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Interlinks Between Improved Cooking Stoves, Forests Conservation & Poverty Alleviation: Experience of North Kordofan-Sudan

Hanan Mohamed Elhadi[a], Adam. E. Ahmed[b]

a Justus-Liebig University Giessen, Project and Regionalplanning, Germany
b University of Khartoum, Faculty of Agriculture, Department of Agricultural Economics, Sudan

Abstract
Rural households in Sudan mostly depend on firewood and charcoal as main source of energy. Therefore, greater pressure on forests of Sudan, resulting from firewood and charcoal production represents the major threat to environment and sustainable forests management. Improved Cooking Stoves (ICS) have been developed to reduce firewood consumption and hence forests conservation. Accordingly, this paper aims to compare and contrast between improved and the traditional stoves with regard to firewood energy consumption, energy utilisation efficiency, cost effectiveness and time consumed in firewood gathering, and hence their implications on forests conservation and poverty alleviation. Primary data were collected using structured questionnaire with 66 ICS user and non-user in North Kordofan State. Moreover, an experiment was conducted to measure the efficiency of the improved stoves versus the traditional ones. The results reveal that all the respondents are totally dependents on the firewood as a primary source of energy. Improved stoves users, agreed that, the new stoves have many advantages over the traditional one such as fast cooking, smoke reduction, and fire lasting long time, sturdy and stable. Moreover, the results showed that using improved stoves reduced per capita wood fuel consumption by 53 percent; household wood energy expenditure by 35 percent and the time spend in firewood gathering by 52 percent, compared to the traditional stoves. It could be recommended that efforts should be made by governmental and non governmental institutions to encourage the adoption and utilisation of the improved stoves so as to conserve forests and consequently improving the livelihood of the rural household.

Keywords: Forest Conservation, Improved Stoves, Kordofan, Poverty, Sudan, Wood Fuel

1. Introduction

The Sudan presently derives over 80% of its total energy use from wood and charcoal, and the highest consuming sector is households (FAO 2007). At the domestic level, energy is important for cooking, heating and lighting; as well as for agricultural activities and semi-industrial usage. Next to this there are other, often-secondary, applications for instance as insects repellent (FNC 1995). It is clear that a single heating source can fulfil several functions at the same time. The demand for wood and charcoal in Africa including Sudan is set to increase by over 45% over the next 30 years, due to increases in population and demand for energy (FAO 2001). Over harvesting of wood for fuel and charcoal production brings changes to the species composition in Sudan. As estimated by FNC/FAO (1995), an equivalent of 15 million cubic meter of solid wood is consumed each year. As energy supply becomes scarcer, the price paid for fuel wood and charcoal increases significantly. According to the FNC/FAO (1995), up to 30% of a family's income can be spent on wood and charcoal. Although many programs and projects contain a component to improve the supply of fuel wood, additional tree planting has not automatically lead to an increase in the supply of woodfuel. Also, plantations which are oriented towards fuel-wood production are being used for non-fuel purposes, for instance, they are used for construction and at the industrial level as pulpwood (FAO, 2000). There is, however, an urgent need for immediate action to conserve, the remaining, forest resources in the country for the future generations. One of them is the stoves' programs, which have an estimated higher advantage, as an immediate energy conservation measure over other activities. They provide immediate direct benefit to rural households. This will justify that stoves' programs will lead to forest conservation. Moreover, the task of firewood collection almost, always, falls on women and children. consequently, efficient use of the available wood will reduce the burden on women and women and children, reduce spending on fuelwood and regeneration of new forests Accordingly this study attempts to investigate the interlink between improved cooking stoves, forests conservation and poverty alleviation in the rural area of North Kordofan State, Sudan. Specifically the study compare and contrast between improved & traditional stoves with regard to firewood energy consumption, energy utilization efficiency, cost effectiveness, time consumed in firewood gathering, and forests conservation

2. Methodology and Techniques

The study depends on primary data drawn from household survey carried out in El Ain area, North Kordofan, Sudan, using structured questionnaires which were developed, tested, and revised specifically to serve the purpose of this study. Moreover, two experiments were conducted depending on The Environmental Research Council (ERC) and Renewable Energy Research Institution (RERI), in 1989, laboratory testing. Firstly, the constant boiling water test which is a simulation of a typical cooking practice where the stove is operated initially for a fixed period of high power followed by a longer low power-simmering phase. The fuel consumption and the water evaporation are measured. Secondly, the standard duration test compares the periods of time, that each cook-stove could maintain the boiling of a standard volume of water, with a fixed mass of fuel. The data obtained from these tests were used to calculate percentage heat utilized, power output, and rates of fuel consumption.

The performance of the mud-stove was compared with that of the traditional three-stone fire. For these experiences the standard source of firewood was used consisting of small pieces 15 cm long with a diameter ranging between 2 cm to 3 cm. The wood was air-dried to residual moisture content of 5%. The pot used was the one which, found to be the most widely used in the household sector. Each test was repeated three times to reduce the expected errors in measurement.

The tests on the charcoal stoves were carried out and the fuel used was from *Acacia seyal* with uniform size distribution. All lighting and operating procedures were standardized. The tests were carried out four times. These experiments on the stoves were carried out in a typical Sudanese rural kitchen setting, consisting of a covered space with three closed sides and open front, allowing the smoke to escape out yet and protecting the fire from the prevailing winds.

3. Results and Discussion

The surveyed results indicate that an average annual firewood consumption of 82 and 168 head bundles per household in (ICS) user_and non user, respectively. The average per head consumption is 7.1 and 6.2 for ICS user and non user, respectively (1 m^3 = 66 head). On the other hand, the results revealed that, households' average annual consumption of charcoal are 8.5 and

12.4 sacks for stove user and non user respectively. (1 sack is equivalent to approximately 35.2 kg of charcoal and $1m^3$ = 224 kg of charcoal), By combining the per capita annual firewood and charcoal consumption in the study area, which represent a total of $0.34m^3$ and $0.72m^3$ for the ICS user and non-user respectively, the difference in per capita consumption for them is estimated to be $0.38m^3$, which equals to 52.7% (Table 1.)

Table 1: The Per capita Firewood and Charcoal Consumption/year

Woodfuel	Traditional stove	Improved stove	Savings
Firewood	0,41 m^3	0,17 m^3	0,24 m^3
Charcoal	0,31 m^3	0,17 m^3	0,14 m^3
total	0.72 m^3	0.34 m^3	0.38 m^3

The value of domestic energy conserved by using ICS was also calculated. The result showed that, using of the ICS will reduce households' energy spending by 35% (125.790 SD).

Table 2: Total amount of money savings in SD by stoves users

	Value of energy collection	Value of energy purchased	Total
Traditional stove	259	102.2	361.20
Improved stove	167.06	68.73	235.79
money saving	91.94	33.47	125.41

1$ = 250 SD

Regarding time spend in firewood collection in the study area wood gathering has become a fulltime occupation. In distance this corresponds up to half a day's walk away, or more. This loss of time places a huge constraint on other activities that are necessary to support the family. The survey results shows clearly significant difference in time spent for such activity to satisfy one weak requirement. The results revealed that non ICS women user spend as much as 112 days a year to provide the minimum energy needs for their household while such requirements take only 54 days per year for ICS user in the study area.

The data obtained from Constant Boiling Water Test and Standard duration tests clearly show that the improved mud stove is up to three times more efficient in transferring the available heat to the cooking pot when compared with the 3-stone fire. It was also found that when operating the mud stove, the feeding rate of the fuel had to be severely restricted to lower the power output of the stove and avoid excess evaporation of the water. This indicates that this highly efficient firewood stove would be ideal when operated with low-grade fuels such as crop residues and small diameter twigs. From the results of the constant boiling water test it is likely that in general domestic use, the mud stove consume less than half the firewood used in a traditional 3-stone fire. Such results are confirmed by the targeted villages respondents as they mentioned that, in general the improved stoves is better and efficient than the traditional one concerning short time boiling, average power output, fuel consumption and other related features of energy conservation.

Table 3: Constant Boiling Water Test with the Firewood and Charcoal Stoves.

stove details	Initial water temperature	time to reach boiling	Total wood used	total water evaporated	Output average	Specific heat Consumption Average.	P.H.U high power	P.H.U low power	P.H.U. average
	C°	mints	g	g	kW	g/kg	%	%	%
traditional 3-stone	35	26	1395	635	4.1	2.2	8.8	9.5	9.1
Improved mud-stove	34	15	728	1404	2.4	0.52	25.7	36.5	31
Traditional charcoal stove	35	27	272	530	1.3	0.51	25	32	27
Improved charcoal stove	35	17	240	752	1.3	0.32	31	58	44

PHU = % of heat utilized (Efficiency in %)

Table 4: Standard Duration Tests of Firewood and Charcoal Stoves

Stove details	Time to reach boiling	Time at boiling	total time	Weigh of wood used	weigh of water evaporated	average power output	Average S.C.	Rate of fuel consumption	Average P.H.U.
	mints	mints	mints	g	g	K W	g/kg	g/mint	%
traditional 3-stone	27	71	98	894	698	2.7	1.28	9.1	15
Improved mud-stove	18	128	146	874	1048	1.8	0.43	6.0	35
Traditional charcoal stove	26	119	160	285	704	1.0	0.40	1.8	30
Improved charcoal stove	17	196	228	221	1522	0.8	0.24	1.4	41

S.C. = Specific consumption (weight of fuel consumed/weight of water evaporated)

It could be concluded, that improved stoves are effectively meeting the needs of the households, as all the stove users agree that the new stoves have gained proper advantage over the traditional one such as fast cooking, fuel saving, smoke reducing, fire last long time, sturdy and stable. In addition to that heat could be controlled, the fire risk is reduced and they cook better food.

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