Biomass fuel use, burning technique and reasons for the denial of improved cooking stove by the Forest User Groups of Rema-Kalenga Wildlife Sanctuary, Bangladesh

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Abstract

Use of biomass fuel in traditional cooking stove (TCS) is the long-established practice that exhibits incomplete combustion and generates substances with global warming potential (GWP). Improved cooking stove (ICS) has been developed worldwide as an alternative household fuel burning device, a climate change mitigation strategy as well. A study was conducted in the female Forest User Groups (FUGs) of Rema-Kalenga Wildlife Sanctuary, Bangladesh to assess the status of ICS disseminated by the Forest Department (FD) under Nishorgo Support Project along with the community's biomass fuel consumption pattern. Consumption of wood fuel was highest (345 kg month-1 household-1) followed by agricultural residues (60 kg month-1 household-1), tree-leaves (51 kg month-1 household-1) and cow-dung (25 kg month-1 household-1). Neighboring forest of the sanctuary was revealed as the core source for wood fuel with little or no reduction in the extraction even after joining the FUG. Twenty two species, both indigenous and introduced, were found in preference for wood fuel by the community. None of the respondents were found willing to use ICS although 43% of them owned it; either as the status symbol or to meet the condition of the FD to continue membership in FUG. Seven negative features of the disseminated ICS were identified by the households that made them unwilling to use it further. Manufacturing faults may be responsible for the ICS's demerits and FD's negligence was liable to the failure of convincing the community. A proper examination of the disseminated ICS's efficacy is crucial with active involvement of the community members. The Sustainable Energy Triangle

Strategy (SETS) could be implemented for this purpose. Findings of the study would be of immense importance in designing the strategy for the introduction of ICS in Bangladesh.

Keywords: cooking stove, biomass fuel, climate change, protected area, Bangladesh

1. Introduction

The energy-poor people, having no access to modern energy services constitute about 30% of the world's total population. The situation remains more vulnerable in developing countries where nearly 2 out of 5 people are under energy-poverty (Birol 2007). It entails these people rely on biomass fuels such as woods, branches, agricultural residues and animal (cattle) dung to meet all their cooking and heating energy needs. Currently, 2.5 billion people- 40% of the world's population- rely on such traditional fuels (Birol 2007). Biomass energy accounts for about 14% of the primary energy consumption in the world and about 38% in developing countries (Raghuvanshi et al. 2008), where household energy consumption is mostly used for cooking and constitutes around half of the total energy use in household (Miah et al. 2010). In a recent estimate, FAO (2010) reported that production and consumption of wood fuel is highest in Asia followed by Africa and Latin America, where most of the world's poor people live. Jankes and Milovanovic (2001) reported about the common usage of biomass in low capacity boilers or furnaces, local household cooking or farm heating, which is the simplest and cheapest way. The combustion process in such traditional devices is non-ideal and favoring incomplete combustion (Panwar et al. 2009) that leads to the formation of pollutants such as carbon monoxide (CO), nitrogen oxides (NO_x), aldehydes, polycyclic aromatic hydrocarbons (PAHs) and primary and secondary particles (Bhattacharya et al. 2000; Miah et al. 2009). The use of biomass fuels contributes 1-5% of all CH_4 emissions, 6-14% of all CO emissions, 8-24% of all total non-methane organic compounds (TNMOC) emissions and thus 1-3% of all human induced global warming (Smith 1994).

Traditional cooking stove (TCS) is the most commonly used device for cooking in rural communities worldwide that generally burns biomass fuels with an efficiency of roughly under 10% (Geller 1980), generating considerable quantities of products of incomplete combustion (PIC) and causing significant levels of indoor air pollution (Smith et al. 2002; Parikh et al. 2009). Along with the CO_2, the PICs have substantial global warming potential (GWP) as well as detrimental effects to the human health (Panwar et al. 2009). Referring from the estimate of World Health Organization (WHO), Moore (2009) reported that TCS are linked to 1.6 million deaths per year from indoor air pollution. Moreover, they are linked to unsustainable harvesting of fuel wood from forests causing rapid deforestation and consequently a change in the ecosystem, leading to soil erosion and change in the climatic pattern (Hossain 2003). Therefore, improved cooking stove (ICS) has been emerged as an alternative fuel efficient cooking device in rural communities of many developing countries in Asia, Africa and Latin America (Westhoff and Germann 1995). On an average, an ICS is in position to save 700 kg of fuel wood per year (Kishore and Ramana 2002) and about 161 kg of CO2 annually (Panwar et al. 2009).

Bangladesh, with a total land area of 147,570 km2 and a population of 156 million possesses 2.52 million ha forest land (17.08% of the total land with actual vegetation coverage of 6.7%) (FAO 2010). There are 20 protected areas covering almost 2% of the country's total area and 11% of the total forest area (BFD 2008). The estimated total biomass in Bangladesh is 63 million tones (72 tones/ha) and total carbon in biomass 31 million tones (36 tones/ha) with a total growing stock of 30 million m3 (34 m3/ha) (FAO 2010). Shin et al. (2007) revealed that on an average, 92 tC/ha is stored by the existing tree tissue in the forests of the country. Bangladesh's protected areas are in the interspersion of human habitation since long and the local communities are extremely dependent on them for livelihoods. Among the dependencies, fuel wood collection for everyday cooking constitutes the major exploitation activity, the unsustainable harvesting of which is shrinking the forest, the carbon stocks. FAO (2010) assessed the annual rate of deforestation as 2000 ha, or 0.3% in the period of 2000-2005 over the whole country. To check such degradation, especially in protected areas, the government introduced an alternative strategy of co-management involving the local communities with a provision of incentives in terms of Alternative Income Generation (AIG) supports under a donor assisted project (Chowdhury et al. 2009). It was started with the name Nishorgo Support Project (NSP) and was implemented in 5 protected areas as pilot project in 2004. A total of 19 various AIG activities have been introduced by NSP and ICS is one of them, which is claimed to save 50-70% fuel as compared to the traditional ones (Islam et al. 2006). It has been disseminated to the Forest User Groups (FUGs) with a view to reducing pressure on forest by cutting less trees, releasing less carbon in the atmosphere and thus mitigating climate change in micro-site level. The present study was conducted in Rema-Kalenga Wildlife Sanctuary of the northeastern part of Bangladesh with the objectives of exploring the status of ICS program and local communities' perception about it along with the pattern of their biomass fuel use.

2. Materials and methods

2.1. Study site

Rema-Kalenga Wildlife Sanctuary (Fig. 1) is situated in Gazipur and Ranigaon unions (small administrative unit of local government) of Chunarughat upazila (sub-district) in Habigonj district. It is under the jurisdiction of Habigonj-2 Forest Range of Sylhet Forest Division locating approximately 130 km east-northeast of the capital Dhaka and 80 km south-southeast of Sylhet city. The sanctuary lying between 24˚06'-24˚14'N latitude and 91˚34'-91˚41'E longitude (BCAS 1997), is bounded by Tripura State of India to the south and east, Kalenga Forest Range to the north and west, and tea estates to the southwest. Bio-ecologically it falls under the Sylhet Hills zones as part of the Tarap Hill Reserve Forest, 1095 ha of which was designated as wildlife sanctuary first in 1982 and expanded further to 1995 ha in 1996 under the Bangladesh Wildlife (Preservation) Order 1973.

The sanctuary is divided into three beats (small administrative units of Forest Department) namely Rema, Chonbari and Kalenga. It encompasses several hills of various elevations and low-lying valleys, with the highest peak at about 67 m above sea level. The area enjoys a moist tropical climate characterized by a period of high rainfall from April to September and a five month relatively dry period from November to March (Rizvi 1970). The forest of Rema-Kalenga was declared as wildlife sanctuary considering its biodiversity values and conservation needs (NACOM 2003). It is characterized as tropical evergreen and semi-evergreen forest housing a total of 606 plant species (Uddin 2001) and 167 wildlife species (Roy and Azam 1995).

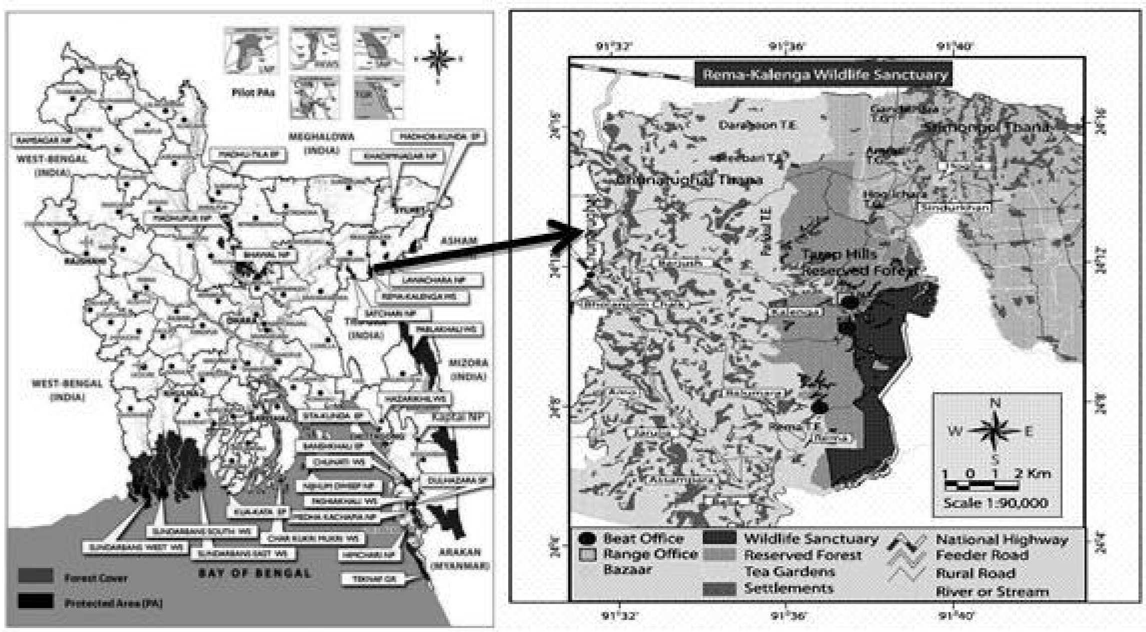

Figure 1. Map of Bangladesh showing the study area.

2.2. Background of the local stakeholders

Settlement history of Tarap Hill Reserve Forest that surrounds Rema-Kalenga Wildlife Sanctuary goes back to 40-100 years (NACOM 2003). A total of 36 villages having varying degrees of stake with the sanctuary have been identified; one located inside, nine at the boundary and 26 are outside (NSP 2009). The households living in villages inside and adjacent the forest are registered with the Forest Department and recognized as Forest Villagers. Eight of them are inhabited by a number of ethnic communities like Tripura, Santal, Urang, Kharia, Kurmi, Goala, Munda and Bunargi among whom Tripura makes up approximately 90% of the total ethnic population (Uddin and Roy 2007). DeCosse (2006) estimated that the total population of these villages is 24000, 90% of whom are poor or ultra poor. He doubted that if the project was to allocate its entire budget to address this huge population, the impact would be negligible. That is why; NSP formed the FUGs consisting average number of 12 members selected amongst the most deprived people from the surrounding communities (NSP 2006). A total of 67 FUGs were formed all over the 36 villages and among them 30 groups are of female stakeholders. The primary occupation of the people living both inside and outside the sanctuary is agriculture, whereas collection of forest resources holds the secondary livelihoods based on which they are categorized into 12 primary stakeholders groups including fuel wood collectors (NSP 2009).

2.3. Methods

This was a micro-approach study, conducted among the members of the female FUGs of Rema-Kalenga Wildlife Sanctuary (RKWS) in the months of January and February 2009. The female FUGs were selected purposively as elsewhere women are the ones, responsible for cooking and feeding other members of the family. By tradition, cooking is exclusively done by women and cooking along with responsibility to other family members occupies a major portion (51-54%) of a woman's daily life in Bangladesh (Alam et al. 2006). In doing so, the rural women play a significant role in procuring and processing fuel for domestic energy generation (Pal and Sethi 2005). A total of 370 female members in 30 groups are there in RKWS. Under the AIG activities, the NSP provided training to 20 selected women on the manufacturing of ICS, with a condition for transfering the technology to others in the study area with a minimum cost of Taka 450 each (Taka 70= US$1). From the total members of the female FUGs, we selected 70 individuals randomly for the study including both the users and non-users of ICS. A semi-structured questionnaire was used for the face-to-face interview of the respondents. The interviewing team was composed of four members headed by the first author; voluntarily assisted by the other three who were the post graduate students of the Department of Forestry and Environmental Science in the Shahjalal University of Science and Technology. In the family level, informal meetings were held in the interviewee's home using the native language (Bangla), sometimes with the participation of more than one respondent together, everyone being selected randomly. Data were sought for various socio-economic and demographic variables, fuel consumption pattern, preference for fuel wood species, and attitude towards ICS etc. In addition, one focus group discussion was arranged in the yard of a member's home to know the overall community perception. After collecting data, the respondents were categorized into three groups with respect to housing status as the owner of tin-shed bamboo fenced house, thatching grass & bamboo fenced and thatching grass & mud-walled house. Since cooking stove-related various parameters (viz., indoor air quality, fire hazards etc.) are linked to the structure and material of housing, the respondents were categorized accordingly. Average age of the respondents was 35 years. The average family size was around 5, literacy score 2.63, landholdings 90.83 decimal and monthly income Tk. 4091.43.

3. Results

3.1. The Cooking Stove Types

Two types of cooking stoves- traditional cooking stove (TCS) and improved cooking stove (ICS) were found in the study area. All the respondents, irrespective of housing status owned the TCS whereas only 43% owned the ICS along with the TCS. But interestingly, none of them were found to use the ICS presently (Table 1).

Table 1. Type of cooking stove owned and used by the FUG in Rema-Kalenga Wildlife Sanctuary, Bangladesh

Parameters	Type of cooking stove	Overall frequency (%)	Frequency with respect to housing status (%)		
			Tin-shed bamboo fenced	Thatching grass bamboo fenced	Thatching grass mud walled
Cooking stove owned	TCS only	57.1	-	66.7	63.2
	Both TCS & ICS	42.9	100	33.3	36.8
Cooking stove presently used	TCS only	100	100	100	100
	Both TCS & ICS	-	-	-	-

3.1.1. Traditional cooking stove (TCS)

This is usually a mud-built device with three raised points on which the cooking pot rests. One opening between these raised points is used as the fuel-feeding port and the other two for flue gas exit. In some cases, two potholes are joined together and a single fuel-feeding port is made for common use. In the study area, the TCS are built with such dimensions as: average diameter of fuel-feeding port 24 cm, average diameter of pothole 23 cm, average depth, i.e., distance between the pot and fuel bed 60 cm and average height of the cones (raised points) of potholes 30 cm. This may be built under- or above-ground and both types were seen in the study area.

3.1.2. Improved cooking stove (ICS)

This is an upgraded and modified version of a TCS developed by the NSP in collaboration with an NGO and the technology is transferred to the FUGs through intensive training. It has two chambers. In the first chamber fuel is burnt and cooking takes place through the direct heat from the fire. The combustion products from the first chamber enter the second chamber on the right through a space and provide heat for cooking in the right chamber. Later the smoke is carried away from the chambers by a chimney. The chimney is built either with PVC (polyvinyl chloride) pipe or simply mud. There are no raised points at the potholes like the TCS. In the study area, the ICS are built with such dimensions as: average diameter of fuel-feeding port 20 cm, average diameter of pothole 18 cm, average depth, i.e., distance between the pot and fuel bed 40 cm, average length of the chimney 180 cm with an average diameter of 8 cm having 3-4 perforations at top with average diameter of 1-2 cm. This is built above-ground only. Figure 2 shows the pictures of TCS and ICS available in the study area.

Figure 2. TCS and ICS in the study area

3.2. Fuel consumption pattern

The respondents were reported to exclusively be dependent on biomass fuels for household uses. Four different kinds of biomass fuel such as wood & branches, cow-dung, agricultural residues and tree-leaves were found in use for household utilities like cooking, paddy parboiling, water heating, and preparing cattle feeds etc. It was revealed that only wood was used by most of the respondents (71.4%) while the other fuels were used in varying intensities along with wood (Fig. 3). Consumption of wood was highest

(345 kg month-1 househod-1; SE 25.07) followed by agricultural residues (60 kg month-1 household-1; SE 9.92), tree-leaves (51 kg month-1 household-1; SE 0.67) and cow-dung (25 kg month-1 household-1; SE 5.00). There was a significant difference in the average monthly consumption of wood fuel among the household categories at the $p< 0.05$ significant level. Respondents with thatching grass and mud-walled houses had higher average monthly consumption of wood than the respondents of other two categories. Use of cow-dung and tree-leaves was not found in the respondents with housing status of tin-shed bamboo fenced and thatching grass and bamboo fenced categories (Table 2).

Table 2. Average monthly consumption of biomass fuel by the FUGs in Rema-Kalenga Wildlife Sanctuary, Bangladesh

Fuel type	Quantity used (kg month-1 household -1)			
	Overall	Tin-shed bamboo fenced	Thatching grass bamboo fenced	Thatching grass mud walled
Wood	344.57 (25.07)*	255 (28.72)a	275 (27.84)b	407.37 (37.09)c
Agro-residues	60 (9.92)	65 (10)	57.50 (14.93)	-
Tree leaves	50.67 (0.67)	-	-	50.67 (0.67)
Cow-dung	25 (5.00)	-	-	25 (5.00)

* Values in parentheses indicate standard error
a,b,c indicate that values are significantly different at the $p< 0.05$ significant level

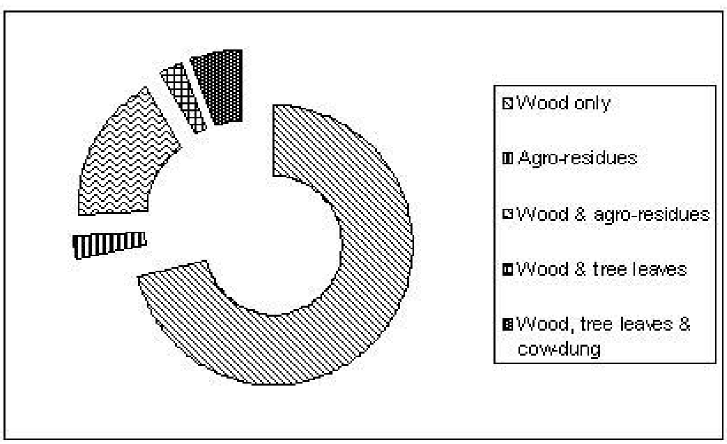

Figure 3. Various biomass fuel used in the study area.

Four different sources of biomass fuel (Table 3) were identified in the study area as forest only, homesteads only, forest & homestead, and forest, homestead & market. Solely the forest constituted the major source (57%) from where all the three categories of respondents collect wood fuel. Only half of the respondents with tin-shed bamboo fenced houses buy wood fuel from market. Females were reported as the predominant collectors of fuel wood from forest (61%) followed by the males (27.4%) and children (11.6%). Females were found to play the major role in procuring the fuel from homesteads also, where children assist them and the males' part is negligible.

Table 3. Source of fuel wood used by the FUGs in Rema-Kalenga Wildlife Sanctuary, Bangladesh

Source of fuel wood	Overall frequency (%)	Frequency with respect to housing status		
		Tin-shed bamboo fenced	Thatching grass bamboo fenced	Thatching grass mud walled
Forest only	57.1	-	58.3	68.4
Homestead only	5.7	-	16.7	-
Forest & homestead	31.4	50.0	25.0	31.6
Forest, homestead & market	5.7	50.0	-	-

During the study, the respondents were asked a specific question "Is there any reduction in wood fuel collection from the forest after joining the FUG?" In response to it, all the respondents with tin-shed bamboo fenced houses reported the positive answer while most of the respondents of the other two categories reported the negative answer and few of them did not agree to make any comment (Table 4).

Table 4. Reduction in fuel wood collection from the sanctuary after joining the FUG

Response	With response to housing status (%)		
	Tin-shed bamboo fenced	Thatching grass bamboo fenced	Thatching grass mud walled
Yes	100	25.0	26.32
No	-	67.67	63.16
No comments	-	8.33	10.52

3.3. Species preference for biomass fuel

Although various parts of different species were used as fuel in the study area, a total of 22 tree and shrub species were found to be preferred as fuel by the respondents. Five species, viz., *Acacia auriculaeformis*, *Acacia mangium*, *Albizia saman*, *Albizia* spp., and *Syzygium* spp. had the high preference level while *Alstonia scholaris* had the low preference (Table 5). About 77% of these species are indigenous and the remaining 23% are exotic in the study area and were introduced as plantation by the Forest Department in the vacant and degraded sites of the protected area.

Table 5. Species preferred for fuel wood by the FUGs in Rema-Kalenga Wildlife Sanctuary, Bangladesh

Botanical name	Local name	Parts used	Preference level*	Occurrence level	Status	
					Exotic (22.73%)	Indigenous (77.27%)
Acacia auriculaeformis	Akashi	L, B, W	+++	+++	√	
Acacia mangium	Mangium	L, B, W	+++	+++	√	
Albizia saman	Raintree	L, B, W	+++	++		√
Albizia spp.	Koroi	L, B, W	+++	+++		√
Syzygium spp.	Jam	L, B, W	+++	+++		√
Aphanamixis polystachya	Pitraj	B, W	++	+++		√
Artocarpus heterophyllus	Kathal	L, B	++	++		√
Artocarpus chaplasha	Chapalish	B, W, R	++	+++		√
Artocarpus lakoocha	Dewa	B, W	++	+		√
Bambusa spp.	Bansh	L, T	++	++		√
Bombax ceiba	Shimul	L, B, W, R	++	++		√
Eucalyptus camaldulensis	Eucalyptus	L, B, W	++	++	√	
Gmelina arborea	Gamar	B, W	++	+++		√
Lagerstroemia speciosa	Jarul	B, W	++	++		√
Litsea monopetala	Menda	L, B	++	++		√
Michelia champaca	Champa	B, W	++	++		√
Psidium guajava	Peyara	L, B	++	++		√
Switenia macrophylla	Mehogoni	L, B, W	++	++	√	
Tectona grandis	Shegun	B, W, R	++	++	√	

Terminalia arjuna	Arjun	L, B	++	+++		√
Toona ciliata	Toon/Kuma	B, W	++	+		√
Alstonia scholaris	Chatim	L, B, W	+	++		√

L = Leaves; B = Branches; W = Wood; T = Twigs; R = Root; P= Petiole
*** Ranked by FUG members in FGD as: +++ high; ++ moderate, and + low**

3.4. Status of ICS and the community attitude towards them

From the survey, it was revealed that about 43% respondents owned the ICS but nobody was using it. To explore the present condition of these ICS, question was asked to the respondents and physical observation was made to their houses. Half of the respondents of both the categories with tin-shed bamboo fenced house and thatching grass roofed bamboo fenced house kept the ICS as it is in their cooking place and the remaining half broke it with rage. About 86% of the respondents in third category kept it as it is and the remaining broke with rage. In response to the question on the willingness to use ICS, about 86% of the respondents, irrespective of housing category strongly opposed to use it, while the remaining did not want to make any comment. The category-wise responses are shown in Table 6.

Table 6. Status of ICS in the respondents' house in Rema-Kalenga Wildlife Sanctuary, Bangladesh

Parameters		With respect to housing status (%)		
		Tin-shed bamboo fenced	Thatching grass bamboo fenced	Thatching grass mud walled
Present status	Kept as it is	50	50	85.7
	Broken with anger	50	50	14.3
Willingness to use ICS	No	100	91.7	78.9
	No comment	-	8.3	21.1

A total of seven reasons for the respondents' denial to use ICS were reported in the study area (Table 7). All of these reasons are either the demerits of using ICS or the indirect impact on other activities because of its use. According to the respondents, the disseminated ICS produces more smokes, creates fire hazards, demands continuous supervision during cooking, needs straight and uniform sized fuel wood sticks, curtails time from other household activities, unable to use tree leaves and agricultural residues, and overall it exerts complexity in set up. Among the seven reasons, most of the respondents (74.3%) reported about the complexity in set up.

Table 7. Reasons for denial of using ICS by the FUGs in Rema-Kalenga Wildlife Sanctuary, Bangladesh

Reasons for denial of using ICS	Overall (%)*	With respect to housing status (%)		
		Tin-shed bamboo fenced	Thatching grass bamboo fenced	Thatching grass mud walled
Produces more smokes	60	100	50	57.89
Creates fire hazards	54.3	50	66.67	47.37
Demands continuous supervision	57.1	100	33.33	63.16
Needs straight and uniform sized fuel wood sticks	62.9	100	50	63.16
Curtails time from other household activities	51.4	100	33.33	52.63
Can’t use tree leaves and agro-residues	31.4	50	41.67	21.05
Complexity in set up	74.3	100	83.33	63.16

* Overall percentage is more than 100, because multiple reasons were reported by each respondent

4. Discussion

Biomass resources are potentially the world’s largest and sustainable energy source, a renewable resource comprising 220 billion oven dry tons of annual primary production (Turker and Kaygusuz 2001). It is normally the main source of energy in the domestic sector of developing countries. 84% of the rural households in India (NSSO 2005), 89% in Kenya (Theuri 2003), and almost all the households in Xian city, China (Tonooka et al. 2006) rely on it as their primary cooking fuel. Traditional biomass fuels supply the major energy needs in rural areas of Bangladesh, constituting 73% of the country’s total energy consumption (Miah et al. 2010); the domestic sector’s biomass consumption is 42% of the total energy consumed (Hossain 2003). Like other rural communities of the world, all the respondents in the study area were found dependent on biomass fuels for everyday household uses. Most of them collected the wood fuel from forests while the others from homesteads and market. Miah et al. (2010) reported about the 56% households’ collection of biomass fuel from their own homesteads and/or agricultural lands in some of the disregarded villages of Chittagong, Bangladesh. Batliwala and Reddy (2003) informed about the use of inanimate energy in the village of Pura at Karnataka State of southern India, 97% of which come from fuel wood and only about 4% of which is purchased as a commodity, the remainder being gathered at zero private cost. In the study area, a considerable portion of the respondents (50%) were found to buy wood fuel from the local market but it is confined only to the category with tin-shed bamboo fenced houses indicating their well-off position among the respondents. Turker and Kaygusuz (2001) recognized fuel wood as a tradable commodity since long in the rural and sub-urban communities but on the contrary, Hillring (2006) assessed that internationally trade in wood fuel is rather new and not as established as for round wood or sawn wood.

The involvement of female members of the family in procuring biomass fuel is much higher than the male counterparts in the study area. It denotes their responsibility to cook and prepare foods for other members as is common in most of the rural communities worldwide. In these communities, the men in the family make decisions regarding all financial matters such as construction or renovation of kitchen, installing of new devices such as ICS etc., while women are responsible for positioning the cook stove in the kitchen, collection and selection of fuel wood species for use, cutting it in small pieces and storing etc. (Malhotra 1998).

The purpose of forming FUGs in pilot protected area sites in Bangladesh was to provide the selected members of deprived sections of the community with trainings on various AIG activities so that pressure on forests would be reduced by diverting them to alternative livelihoods. To what extent did this purpose work? From the opinion of respondents it was seen that reduction in fuel wood collection from forest occurred only in the category with tin-shed bamboo fenced house and no reduction in the other two categories. The latter categories are less well-off than the former one and have less plant resources in homesteads to use as fuel that may drive them continue collection from forests.

Like any other necessary commodity, demand for timber and wood products is connected to dense and fast growing populations. The situation of Bangladesh seems severe with a high population density (1198/km2) and annual growth rate (1.8%), where rural people constitutes 74.5% of the total population and forest area per 1000 people is only 6 ha (FAO 2010). In addition, about 90% of all families in the country use TCS for cooking and other heating purposes (Hossain 2003) indicating an extreme pressure on biomass fuels. Since wood fuel gathering was thought to be the primary cause of deforestation in such agrarian society, ICS have been long known as a major imperative for reducing deforestation (Karekezi and Turyareeba 2009). Miah et al. (2010) also urged on the reduction in the present exploitation rates of biomass fuel use in Bangladesh for checking deforestation and reducing environmental degradation. ICS saves 50-65% fuel and cooking time compared with TCS and the maximum overall efficiency is estimated at 30% (Alam et al. 2006). In that sense, introduction of ICS in the local communities in and around protected areas of Bangladesh was appropriate and time demanding decision. But the efficacy of the program is questionable and needs proper evaluation. In fact, it is important that new technologies or policies favoring changes in rural energy use patterns should be fully evaluated with respect to all major impacts of their use, positive or negative, at the outset (Edwards et al. 2004). In that perspective, the present study is a very little initiative in Bangladesh being conducted with the ICS program of NSP in Rema-Kalenga Wildlife Sanctuary where the program seems to be unsuccessful.

A wide variety of improved stoves have been developed and disseminated throughout Asia, Africa and Latin America (Westhoff and Germann 1995). A very few of them was ended with success story; most of them remained unsuccessful. The programs initiated by the government of India to improve the stove’s efficiency and disseminate improved models showed negligible impact and therefore, TCS still predominates in rural Haryana (Joon et al. 2009). In Thailand, ICS has been developed and implemented by the government since 1984, but the project still has failed (Limmeechokchai and Chawana 2007). In Bangladesh, many of the ex-users of ICS were unconvinced of its advantages in southwestern rural areas (Alam et al. 2006). On the other hand, China’s dissemination of ICS remains the most successful such program worldwide (Edwards et al. 2004). In our study area, the ICS program failed to convince the users who experienced a total of seven demerits of this stove. Every respondent reported multiple negative features and thereby each feature was overlapped every time with each single interviewee. For instance, producing more smokes and creating fire hazards were reported by 60% and 54.3% of the respondents respectively. Although the ICS is to produce less smoke with zero fire hazard, as always claimed by its developers, the respondents experienced both of these features in the study area with the ICS disseminated by NSP. They commented, due to the lack of proper chimney outlet, the smoke is unable to escape into the atmosphere and becomes trapped inside. It was seen that, all the demerits reported were interlinked. About 57% of the respondents commented that the ICS demands continuous supervision and 51.4% commented that it curtails time from their other productive household activities. This is the impact of their giving more time for continuous supervision during cooking. On the other hand, when they gave break in the continuous supervision and paid attention to other activities like feeding cattle, weaving mats, processing agricultural products etc., they sometimes experienced the house full of smokes or fire hazards. As mentioned earlier, the housing materials in the study area are such that can catch fire easily if left careless during cooking. In TCS, various types of biomass fuel with irregular shapes and sizes can be used simultaneously which is not possible in ICS that needs straight and uniform sized fuel wood sticks as reported by about 63% respondents. This type of fuel wood cannot be used in ICS due to its structural design that was seen inconvenient to the users who do not want to take extra load of work to cut the rough woods into pieces suitable to burn in ICS. Moreover, dried tree leaves and agricultural residues like paddy straw can not be used easily in ICS as reported by 31.4% respondents. In rural Bangladesh, tree leaves serve as a potential cooking fuel, particularly to the poor people who collect it free from forests, roadsides, and their own and neighbors' homesteads. Additionally, paddy straw is also freely available during the paddy harvesting seasons when the villagers use it as fuel. Along with all these negative features, complexity of set up of the ICS was observed as the topmost barrier (74.3% of respondents) to accept it by the community. Alam et al. (2006) commented that the quality of an ICS depends on its construction and maintenance and problem arise when the stove-maker does not adhere to technical specifications during installation. This may be true for the study area where NSP supplied the technology to selected FUG members through training, most of whom failed to disseminate the actual design to the users. In real sense, this is the project authority's failure to disseminate the technology properly to such a marginal community as having lower educational background. Elsewhere in the world, ICS programs were not welcomed easily, for instance, in Thailand the three most important barriers to the adoption of ICS were identified as: high cost of investment, lack of information and lack of source of finances (Limmeechokchai and Chawana 2007). But in our case, only lack of information and/or ineffective flow of information could be viewed as the major constraint to convince the FUGs that is evident from the Focus Group Discussion with the community members. Gill (2003) also explored reasons of the failure of ICS programs to achieve widespread dissemination in developing countries. According to Gill, ICS are not necessarily more efficient than TCS designs nor are they always smokeless. Rather, ICS programs emphasize fuel economy whilst stove users regard versatility and the ability to cook quickly as being more important.

5. Concluding remarks and policy implications

It has been seen that the ICS program of NSP, i.e., the Forest Department failed to work out in Rema-Kalenga Wildlife Sanctuary, the most biodiversity rich protected area of Bangladesh. The community was found unconvinced with the performance of ICS disseminated by NSP; rather, they reported a number of nuisances of its usage despite the NSP claimed it as a user-friendly and fuel saving device. It depicts that there is a conflict between the two parties- the FD and the local community. The consequences of this conflict represent severe threats to the surrounding forests, particularly when the community was found using TCS with a total dependency on biomass fuels. Therefore, the ultimate impacts would be twofold: more extraction of wood fuel by cutting more trees from forests and thus release of more GWP substances to the atmosphere. The improper manufacture of the stoves might be responsible for exhibiting the inconveniences while the project authority's apathy could be liable to the failure of motivating the users in accepting new technology. Since ICS is very much interlinked to the mitigation of climate change, the authority should be more concern about their effort to influence the stakeholders. Konkin and Hopkins (2009) suggested that in order to succeed in addressing climate change, behavioral change is the key, but most people do not change their behavior because of data or information. The FD should exactly address this point of the local community. Involvement of the local community is imperative in every stage of the program's development. The situation of the study area implies that the existing strategy of the FD is not suitable to resolve the problems. It is realized that to succeed in the implementation of ICS program the proper policy is needed as the first priority. As a result, an alternative strategy is required to obtain proper policy in order to succeed in its implementation. The Sustainable Energy Triangle Strategy (SETS) (Fig. 4) could be the appropriate approach of the ICS implementation as in Thailand. Limmeechokchai and Chawana (2007) described the SETS as: "unlike the traditional top-down approach and strategy, the SETS starts at the users who are the target group of the project. The SETS is designed under the belief that the success of everything is based on the cooperation of concerned people and it will occur when the people understand how it affects them. By using the SETS, the process starts with telling and teaching the target groups about the effectiveness of the use of energy, and then training them to collect and investigate the energy used in their area. The result from this step is the energy situation of that area. The next step is to help them understand about the data of energy used in their area; for example, how much they have to pay for the use of energy compared with the total revenue, how to reduce their energy consumption, and what is the benefit from the energy consumption reduction. Consequently, the energy planning for that area is obtained together with the strategies to reduce energy consumption which are designed by local people and one of those strategies is the ICS".

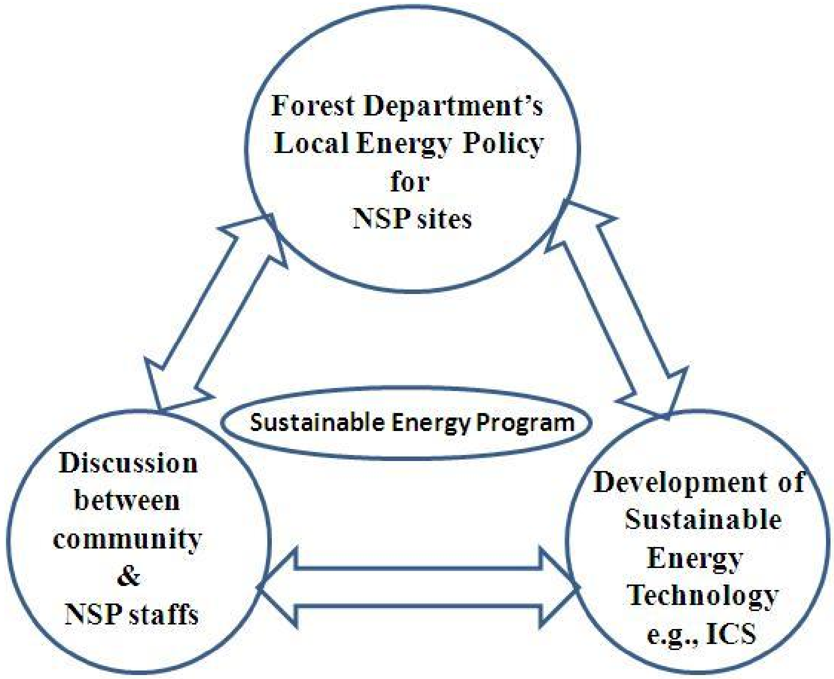

Figure 4. The Sustainable Energy Triangle Strategy (SETS)

The SETS was found as the appropriate strategy to promote the use of ICS in Thailand and it would certainly be replicated in the study area. Some other issues could be incorporated during its exercise in Bangladesh such as the assessment of the efficacy of disseminated ICS, making trial with other varieties of ICS used in successful programs in other places like China, Kenya and eastern Africa, *in situ* demonstration of ICS's positive impacts on health and indoor air quality in the users' cooking place. The Forest Department would involve the national Institute of Fuel Research and Development (IFRD) in these activities. Additionally, campaigning awareness programs on the health and environmental benefits of ICS is to be strengthened through mass media to convince the community for increased usage. Because developing and implementing 'climate change mitigation' necessitate institutional interventions aimed at raising the awareness of society about current and/or future climate changes (Guariguata et al. 2008). Climate change and its consequences are one of the well-known concerns in policy making level of Bangladesh that has been evident from the country's recent 'voice raise' in the COP-15 in Copenhagen. Similarly, implementation of the appropriate policies in the communities of the root level would result in the protection of forest resources in one hand, and contribute on the mitigation of regional climate change on the other.

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