of the study area (six dry months and six rainy months) within a year (AWADO, 2010), the researcher calculated the amount of fuel wood collected per year was 3804 kg (Table 5). Among 178 charcoal ICS users household respondents, it was also recorded that majority 132(74.16%) were obtaining charcoal by purchasing, 29(16.29%) by producing it from the forest and 17(9.55%) were by both means. In general, regarding the amount of fuel wood collected, similar finding was also conducted in Ethiopia by Zenebe (2006) predicted that ICS adopters per household basis collected 68.278 kg less wood each month, while more dung in the form of manure becomes available as 19.899 kg less dung is collected each month.

Conclusion

The mean difference of fuel collectors between non-users and user household groups per a week was approximately about one collector. Regarding fuel wood collecting frequency traditional cook stove users were more frequently accessing the fuel wood from different sources than the user groups per week. The fuel wood collection frequency also depends on the family size and distance to fuel wood collection source. It was found that households near the forest, collected fuel wood more frequently per week than those household who were very far away from the forest. Households whose family size was larger than the mean size of family, which is 4.36, collected fuel wood less frequently than those who have less than the mean family size. Therefore, we can also say that the fuel wood collection frequency decreases with an increase in family size and vice versa. The non-user households of ICS were spending an additional of more than 5 hours per a day on cooking and cooking related activities than the user household groups. Regarding the finding on health, non-user households of ICS were more likely to suffer from eye disease, lung cancer, cough, headache and phlegm due to indoor smoke and back pain due to the frequent collection of fuel wood. Women and children contributed almost over 98.95% and 80% of the domestic cooking and fuel wood collecting responsibility in the household of the study area respectively. Due to more work burden female had less time for educational activities and hence their schooling were affected. Women and girls were sometimes facing a risk of violence and rape by some peoples in the forest area during fuel wood collecting time. Individual non-user households of ICS as compared to user households of ICS additionally collected an average load of 3804 kg of fuel wood per year. Therefore, an average of 660 square meter of forest was additionally cutting down by an individual non-user of ICS household as compared to users per year. Therefore, in general the use of traditional cooking stove was found more likely to affect household's livelihood and the nearby forest resource negatively as compared to ICS.

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Appendices

Appendix 1: *comparison of frequency of fuel wood collection and number of fuel wood collectors in dry season among ICS user and traditional CS users.*

```
. ttest  COLLWIN, by(UTLIZATION)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
non-user	117	2.418803	.0885746	.958081	2.24337	2.594237
user	167	1.413174	.0525283	.6788146	1.309464	1.516883
combined	284	1.827465	.0560554	.9446628	1.717126	1.937803
diff		1.00563	.097112		.8144733	1.196786

```
    diff = mean(non-user) - mean(user)                          t =  10.3554
Ho: diff = 0                                   degrees of freedom =      282

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
. ttest FREQWIN, by(UTLIZATION)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
non-user	117	2.82906	.0834796	.9029702	2.663718	2.994402
user	167	2.251497	.051469	.6651258	2.149879	2.353115
combined	284	2.489437	.0487448	.8214619	2.393488	2.585385
diff		.5775628	.0930597		.394383	.7607427

```
    diff = mean(non-user) - mean(user)                          t =   6.2064
Ho: diff = 0                                   degrees of freedom =      282

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```

Appendix 2: *Comparison of frequency of fuel wood collection and number of fuel wood collectors in rainy season among user and non-users of ICS*

```
. ttest   COLLSUM, by(UTLIZATION)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
non-user	117	2.102564	.0722105	.7810759	1.959542	2.245586
user	167	1.095808	.0228443	.2952135	1.050706	1.140911
combined	284	1.510563	.0439106	.7399941	1.424131	1.596996
diff		1.006756	.066282		.8762854	1.137226

```
    diff = mean(non-user) - mean(user)                          t =  15.1890
Ho: diff = 0                                   degrees of freedom =      282

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
. ttest    FREQSUM, by(UTLIZATION)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
non-user	117	3.299145	.0689539	.7458501	3.162573	3.435717
user	167	2.377246	.0527826	.6821013	2.273034	2.481457
combined	284	2.757042	.0499136	.8411584	2.658793	2.855291
diff		.9218998	.0854802		.7536395	1.09016

```
    diff = mean(non-user) - mean(user)                          t =  10.7849
Ho: diff = 0                                   degrees of freedom =      282

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```

Appendix 3: *comparison of cooking time among user and non-user of ICS groups*

```
. ttest    TWOODC, by(UTLIZATION)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
non-user |     117    3.448718     .100724    1.089497    3.249221    3.648214
    user |     167    3.556407    .0559789    .7234074    3.445885     3.66693
---------+--------------------------------------------------------------------
combined |     284    3.512042    .0529526    .8923725    3.407811    3.616273
---------+--------------------------------------------------------------------
    diff |           -.1076892    .1075852               -.3194613    .1040828
------------------------------------------------------------------------------
    diff = mean(non-user) - mean(user)                            t =  -1.0010
Ho: diff = 0                                     degrees of freedom =      282

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.1589         Pr(|T| > |t|) = 0.3177          Pr(T > t) = 0.8411

. ttest    TCOOK, by(UTLIZATION)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
non-user |     119    8.411597    .1211504    1.321595    8.171686    8.651507
    user |     179    3.255307    .0565444    .7565128    3.143724    3.366891
---------+--------------------------------------------------------------------
combined |     298    5.314362     .157963    2.726865    5.003494    5.625231
---------+--------------------------------------------------------------------
    diff |            5.156289    .1206474                4.918854    5.393725
------------------------------------------------------------------------------
    diff = mean(non-user) - mean(user)                            t =  42.7385
Ho: diff = 0                                     degrees of freedom =      296

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```

Appendix 4: *Comparison of ill effect reports among user and non-users of ICS per month*

```
. ttest      FRQEYED, by(UTLIZATION)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
non-user |     119    3.067227    .1820655      1.9861    2.706688    3.427766
    user |     179    1.094972    .0881151      1.1789    .9210873    1.268857
---------+--------------------------------------------------------------------
combined |     298     1.88255    .1058099    1.826562    1.674318    2.090782
---------+--------------------------------------------------------------------
    diff |            1.972255    .1835526                1.611021    2.333488
------------------------------------------------------------------------------
    diff = mean(non-user) - mean(user)                            t =  10.7449
Ho: diff = 0                                     degrees of freedom =      296

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
. ttest       FRQRESPD, by(UTLIZATION)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
non-user |     119    2.478992    .1436342    1.566864    2.194557    2.763426
    user |     179    .9832402    .0757756    1.013808    .8337061    1.132774
---------+--------------------------------------------------------------------
combined |     298    1.580537    .0845409    1.459402    1.414162    1.746912
---------+--------------------------------------------------------------------
    diff |            1.495751     .149462                1.201609    1.789894
------------------------------------------------------------------------------
    diff = mean(non-user) - mean(user)                            t =  10.0076
Ho: diff = 0                                     degrees of freedom =      296

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
. ttest        FRQHDAD, by(UTLIZATION)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
non-user |     119     1.94958    .1086284    1.184996    1.734466    2.164694
    user |     179     .972067    .0706108    .9447083     .832725    1.111409
---------+--------------------------------------------------------------------
combined |     298    1.362416    .0666242    1.150112    1.231301    1.493531
---------+--------------------------------------------------------------------
    diff |            .9775128    .1238535                .7337678    1.221258
------------------------------------------------------------------------------
    diff = mean(non-user) - mean(user)                            t =   7.8925
Ho: diff = 0                                     degrees of freedom =      296

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```