Assessment of Woody and Non-Woody Fuel Biomass Resource Availability and Rate of Consumption in the Somodo Model Watershed South-Western Ethiopia

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Abstract
Plant biomass is a major source of energy for rural households in Ethiopia. Nevertheless, the heavy reliance on this form of energy is a threat to forest ecosystems and a root cause for accelerated land degradation. Due to the increasing scarcity of fuel wood resources, rural communities have shifted to utilization of crop residues which important resources for soil fertility improvement. Therefore, this study was focused on assessment of woody and non woody fuel biomass resources availability and the rate of consumption in the Somodo model watershed. A survey was conducted in the Somodo model watershed, using a semi-structured questionnaire and focus group discussions for primary data collection. The data was analyzed by using SPSS version 16. The household survey result shows that, the main source of energy in both improved fuel saving stove user and non-user were fuel wood, crop residue and coffee husk for cooking activities. With regard to annual energy consumption, the amount of energy consumed by improved stove non-user is twice higher than improved fuel saving stove user. In addition, the result indicates that both groups (improve fuel saving stove user and non-user) mainly got fuel wood from forest found around their home and from their own farmlands. Hence, the pressure on woody biomass in both groups implies the absence of electricity in the model watershed and this is one of the major factors of exploiting forest resources. As a result, forest resource degradation is the primary threats. Therefore, the study suggests that government and nongovernmental organizations should provide alternative energy sources that can simplify the pressure on the forest resources in the area.
Keywords: Woody and Non-woody biomass, Forest resource, Improved stove, Model watershed, Energy

1. INTRODUCTION

Renewable energy can support countries to achieve their policy objective for affordable energy to expand electricity access and promote overall growth. As economies develop and become more complex, energy needs increase greatly. From supply point of view, biomass is a renewable energy source because its supplies or endowment are not limited. In the other words, As long as, we grow trees and crops, and waste will always exist. That's why biomass is defined as the term for all organic material that stems from plants. It is produced by green plants converting sunlight into plant material through photosynthesis and includes all organic wastes. Different studies verdict that biomass is the most common form of renewable energy, widely used in the third world countries. According to Kambewa and Chiwaula (2010) report, biomass services exclusive energy source for developing countries. Dunkerely (1981) also summarize in his research that biomass accounts a high proportion of gross national energy consumption at household level. In Ethiopia, Plant biomass fuel is a major source of energy for rural parts and it contributes about 95% of the country's total energy, of which woody biomass provides 82% (EFAP,1993). Though, the heavy reliance on biomass energy has become a threat to forest ecosystems and a major cause of land degradation (Kassahun *et al.,* 2013). As fuel wood resources become scarce, Ethiopian rural communities are left with no alternative source of energy other than depending on locally available resources. According to FAO, in Ethiopia, the supplies of fuel wood are inadequate to meet the existing demand. In developing countries, about 10 million hectares of forest loss in each year as a result of fuel wood collection (FAO, 2010). Due to this reason, fuel wood scarcity and increasing firewood cost become a common phenomenon and crop residue and animal dung are being substituted for fuel wood. In the contrary, this substitution reduces the availability of valuable soil nutrients and hence reduces soil fertility, contributing to reduction of agricultural production (Bewket, 2003). The practice of using crop residue and cattle dung for fuel resource has potential for consequently affecting soil nutrient stocks. The extent to which such widespread use of biomass as fuel energy sources has affected the level of nutrient stocks in the watersheds of Ethiopia remains uncertain. Inefficiency in utilization of energy resources are the other huge problem in the country. The research work by Peter confirmed that traditional energy usage and cooking on open fire stove are contributing to high level of biomass resource extraction and consumption and leads to inefficient utilizations (Peter, 2002). The inefficient utilization use of biomass has directly linked to deforestation, indoor air pollution and decline in agricultural production. Therefore, the objective of this study is to assess the availability of woody and non woody fuel biomass resources, Utilization efficiency, transformation technologies and the rate of consumption in the Somodo model watershed south-western Ethiopia.

2. MATERIALS AND METHODS

2.1. Description of the study area

Somodo model watershed is one of the major coffee producing areas in Manna district of Jimma Zone, which is located at 368km South-west of Addis Ababa the Capital City of Ethiopia and 15km west of Jimma town.It is geographically located between 7^{0}46’00”-7^{0}47’00”N latitude and 36^{0}47’00”-36^{0}48’00”E longitude. The total area of the watershed is covered about 400ha and the altitude of the study area ranges between 1900-2050meter above sea level (ARDO, 2008).The minimum and maximum temperature of the watershed is 13^{0}C and 25^{0}C, respectively and also the average annual rainfall is 1800mm. Nitosols and Orthic Acrisols are the dominant soil types with slightly acidic PH, which is suitable for coffee and fruit production (ORG, 2003).

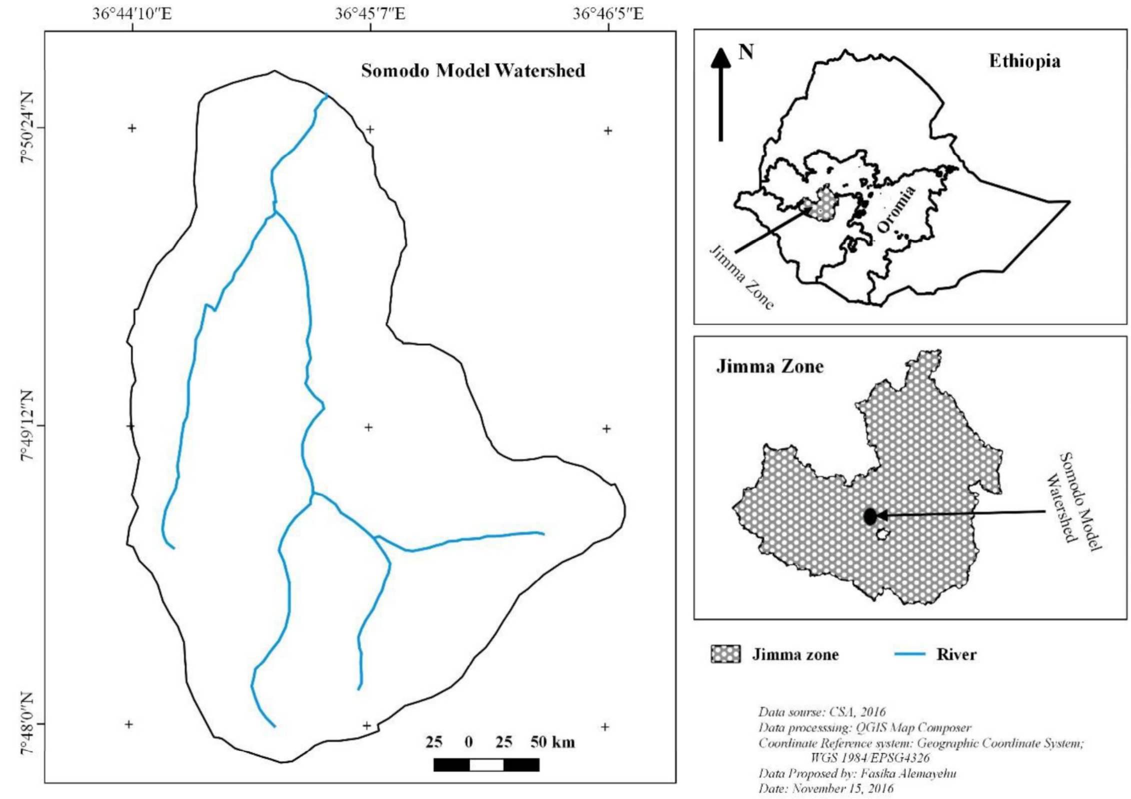

Figure 1**:** Map of the study area

2.2. Data collection

The household survey was conducted using a semi-structured questionnaire and focus group discussions. Clustered and simple random sampling methods were used to select the respondents. The stratification of the households was made based on improved stove user and non-user in the Somodo model watershed. Accordingly, a total of 89 respondents, comprising of 32 improved stove user and 57 non-user respondents were selected in a proportional random sampling method per category from three villages. The questionnaire was contained types of fuel wood used, quantity of fuel wood resource availability and households’ daily usage of fuel wood resources. The total annual biomass fuel consumption was calculated as: biomass consumption ($meal^{-1}yr^{-1}$) = Biomass (kg $day^{-1}meal^{-1}$) X Number of cooking (days yr^{-1}). The respondents’ energy utilization was determined by multiplying biomass consumption by the respective specific energy contents of the different biomass resources in Mega joule given from secondary source.

3. RESULTS AND DISCUSSIONS

3.1. Demographic characteristics of sampled households

The total sample of the study is composed of 36% of improved stove user while the remaining 64% of non-user. This result is clearly shows that improved stove users in the watershed are limited in number (Table 1).Discussion with sample respondents revealed that the lower users of improved stove in the study area are mainly due to lack of awareness, shortage of income and access to adequate improved stove in the watershed. The result in table 1 also indicated that there is significant difference between the numbers of improved stove user across different villages.

Table 1: Improved stove users and non-users within village

	Improved stove user (n=32)	Improved user non-user (n=57)
Village	%	%
Kore	44.1	55.9
Leku	34.5	65.5
Bureya 1	26.9	73.1

The mean age of sample respondents is 34 with minimum and maximum age of 19 and 60 respectively. The F value shows that there is insignificant difference between improved stove user and non-user with regard to age status. The average family size for both improved stove user and non-user was 5.39 in the study area which is smaller than the average family size of 6.4 people per household. The result of one way ANOVA confirms that the existence of statistically not significant difference (P>0.05) in family size between improved stove user and non-user (Table 2).

Table 2: Demographic characteristics of the respondents

Age of HHs	Minimum	Maximum	Mean	Std. Error	F-value
User	19	60	34.28	1.67	
Non-user	18	70	33.84	1.68	
Average	18	70	34	1.23	0.29 (0.86)NS
Family size					
User	3	11	5.7	0.355	
non user	2	9	5.17	0.249	
Average	2	11	5.39	0.205	2.02 (0.15)NS
	User	Non-user	Overall	χ^2	P-value
Marital status	%	%	%		
Married	34.1	65.9	95.5		
Widowed	75	25	4.5	2.77	0.13NS

Note: not significant at P>0.05

Concerning the marital status, about 34.1% of improved stove user and 65.7% of non-user respondents were married. The chi-square test result shows that there is insignificant difference between improved stove user and non-user with regard to marital status (Table 2).

3.2. *Socio-economic characteristics of the respondents*

Education level

Education is an important factor that plays a main role on household decision in adopting new technology. It helps much in creating awareness on new technologies and its applications. The study showed that most respondents from both groups were found to be illiterate and the remaining at the level of read and write (1-4). From the total sampled respondents only few respondents have completed their high school education. The statistical test result showed that there is insignificant difference between both groups via educational status in the study area (Table 3).

Table 3: Educational level of the respondents

	% of respondents (n=89)							
Variables	User		Non-user		Overall		χ^2	P-value
Educational level	No.	%	No.	%	No.	%		
Illiterate	14	43.8	19	33.3	33	37.1		
Read and write	9	28.1	12	21.1	21	23.6		
Elementary school	6	18.8	19	33.3	25	28.1		
High school	3	9.4	7	12.3	10	11.2		
Total	32	100	57	100	89	100	2.74	0.43NS

Note: not significant at P<0.05

Wealth Status

Large proportion of improved stove user is in the medium and rich category as compared to non-user (Table 4). The statistical result shows that there are significant difference in wealth status between improved stove user and non-user (P<0.05). Thus, women improved stove users are better in wealth status than non-user women in the study area.

Table 4: Wealth status of the respondents and wealth classification criteria

	Respondents (n=89)							
Variables	User		Non-user		Overall		χ^2	P-value
Wealth status	Frequency	%	Frequency	%	Frequency	%		
Poor	4	22.2	14	77.2	18	20.2		
Medium	14	27.5	37	72.5	51	57.3		
Rich	14	70	6	30	20	22.5	13.14	0.01**

***Local Wealth Classification Criteria**

Wealth class	Coffee land (ha)	Khat land (ha)	Fruit land (ha)	TLU ownership (#)
Poor	0.125	0.125	0.125	<3
Medium	0.25	0.5	0.25	4-5
Rich	0.5-1	0.75-1	0.5	6-10

*** Significant at P<0.05*

3.3. *Woody and non-woody fuel biomass resource*

Woody biomass resources-in previous, local communities used to collect wood for construction and fuel wood from the forest located far away from the Somodo model watershed. Local communities started growing different tree species around the homesteads as a result of forest resource degradation and less access to the forest resources. Therefore, fuel wood requirement of the respondents partially met from trees grown around the homesteads. Accordingly, 34.4% of improved fuel saving stove users and 56.1% of non-users used forest resource from lopping, tree residue and pruning for fuel wood consumption in the study area (Figure 2).While the rest 12.5% of improved fuel saving stove user and 22.8% of non-user collected fuel wood from woodlot found near their villages. Statistically there was a significant difference between improved fuel saving stove user and non-user with regard to source of fuel wood availability.

Non-woody biomass resources- regarding non-woody biomass resources, coffee husk and crop residue (maize and sorghum) are the most common non woody fuel wood biomass resource in the Somodo model watershed. Maize, teff, soybean, wheat, barley, sorghum, coffee, khat, fruit tree were the main grown in the study area (ARDO. 2008).Crop residue in the Somodo model watershed were utilized for livestock feed, and energy sources. The portion above ground biomass of different crops that remains on the field is used for fuel resources. Among this 50% of improved fuel saving stove user and 15.8% of non user were used coffee husk and crop residue for energy sources (Figure 2). The P value showed that there is significant difference (P<0.05) between improved fuel saving stove user and non-user with regard to non woody fuel resource preference. This result is in line with Kassahun *et al.*, (2013) who conclude that, the demand of traditional fuel wood resources increasing time to time, as a result rural communities have shifted to utilization of crop residue in Mukehantuta watershed.

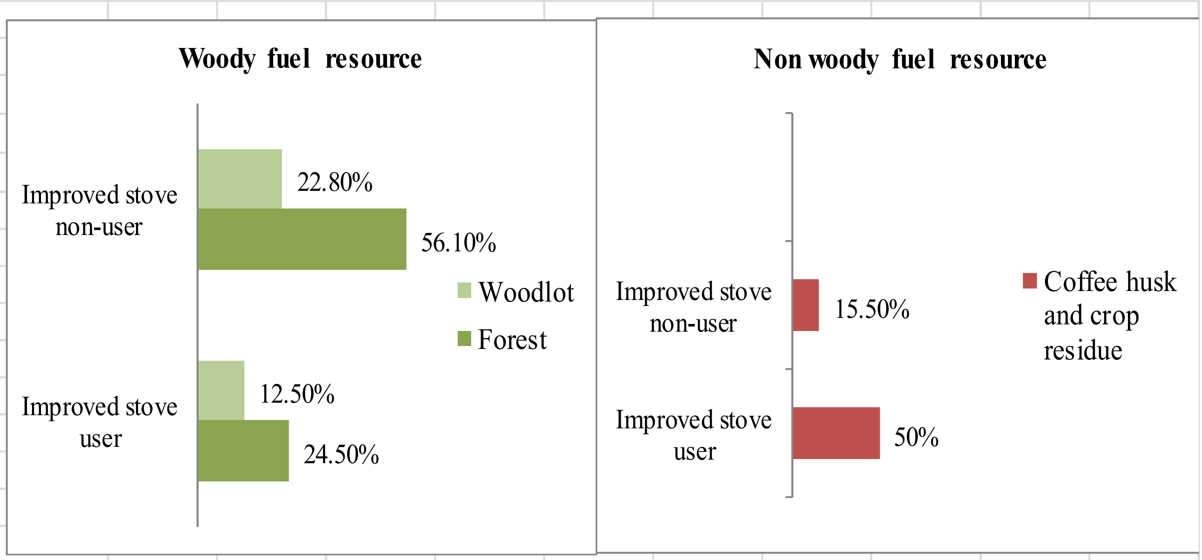

Figure 2: Woody and non woody fuel resources usage

3.4. *Availability of fuel wood biomass*

Based on the household survey made in Somodo model watershed, more than half percent of both groups get acquired fuel wood (woody biomass fuel sources) by collecting from forest found far away from their home (Figure 3).On the other hand, 21.9% of improved fuel saving stove user and only 15.8% of non-user respondents collect fuel source (non woody) from their own farmlands and around homesteads. The rest 12.5% of improved fuel saving stove user and 22.8% of non-user were get energy sources from woodlot. The chi-square test result shows that there is no significance difference (P>0.05) between improved fuel saving stove user and non-user with regard to place of energy source.

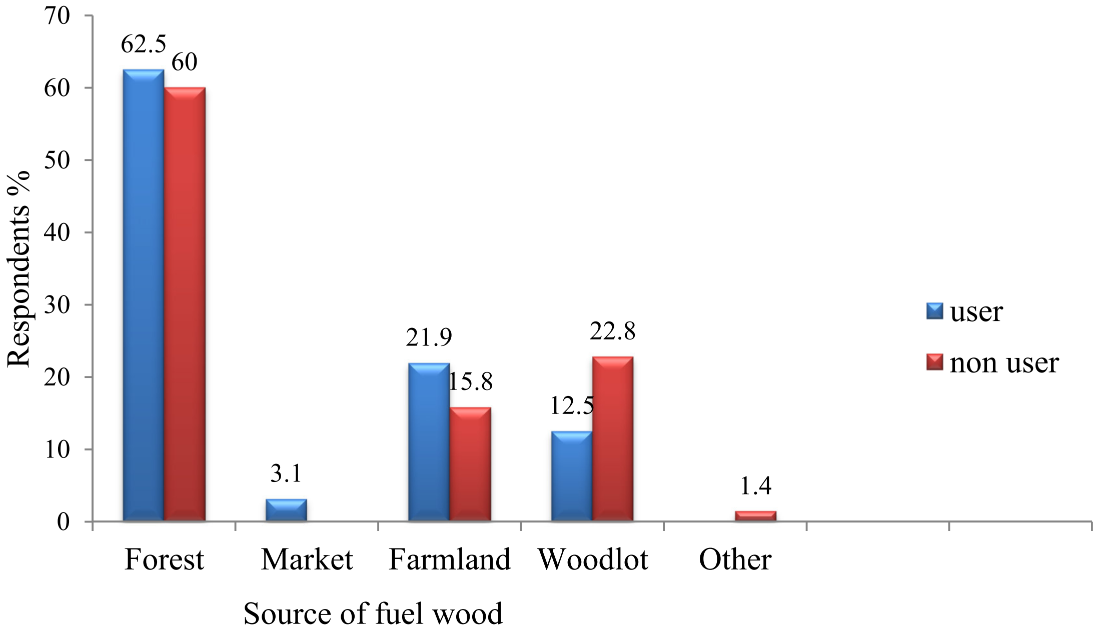

Figure 3: Availability of fuel wood in the study area

3.5. Rate of Fuel Wood Consumption in Somodo Model Watershed

The estimated annual biomass fuel consumption in the Somodo model watershed was 1,444,044.94 $kgyr^{-1}$ and average annual biomass fuel consumption per households was 4813.48$kgyr^{-1}$. In the same manner, the estimated total per capita consumption per day was12kg.The per capita consumption of wood was higher than estimated (2.6kg) provided by the cooperation agreement in the energy sector (CESEN, 1987) and the estimate 2kg used by UNDP and World Bank energy demand assessment (World Bank, 1984).The possible reason is that the family size of the respondents were higher and the calorific value for non woody is low, hence more biomass is burnt to acquire the desired amount of energy.

Figure 4 indicates that, 87.5% of improved fuel saving stove user and 50.9 % of non-user consumed >12kg fuel wood day^{-1} and 42.1% of improved fuel saving stove non-user and only 12.5% of user were consumed 18-24$kgday^{-1}$. The rest 5.3% and 1.8% of improved fuel saving stove non-user were consumed 30-39kg day^{-1} and 45-48$kgday^{-1}$ respectively. The statistical test result revealed that there is significant difference between improved fuel saving stove user and non-user via fuel wood consumption rate in a day. This implies that improved fuel saving stove users were consumed a little fuel wood in a day compared to non-user in the watershed. In addition to this, during focus group discussion, discussants pointed out that, during cooking, the improved fuel saving stove (IFSS) is comfortable, time saving, easy and fast than traditional stove.

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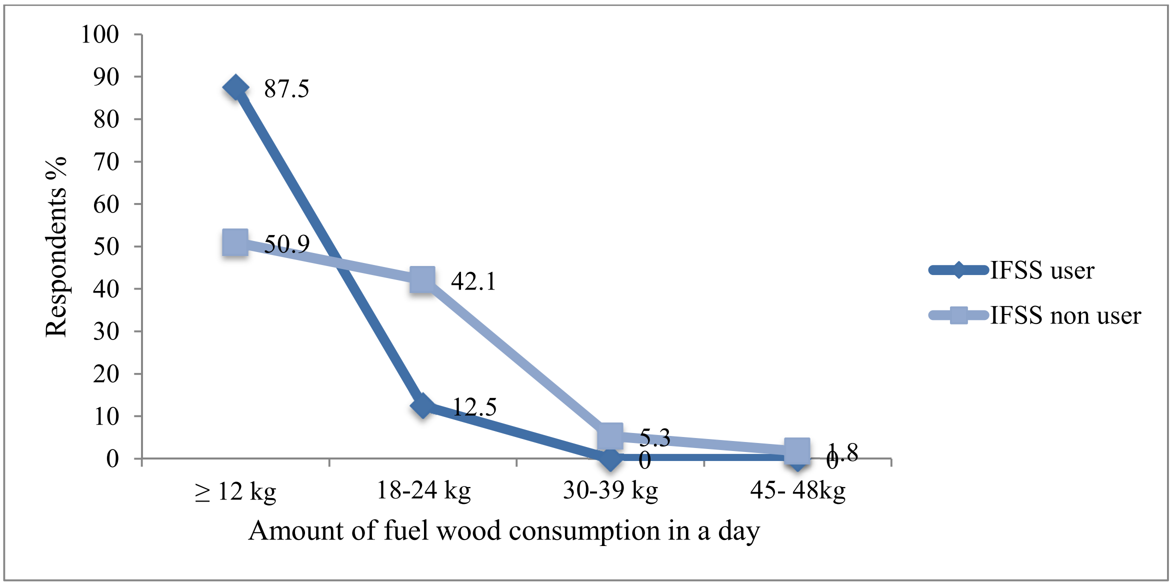

Figure 4: Amount of fuel wood consumption in a day by IFSS user and non-user

3.6. Implication for soil and water conservation

The heavily dependence of households on woody biomass fuel resource indicates that high pressure on forest resource in the watershed leading to forest degradation. As a result, soil erosion, land degradation and biodiversity loss in the study area. In addition to this, soil erosion will again lead to loss of ground water loss due to poor infiltration capacity and washed away the soil nutrient and desertification will occur. This all will contribute to low productivity leading to poverty.

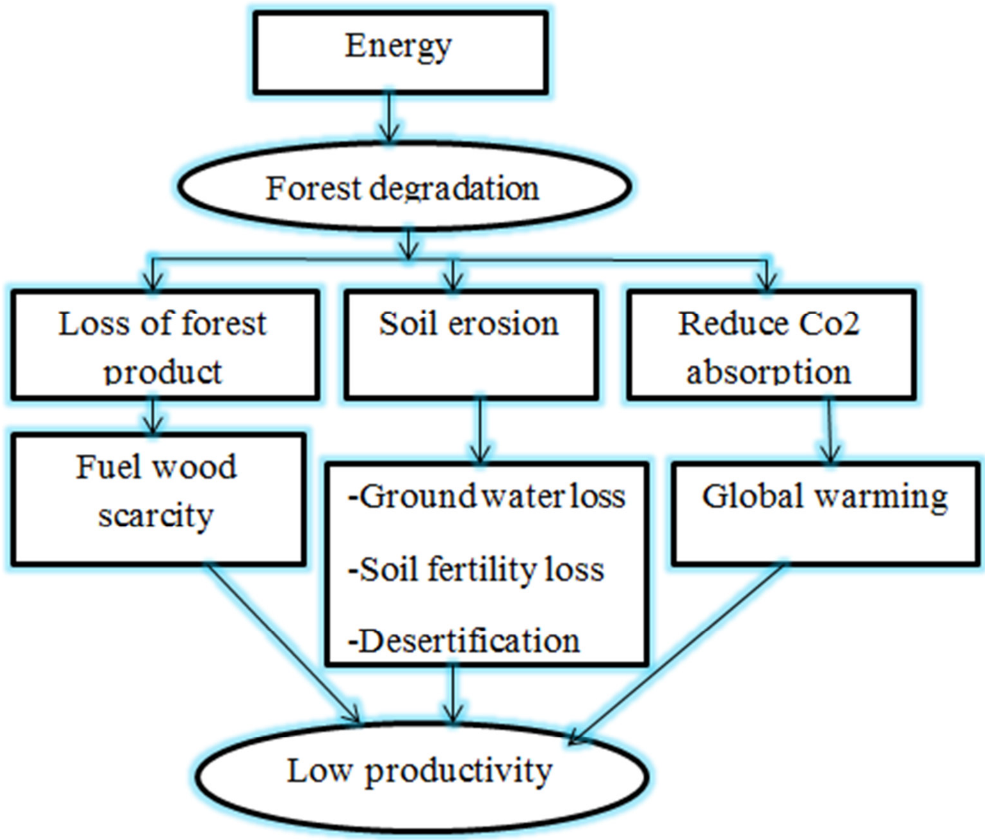

Figure 5: Cycling of deforestation

4. Conclusion and Recommendations

It can be conclude from this study, plant biomass fuel is a major source of energy supply in Ethiopian, more than half percent of country's total energy is woody biomass. Though, the heavy reliance on biomass energy has become a threat to forest ecosystems and a major cause of land degradation. The demand and supply pattern of fuel biomass in the study area shows a high pressure on woody biomass fuel resources. Almost all households in the Somodo model watershed used woody and non woody biomass fuel resources for cooking their food and for the purpose of light. In general, the households' energy source in the Somodo model watershed is totally based on woody biomass fuel resources. However, the rate of consumption between improved fuel saving stove user and non-user is quite different. The daily amount of woody biomass consumed by improved fuel saving stove user is twice less than improved fuel saving stove nonuser in the study area. To sum up, the pressure on woody fuel biomass might be lead deforestation at alarming rate which is at the end of the day will cause of land degradation and increasing soil erosion.

Therefore, based on the above findings the following recommendations are drown.

Policy makers need to focus on investment in strengthening institutional arrangement in the energy sector, development of alternative energy resources, build the awareness of rural communities and facilitate credit schemes to utilize biomass resource with the energy efficient technologies and increase occurrence of multipurpose trees in order to prevent biomass resources degradation and subsequent growth of food security and poverty in the regions. Policy makers should thus target technological innovation both from demand perspective and supply side to ensure sustainable production and utilization of biomass resources that can provide energy security.

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