Energy for Sustainable Development 45 (2018) 186–189

Contents lists available at ScienceDirect

Energy for Sustainable Development

Adoption and kitchen performance test of improved cook stove in the Bale Eco-Region of Ethiopia

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ARTICLE INFO

Article history:
Received 19 August 2017
Revised 6 July 2018
Accepted 9 July 2018
Available online xxxx

Keywords:
Adoption
Improved cook stove
Kitchen performance test
Carbon dioxide

ABSTRACT

This study was conducted to assess the determinants of households' decision for adoption of improved cook stoves (ICS), the performance of the stoves under real kitchen conditions and their potential in the reduction of greenhouse gas emission in Bale Eco-region, Southeastern Ethiopia. Data for this study were collected from 342 household heads that were randomly selected from four rural kebeles. For Kitchen Performance Test (KPT), 25 ICS and 30 traditional cook stove (TCS) user households were selected using stratified random sampling. The data gathered through questionnaire were analyzed using descriptive statistics and binary logistic regression. The data gathered from KPT were analyzed using independent *t*-test. Accordingly, the regression result revealed that higher education level of household head, larger family size and presence of separate kitchen house were significantly and positively related to the adoption of ICS. On the other hand, having men-headed household was related negatively to the decision of households adopting ICS in a significant manner. The KPT result showed that an average of 1.12 (SD = 0.3) kg of firewood is consumed per day for each Standard Adult Equivalent (SAE) for TCS users while an average of 0.79 (SD = 0.2) kg of firewood is consumed per day for each SAE for ICS. The KPT result also showed that using an ICS results in an annual emission reduction of 0.494 tons of CO_2 equivalent.

Introduction

The energy supply of Sub-Saharan African countries is heavily dominated by biomass which accounts for above 90% of energy use. The dominant cooking practice is a three-stone open fire system (Adkins, Tyler, Wang, Siriri, & Modi, 2010; Schlag & Zuzarte, 2008). Such cooking stoves are not efficient in energy use, and they also bring about environmental impacts like decline of forest and associated emission of greenhouse gasses such as carbon dioxide (Lee, Chandler, Lazarus, & Johnson, 2013). Like many other sub-Saharan African countries, Ethiopia's energy supply is heavily dependent on biomass which accounts for above 95% of the energy use (NCCSPE, 2011). Therefore, efforts need to be made to develop or adopt and use improved energy saving cook stoves as an intermediate solution to minimize the adverse impacts of using TCS (GIZ, 2013). Strategies that aim at improving the efficiency of fuel-wood consumption have the potential of conserving forests, mitigating climate change and improving human health simultaneously. Accordingly, the Ethiopian Energy Studies and Research Center (EESRC) has developed ICS as one intervention strategy and such technologies are being disseminated within the country by various actors (MME, 2010).

Despite distributing ICSs to different households, studies on determinants of their adoption, their performances in saving fuel-wood in real kitchen of households and their emission reduction potential have never been conducted in most of the forested landscapes in Ethiopia where ICS were distributed. This study was initiated to determine factors that affect adoption of ICS, assess its performance under real kitchen conditions and estimate its contribution in emission reduction in Bale Eco-region, Ethiopia, where about 1000 ICSs where distributed by a consortium of non-governmental organizations (NGOs) working on sustainable management of forests.

Background

According to climate resilient green economy (CRGE) strategy of Ethiopia (2011), fuelwood (firewood and charcoal) consumption in Ethiopia has led to woody biomass degradation of about 14 million tons in 2010 and this is projected to increase to about 23 million tons in 2030 due to expected continual use of biomass for cooking and baking. This heavy reliance on biomass resources play major role in the depletion of the country's forest resources (Asres, 2002; Gebreegziabher, Mekonnen, Kassie, & Köhlin, 2010;

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https://doi.org/10.1016/j.esd.2018.07.002
0973-0826/

Shanko, 2001). According to CRGE (2011), the greenhouse gas emission from forest degradation due to heavy dependence on biomass energy source in Ethiopia is expected to increase from 24 Mt CO_2e in 2010 to 41 Mt CO_2e in 2030 if no action is taken.

Wider dissemination of ICS is expected to reduce forest degradation and GHG emission from using fuelwood. Accordingly, the Ethiopian government has planned to reach about 16 million households with ICS to reduce consumption of fuelwood with a potential of about 35 Mt CO_2e reduction in annual GHG emission in 2030 (CRGE, 2011). To this end, awareness creation and dissemination of ICS is currently being carried out in different forested landscapes of Ethiopia by government and NGOs. Accordingly, 1000 ICSs (specifically called mirt stove) were purchased by households (about 7 USD) in Bale Eco-region through a facilitation and awareness creation program by a consortium of NGOs working on sustainable forest management in the study area.

Mirt stove was first developed by the Ethiopian Rural Energy Development and Promotion Centre in the early 1990s in Ethiopia (Assefa, 2007; Dawit, 2008; GTZ, undated; Fig. 1). It is produced mainly from red ash (or in its absence, pumice or river sand) mixed with cement (Gashie, 2005; GTZ, 2007). Mirt stove is mainly used for baking injera, a staple food for the majority of Ethiopians, which consumes large amount of firewood in the baking process (Gashie, 2005). Injera is prepared on a clay plate, called mitad, which is placed on the mitad rest (Fig. 1). On top of baking injera, the chimney side of the stove (Fig. 1) can be used for cooking and boiling (e.g. wot, coffee) activities (Dresen, DeVries, Herold, Verchot, & Müller, 2014).

Methods

Study area

The study was carried out in Bale Eco-Region, Southeastern Ethiopia. Bale Eco-Region (BER) lies 400 km southeast of Addis Ababa, capital of Ethiopia. The Bale eco-region is geographically located between 5°22′–8°08′ North and 38°41′–40°44′ East (Charlene, 2013).

Household survey

Multi-stage sampling technique was used to select the study districts and kebeles (administrative hierarchy next to district). Two districts were randomly selected from the districts in which the ICS was disseminated. Then, four kebeles were randomly selected from those kebeles among which ICS was disseminated. Household surveys were conducted in the selected kebeles to gather data on determinants of adoption of ICS and firewood consumption. The number of households included in the survey was determined following the formula of Yamane (1967), at 95% confidence level;

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

where “n” is the sample size, “N” is total household heads in the four kebeles, and “e” is the level of precision (i.e. 5%).

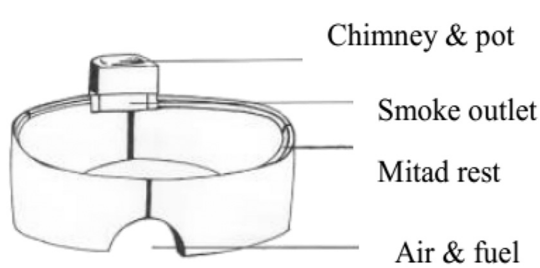

Fig. 1. Design of mirt stove (GTZ, undated).

Accordingly, data were collected from 342 household heads and the sample size in each kebele was determined in proportion to the number of household heads in each kebele. The household survey was conducted with household heads randomly selected from each kebele.

Kitchen performance test

Kitchen performance test (KPT) was conducted to assess the level of firewood consumption of ICS as compared to the TCS (e.g. VITA, 1985). In this study, a cross-sectional approach was used to collect data of firewood consumption from two separate groups of families using ICS and TCS following the method suggested by Bailis et al. (2007). The study was conducted with 25 and 30 randomly selected households of ICS and TCS users, respectively. Both groups of households were selected from households with similar socio-economic status (e.g. wealth, based on local criteria) and they also have no difference in access to the nearby natural forest. Prior contact was made with the selected households to create awareness on the procedures for KPT and get consent of each selected households to participate in the KPT study.

The KPT study was conducted for eight days. On the very first day of the study, the initial mass of wood for each household was weighed and given to study participants reminding them to use only the wood provided to them. To help ensure this, the wood provided to each household was stored in a designated inventory area. On days two up to eight, the supplementary wood and the wood remaining from the previous day was weighed. In addition, the number of meals served and the age, gender and number of people served at each meal was recorded for each day under investigation. On the final day, the remaining wood was weighed. The wood used in this test was air dried and the dominant species used as firewood in the study area were *Erica arborea* and *Erica trimera*, which are common for both categories of households.

Data analysis

Firewood consumption

The per capita firewood used and the number of person-meals cooked during each day of the KPT were determined through the daily KPT survey. Per capita firewood consumption was reported based on standard adult equivalents (SAE). The SAE was determined using FAO standard adult weighting values; $<$14 years = 0.5, adult female $>$14 years = 0.8, adult male between 14 and 59 years = 1.0, and adult male $>$59 years = 0.8 (FAO, 1983).

Independent *t*-test was used to determine if there is significant difference in mean per capita consumption of firewood between households using TCS and ICS.

Estimation of reduction in CO_2 emission

The contribution of using ICS in reducing CO_2 emission was estimated based on efficiency of firewood saving per SAE of households using ICS. The calculation was done based on clean development mechanism and United Nation's framework of Convention on Climate Change (UNFCCC, 2013; Table 1) using the formula;

$$ER_y = B_{y,\,savings} \times f_{NRBy} \times NCV_{biomass} \times EF_{fuelwood}$$

where;

ER_y = Emission reduction during the year in tons of carbon dioxide equivalent (tCO_2e)

$B_{y,savings}$ = Annual fuelwood saved per ICS in tons

f_{NRBy} = Fraction of non-renewable biomass

$NCV_{biomass}$ = Net calorific value of the non-renewable biomass

$EF_{fuelwood}$ = Emission factor of fuelwood.