방글라데시 치타공 산악지방의 목재연료를 이용하는 전통 풍로와 온실가스의 배출

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Traditional cooking stoves, woodfuel use and greenhouse gas emissions in Chittagong hill tracts, Bangladesh

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1. Introduction

Biomass is by far the dominant energy source in the South-Asian region, accounting for approximately 50% of the region's total energy consumption. For most rural areas in the region biomass is the only available energy source and 70% of all biomass used for energy is consumed by the households (RWEDP/UNEP, 2000). In Bangladesh, using traditional stoves or simple boilers or furnaces burns almost all biomass. The efficiency of these devices is very low, resulting in waste of energy and GHG emissions (RWEDP/UNEP, 2000). Conventional *chulhas* (cooking stoves) used in rural households has a low thermal efficiency (around 8%) whereas the improved *chulhas* have an efficiency of around 25% (Natarajan, 2000).In addition to advantages to the user, the improved stoves imply reduced emission of greenhouse gases. However, the amount of emission from small-scale combustion of biomass and other fuels commonly used in households of the country are still not well known. But, a few questions may arise in this regard: what is the present stove situation in the households of the country? Are they responsible for excessive emission of green house gases? Are there any effective options available to reduce national green house gas emissions through changes in the cooking technologies of households? Chittagong Hill Tracts constituting of Rangamati, Khagrachari and Bandarban district, is an area originally inhabited by 11 ethnic communities mostly dominated by indigenous people who are still fostering their distinct cultural practices. For most of the households of tribal communities, the national gas supply network and the electrification program is far beyond reach. Again, their traditional combustion processes like three- stone free and other traditional stoves is aggravating this situation. Therefore, it was hypothesized

that "Traditional cooking stoves in the Chakma community of Rangamati were releasing a huge amount of greenhouse gases to the atmosphere as compared to the improved stoves and declining a large quantity of wood volumes from the forests". Taking this hypothesis, the study was undertaken.

2. Materials and Methods

2.1. Study area

For the study, the Chakma Community from Rangamati Sadar Upazila (Sub-district) under Rangamati district of Chittagong Hill Tracts was taken purposively. The study was carried out over a period of five months from March 2003 to July 2003. Rangamati lies in the eastern part of the country between 21°54′ and23°44′ North latitudes and 91°56′and 92°33′East longitudes (BBS, 2002). The climate of the district is tropical in nature. The district is remarkable for its uniform temperature, high humidity and heavy rainfall from May to October. The climate is moist, warm and equable, the maximum and minimum mean temperature during the winter vary from 25.3° to 12.6°C; during summer the maximum and minimum mean temperatures vary from 33.3° to 24.1°C (BBS, 2002).

2.2. Sampling method

Rangamati Upazilla consists of 9 Union Parishads and 171 villages. Total population is 76732; male 55.79%, female 44.21%; Muslim 37.80%, Hindu 12.27%, Buddhist 49.25% and others 0.68%. Average literacy rate is 48.4%. Agriculture is the main occupation (23.23%) of the inhabitants. There is one municipality area in Rangamati Sadar Upazilla consisting of 9 wards. From the urban area of the Upazilla 3 wards and from the rural area 3 Unions were selected randomly. From each ward and union 2 mahallas/villages were selected randomly. From each mahalla/village, 5 households were selected. Thus, a total of 60 households were selected for the study. After collecting all the data, the households were sub-classed into four based on family size, i.e., small (3-4), medium (5-6), large (7-8) and very large (9-10). Consumption patterns of wood fuel and non-wood fuel were studied by semi-structured questionnaire. Data of information about design of stoves, raw material used for cooking stove, sources and quantity of wood fuel, socio-economic information and problems occurred by using traditional cooking stoves were collected by interviewing of the cooker of each selected household. The data were collected in local units, such as head loads, cartloads and mound etc. The consumption of wood fuel was recorded over a period of 24 hours of each day. The methodological approach used in this paper followed the procedures outlined by the

Intergovernmental Panel on Climate Change for conducting deforestation and greenhouse gas inventories (IPCC, 1996).

3. Results and discussion

3.1. Cooking stove dimensions and characteristics

The study found out three categories of traditional cooking stoves in the study area. These are (1) Three stone fire (2) Single mouth stove (3) Combined single mouth stoves (two stoves in a single unit). Three stone fires consist of a simple arrangement of three stones around a fire, on which a pot is balanced for cooking. Three stone fires are popular for 'cheap and easy to build' facilities. They are easy to use and require no expertise. They accept many types of fuel, and fuel does not need to be chopped into small pieces. In the study, it was found that the "single mouth stoves" were made of sandy clay soil, cow dung, rice husk, saw dust, bricks. The average depth, width and length were 35-40, 50, 55cm and the average cost/ stove is US$ 1.8. The average diameter of feeding hole and mouth were 15-16cm and 20cm, respectively; the cones on the mouth were about 3.5cm in height. The dimensions of the "combined single mouth stoves" (two stoves integrated in a single unit) were almost the same except its length becomes nearly double of a "single mouth stove" and it costs about US$ 3.4 approximately (Table 1). Usually, a blowpipe was observed to be used to provide entry of air at the bottom of the stoves, which facilitates the ignition of fire.

Table 1. Cooking stove dimensions and their characteristics in the Chakma community, Chittagong Hill Tracts, Bangladesh.

Type of stove	Raw materials	Mouth/ Pot hole	Feeding hole	Cones in a mouth	Depth (cm)	Width (cm)	Length (cm)	Cost (US$)
		Diameter (cm)	Diameter (cm)	Height (cm)				
Single mouth	Sandy clay soil, cow dung, rice husk, saw dust, bricks	20	15-16	3.5	35- 40	50	55	1.8
Combined single mouth stoves	That	20-22	18-19	3.5	35- 42	55	94	3.4
Three stone fire	Bricks/stone	–	–	–	–	–	–	0

The single mouth stoves and combined single mouth stoves had some limitations such as, there was too large a distance between the pot and the fuel bed (35-42cm), a large space in between the raised points (cones) is used as exit of flue gases causing much of flue gases to

exit the stove without coming into contact with the cooking pot; absence of holes for entry of air at the fuel-bed which hinders complete combustion of fuel.

3.2. Estimation of the amount of wood fuel use, burning time and estimated market value of fuels

The study revealed that the level of income of 60 families ranged from US$ 55- 120 with the lowest average income in small family [US$ 64/month] and the highest average income in very large family (US$ 112/month) (Table 2). The average wood fuel consumed/year/family was 6.57 ton with a market value of US$144 (Table 2). Burning hours varied from 2.00 hours to 5.00 hours due to the change in family size from small to very large.

Table 2. Estimation of the amount of wood fuel use, burning time and estimated market value of fuels in the traditional cooking stoves in the Chakma community, Chittagong Hill Tracts, Bangladesh.

Family size	Average income /month US	Burning time Hour/day/family	Woodfuel consumed/family/year ton	Estimated market value US
Small	64 (37)*	2.34 (0.559)	4.58	100
Medium	78 (33)	2.56 (0.505)	5.96	131
Large	82 (39)	3.05 (0.37)	7.3	161
Very large	112 (53)	4.50 (0.57)	8.42	185
Average	84	3.11	6.57	144

*Figure in the parentheses indicate the Standard deviation

3.3. Estimation of collection of wood from the neighboring forest for fuel use in the traditional stoves of Chakma community of Rangamati

The study indicates that the average annual collection of wood from the neighboring forest for the use of fuel in the traditional cooking stoves is 10.1 m^3 per family per year (Table 3). Lowest volume was collected by the small family as 7.05 m^3 and largest by the very large family as 12.95 m^3. The study also states that the average per capita annual consumption of wood fuel in *Chakma*community is 1.55 m^3.

Table 3. Estimation of collection of wood from the neighboring forest for fuel use in the *Chakma* community of Chittagong Hill Tracts, Bangladesh.

Family-size	Wood fuel collection (m^3/family/year)	Annual per capita consumption (m^3)
Small	7.05	1.55
Medium	9.17	
Large	11.23	
Very large	12.95	
Average	10.1	

3.4. Fuel use pattern in the Chakma Community of Rangamati

It was found that among the selected households; about 96% families were totally dependant on wood fuel for cooking, 2% Biogas and 2% LPG along with wood fuel (Figure 1).

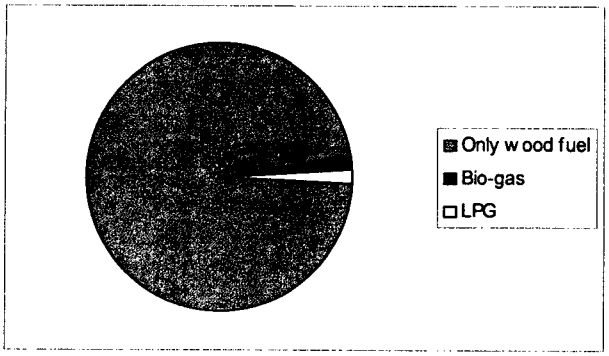

Figure 1. Fuel use pattern in the Chakma community of Chittagong Hill Tracts, Bangladesh.

3.5. Species used for energy

The study reveals that among the species used for fuel, Aam *(Mangifera indica),* Kanthal *(Artocarpus heterophyllus)* come from the homesteads; Koroi *(Albizia spp.)*, Kurchi/Kurus *(Holarrhena antidysentica)*, Udal(*Sterculia villosa)* from forests and Shegun *(Tectona grandis)*, Mangium *(Acacia mangium)* from plantations. Jam *(Syzyzium grande)* is collected from both homesteads and forests (Table 4). It is to be noted that in case of shegun, only the branch portion or heavily defective trunks are used as fuel.

Table 4. Species used as fuel in the Chakma community in Chittagong Hill Tracts, Bangladesh.

Local name	Scientific name	Source
Aam	*Mangifera indica*	Homesteads
Kanthal	Artocarpus heterophyllus	Homesteads
Jam	*Syzyzium grande*	Homesteads and forests
Koroi	*Albizia spp.*	Forests
Mangium	*Acacia mangium*	Plantations
Kurchi/Kurus	*Holarrhena antidysentica*	Forests
Udal	*Sterculia villosa*	Forests
Shegun	*Tectona grandis*	Plantations

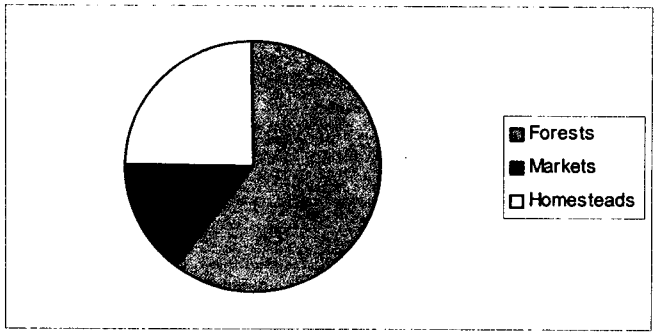

Figure 2. Sources of wood fuel in the Chakma community in Chittagong Hill Tracts, Bangladesh.

*Here both plantations and forests are considered as the general term 'forests'

3.6. Estimation of green house gas emissions

The study revealed that average woodfuel consumed by a family per annum was 6.57 ton with the ranges from 4.58 ton to 8.42 ton for different family sizes (Table 5). However, according to the study, due to the burning of woodfuel 2.95 ton of total carbon, 10.84 ton of CO_2, 0.11 ton of CH_4, 0.92 ton of CO, 0.0007 ton of N_2O, 0.026 ton of $NO_x$and 0 .017 ton of NO were emitted per family per year (Table 5).

Table 5. Estimation of green house gas emissions due to the use of wood fuel in the cooking stoves of Chakma community in Chittagong Hill Tracts, Bangladesh

Family size	Amount of Woodfuel Consumed (ton)	Total carbon released (ton)	(Emission/year/ family) ton					
			CO_2	CH_4	CO	N_2O	NO_x	NO
Small	4.58	2.06	7.56	0.07	0.64	0.0005	0.018	0.012
Medium	5.96	2.68	9.84	0.10	0.83	0.0007	0.024	0.015
Large	7.3	3.29	12.06	0.12	1.02	0.0008	0.029	0.019
Very large	8.42	3.79	13.91	0.13	1.18	0.0009	0.034	0.022
Average	6.57	2.95	10.84	0.11	0.92	0.0007	0.026	0.017

The study indicates that highest emissions come from the very large family whereas the lowest emissions come from the small family.

3.7. Problems and constraints of women while cooking with traditional stoves

The wood fuel use in traditional stoves was responsible for eye-irritation as reported by 38% women followed by headache (32%). About 18% and12% reported to be affected by coughing and sneezing (Figure 3). In the study, it was found that 68% families showed

positive approach to accept improved stoves but the remaining 32% did not want to adopt improved cooking stoves as it requires hiring a trained person and the cost of improved stoves was also felt higher to them in comparison to traditional stoves.

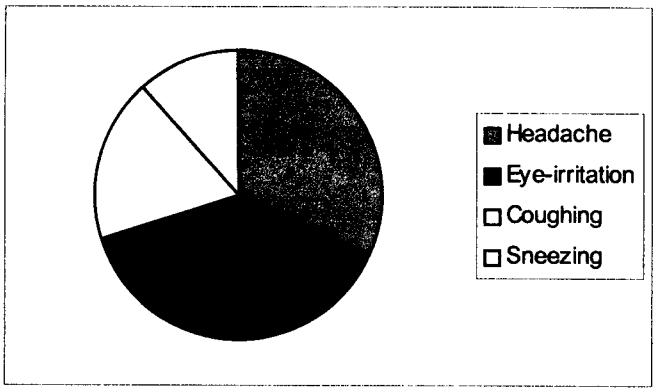

Figure 3. Health problem faced by the cooker due to the use of traditional cooking stove in the *Chakma* community, Chittagong Hill Tracts, Bangladesh.

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