Impacts of Improved Cooking Stoves: Evidence Relating to *Bondhu Chula*

Nazneen Ahmed
Senior Research Fellow
Bangladesh Institute of Development Studies (BIDS)

Background

- *Around 80 percent of Bangladesh's population relies on solid fuel for their household cooking and heating needs.*

- *Household air pollution from burning biomass fuel for cooking and heating is responsible for some 4 million deaths globally in a year, including nearly 106,900 deaths in Bangladesh, with women and children at the greatest risk.*

- Improved cooking stoves (ICS) potentially help to alleviate the negative implications of biomass fuel usage as an ICS lowers the biomass fuel consumption per meal and produces almost zero air pollution in the kitchen.

- Global Alliance for Clean Cookstoves (GACC) is working to expedite the access to clean cooking technology, especially ICS. But there are lots of opportunities for the expansion of ICS by replacing traditional stoves by disseminating the benefits of an ICS use.

- This study makes an attempt to evaluate the benefits of an ICS intervention in Bangladesh, named *Bondhu Chula.*

To be specific, this study evaluates the project "Market Development Initiative for *Bondhu Chula*" financed by Bangladesh Climate Change Trust (BCCT) and implemented by the Department of Environment (DoE) and German International Cooperation (GIZ).

Under this project, DoE and GIZ installed 500,000 *Bondhu Chula* across different parts of the country with a view to develop a market for *Bondhu Chula* and to expand the use of *Bondhu Chula* which reduces biomass fuel consumption and indoor air pollution. *Bondhu Chula* is one of the various models of Improved Cook Stove (ICS) being used in Bangladesh.
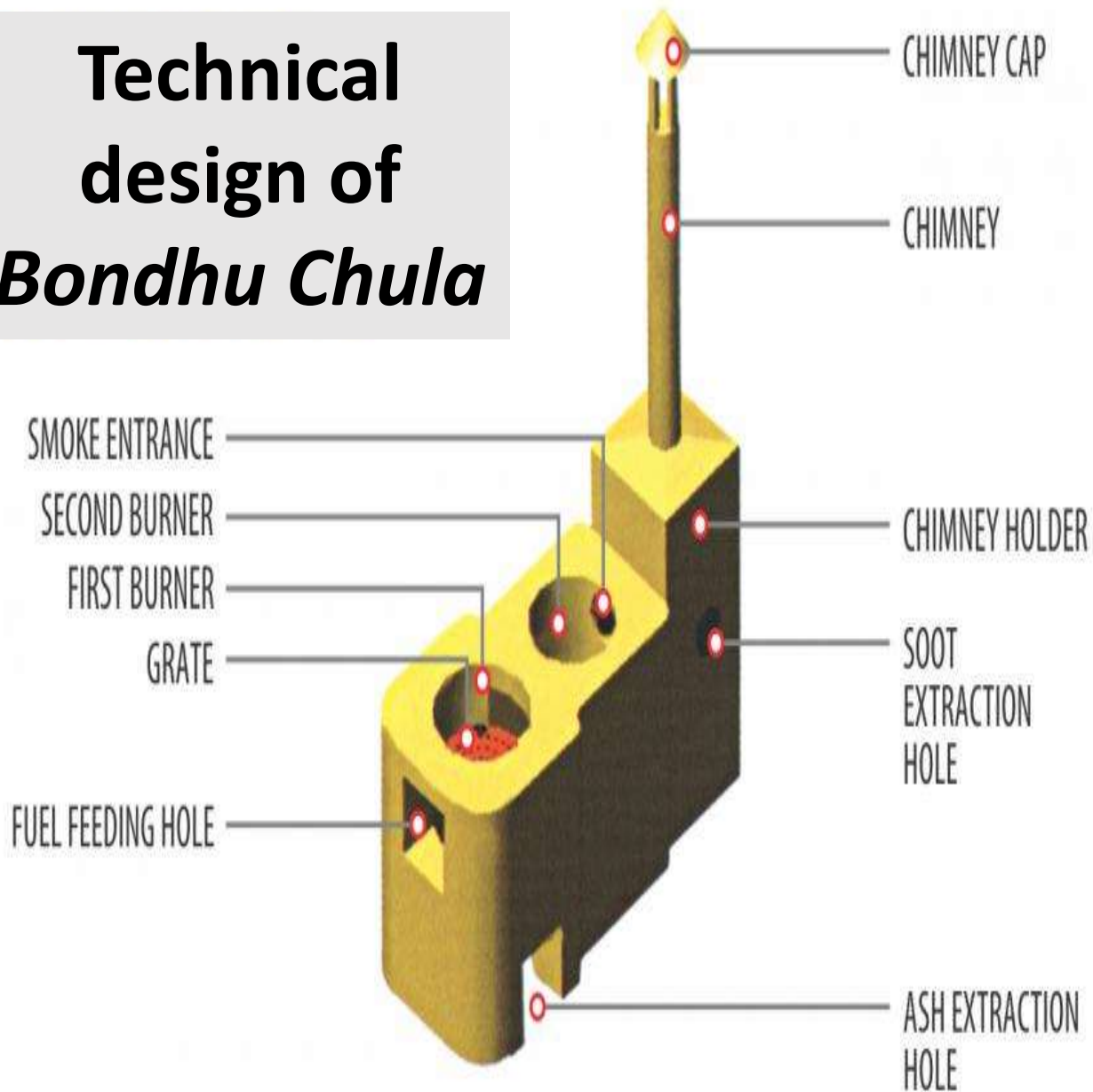
Basic features of a *Bondhu Chula*

Bondhu Chula is an improved oven. It is based on the scientific method and made available in accessible materials. Strains, chimneys and hats are an important part of the oven. The fuel is burnt on the filter. The stove is connected to a long pipe for the smoke produced to be passed in the air outside in such a way that anyone in or outside the kitchen would not be affected by the smoke.

The fire heat is more useful because there is no blisters in this *Chula*. As a result, food is cooked in low fuel and also require lower cooking time.

Technical design of *Bondhu Chula*

- CHIMNEY CAP
- CHIMNEY
- SMOKE ENTRANCE
- SECOND BURNER
- FIRST BURNER
- GRATE
- CHIMNEY HOLDER
- SOOT EXTRACTION HOLE
- FUEL FEEDING HOLE
- ASH EXTRACTION HOLE

Materials of *Bondhu Chula*

- Concrete (brick, sand and cement) is used for making stoves.
- Iron wire and wire mesh are used to ensure reinforcement. Grates are made of cast iron and chimney caps are made of burnt clay.
- The concrete parts are usually covered with a clay layer.

Facilities expected from *Bondhu Chula*

- Reduces indoor air pollution in the
- kitchen and reduces fuel consumption
- Provides comfortable cooking
- Environment friendly
- saves time
- Durable
- Use of locally available materials and
- Pre-fabricated moulds to produce

Methodology and Data

Basic Methodology

- Descriptive statistical methods such as percentage, frequency distribution, mean, and t-test

- An econometric method namely propensity score matching (PSM) method. The study mainly considers energy use, cooking time, and health as the outcome of interest variables.

- The t-test measures the mean difference of the outcomes of interest variables between the program (HHs with *bondhu chula*) and non-program (HHs with *traditional chula*) households.

- In measuring the mean difference, the t-test assumes two groups have homogenous variance, data are normally distributed and each value is sampled independently from each other value.

Propensity score matching (PSM) method

- Since the seminal work by Rosenbaum and Rubin (1983), PSM methods have become increasingly popular and widely used in the studies that use observational data to evaluate the causal impact of economic policy intervention.

- This study also uses the PSM method to estimate the causal impact of *bondhu chula* (treatment) because our data is observational.

- In an observational study or data, the estimation of the treatment effect is likely to be biased, because subjects are assigned to the treatment and control groups non-randomly and because confounding effects are present. Without accounting for this bias, the observed difference in outcomes cannot be attributed to treatment or intervention effect (Austin 2011).

- In this case, PSM is an effective technique that accounts for confounding bias between groups of participants in an observational study and provide reliable estimates of the treatment effect. "The propensity score allows one to design and analyze an observational (nonrandomized) study so that it mimics some of the particular characteristics of a randomized control trial (RCT) and provides reliable estimates" (Austin 2011).

Propensity score matching (PSM) method

- The PSM tries to find for every participant (in our case household with *bondhu chula*) a non-participant (household with *traditional chula*) similar in characteristics to the participant from the surveyed samples so that comparisons can be made within these matched participants.

- We matched household with *bondhu chula* with a household with traditional chula based on the propensity score and the difference in the mean outcome of these two groups is attributed to the impact of using a *bondhu chula*, under the assumption the use of *bondhu chula* is based only on observables and not on unobservables.

The Basic steps of impact evaluations of a Bondhu Chula adoption using PSM

We estimate the propensity score by using probit model

We examine the region of common support

We choose and execute a matching algorithm using nearest neighbor propensity score matching with one neighbor (and no caliper

Then we examine covariate balance after matching.

We estimate treatment effects: the mean differences of the treatment and non-treated outcome

Average Treatment and Treatment outcome formula

$$ATT = \frac{1}{N_1}\left[\sum_{i \in I_1 \cap S_p}\left[Y_{1,i} - \widehat{Y}_{0,i}\right]\right]$$

$$\widehat{Y}_{0,i} = \sum_{j \in I_0}\widehat{W}(i,j)Y_{0,j}$$

where Y is outcome variable (energy use, cooking time, health);
l_1 denotes set of treatment observations,
l_0 denotes the set of control observations;
N_1 is the number of treated observations,
S_p denotes region of common support,
$\widehat{W}$ **(i, j)** are weights that depend upon distance between the propensity scores for individual i and j and number of matches per treatment observation.

Probit Model: $t_i = \alpha + \beta x_i$

Where t_i =1 if a household use a bondu chula and t_i = 0 if a household uses a traditional chula, x_i is a vector covariates that include household head age, gender, education, and employment status, maximum male years of education, household having improved toilet, improve water, brick made house, household income, total own land, and asset.

Sample Distribution by district

| District	HH with *Bondhu Chula*	HH with traditional *chula*	HH stopped using *bondhu chula*	Total
Bandarban	60	40	10	110
Barisal	20	13	4	37
Norshigdhi	60	36	10	106
Dinajpur	60	40	10	110
Hobigonj	60	40	10	110
Mymenshing	60	40	10	110
Chittagong	60	40	10	110
Patuakhali	40	27	6	73
Rajshahi	60	40	10	110
Satkhira	60	40	10	110
Tangail	60	40	10	110
Total	600	396	100	1,096

FUEL CONSUMPTION
-A comparison between Bondhu and Traditional Chula
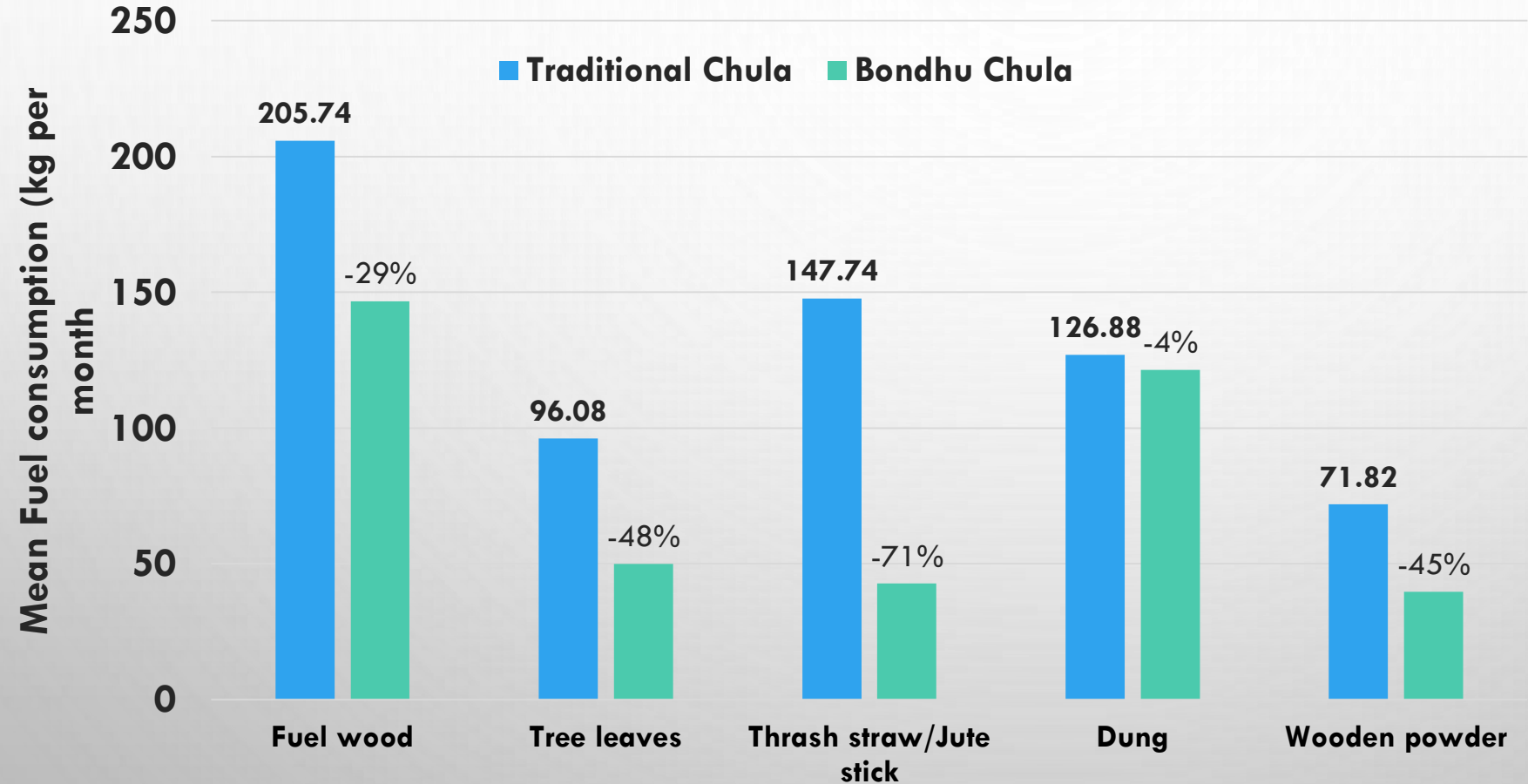
HHs who use *Bondhu Chula* require 29% and 48% lower fuelwood and tree leaves in amount, respectively, compared to HHs with traditional chula

Fuel Consumption before and after the use of *Bondhu Chula*
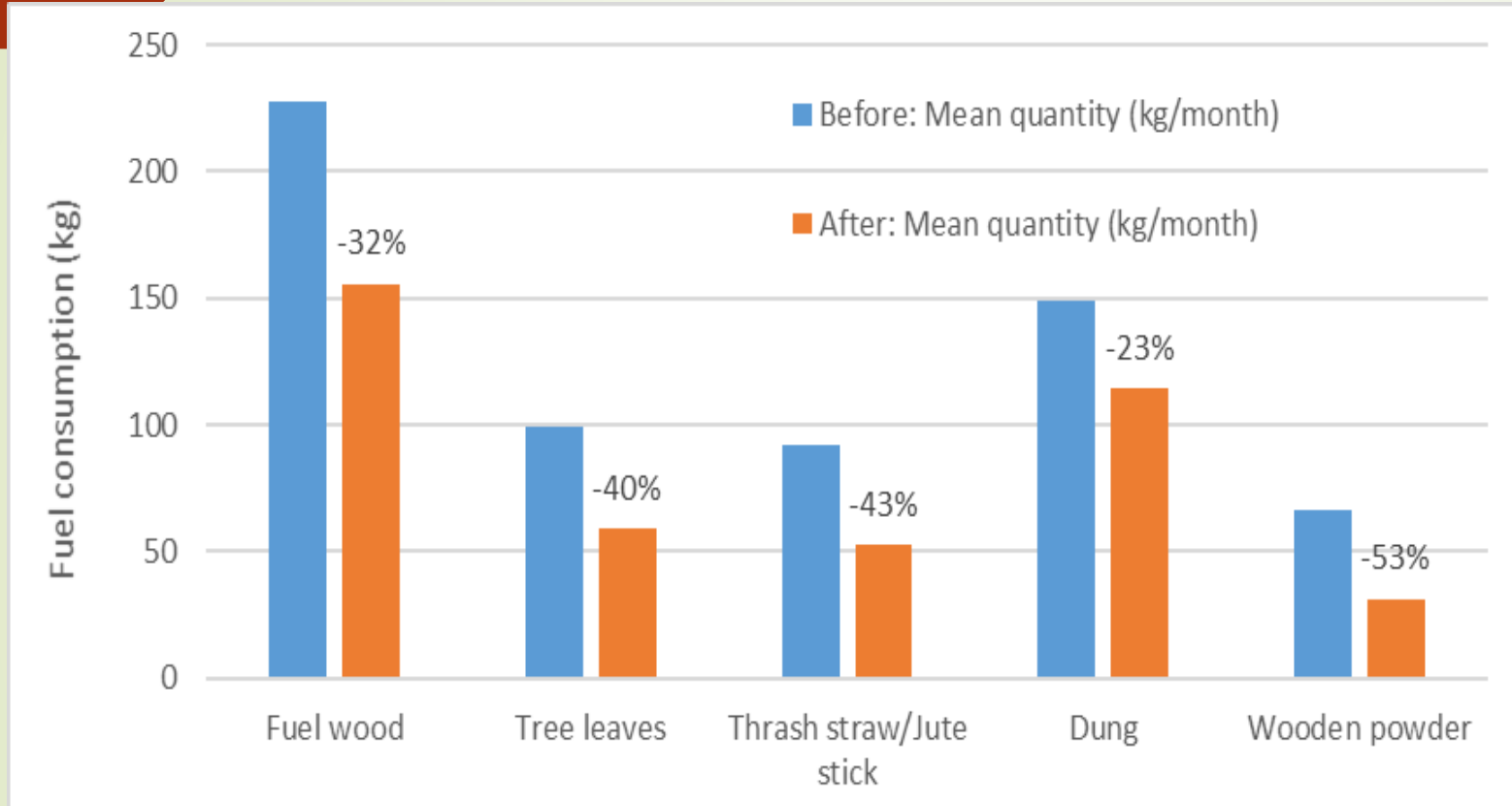
- Turning to our analysis to the before-after comparison of the *Bondhu Chula* use, the study finds that on average the monthly biomass fuel consumption reduces by 23% to 53% depending on the types of fuel a household uses.

- The monthly fuel expenditure is also lower in all fuel types

The estimated results show that an adoption of *bondhu chula* lowers the per capita and per HH fuel use by about 15-18 kg and 65-78 kg respectively, which are about 30-33% lower than the traditional *chula*. These differences are statistically significant as confirmed by significant t-test.

FUEL CONSUMPTION: ESTIMATES OF THE BENEFITS USING T-TEST

Indicators	Treatment: ICS (*bondhu chula*)		Control: traditional *chula*		Difference	t-test: t-statistics	Indicators	Treatment: ICS (*bondhu Chula*)				Difference	t-test: t-statistics
								Before: with traditional chula		After: with bondhu chula			
	N	Mean (kg/month)	N	Mean (kg/month)				N	Mean(kg/month)	N	Mean(kg/month)		
Per capita energy use	600	35.68	396	50.88	-15.20	-9.84	Per capita energy use	600	38.39	600	56.84	-18.45	-22.78
Per HH energy use	600	153.61	396	219.32	-65.71	-9.62	Per HH energy use	600	166.05	600	244.24	-78.19	-22.04

Cooking Time

Bondhu Chula and rice cooking time

Indicators	*Bondhu Chula*		Traditional *Chula*		Difference	t-test: t-statistics
	N	Mean (minutes)	N	Mean (minutes)		
Per capita cooking time for rice	573	6.67	376	8.12	-1.44	-7.19
Per HH cooking time for rice	573	27.39	376	33.42	-6.02	-11.33

- Per capita rice cooking time is 1.44 minutes lower with a *bondhu chula* than with a traditional *Chula*.

- This result is statistically significant as confirmed by significant t-statistics.

- The result implies that cooking with a Bondhu Chula saves household cooking time and creates an opportunity to allocate more time to other works.

INDOOR AIR POLLUTION AND HEALTH

Opinion on the smoke reduction along with other indicators

Indicator	%					
	Fully agree	**fairly agree**	**neutral**	**Do not agree**	**Highly disagree**	**All**
No smoke in the kitchen/Smoke is lower	86.3	12.3	1.2	0.0	0.2	100.0
Cooking with a *bondhu chula* is good for health	88.3	11.0	0.7	0.0	0.0	100.0
Cooking with a *bondhu chula* is quicker than traditional chula	76.2	20.7	3.2	0.0	0.0	100.0
Rice can be cooked quicker with a *bondhu chula*	76.7	21.0	2.0	0.3	0.0	100.0
Not much monitoring is required	62.3	27.7	8.5	1.5	0.0	100.0
Bondhu Chula has more burner so more than one item can be cooked at the same time	71.7	22.7	5.2	0.3	0.2	100.0
Cost is low	79.8	18.0	2.2	0.0	0.0	100.0
Time saved	56.3	33.2	8.8	1.7	0.0	100.0
cleaning of kitchen is easier	61.8	32.2	3.5	2.2	0.3	100.0

About 99% percent of the total respondent says *Bondhu Chula* emits no smoke in the kitchen.

>>>>> reduces indoor air pollution

>>>>> positive impact on the health of the women.

For all other indicators such as health benefits, saving of cooking time and the lower monitoring, more than 90% respondent agreed that *Bondhu Chula* is better than traditional *chula*.

Indicators	Before the use of ICS: with traditional Chula		After the use of ICS		Difference	t-test: t-statistics
	N	Mean	N	Mean		
Frequency of visit to doctor due to respiratory problems (number of times/month)	581	1.78	544	0.145	1.64	26.18
Expenditure for treating respiratory symptoms (Tk/month)	581	205.69	545	32.50	173.18	10.92

Impacts of *Bondhu Chula* on Women's Health

The results show that on average the frequency of visit to doctor caused by indoor air pollution goes down by 1.64 times because of the use of a *Bondhu Chula*. The corresponding health expenditure for the treatment reduces by Tk 173.
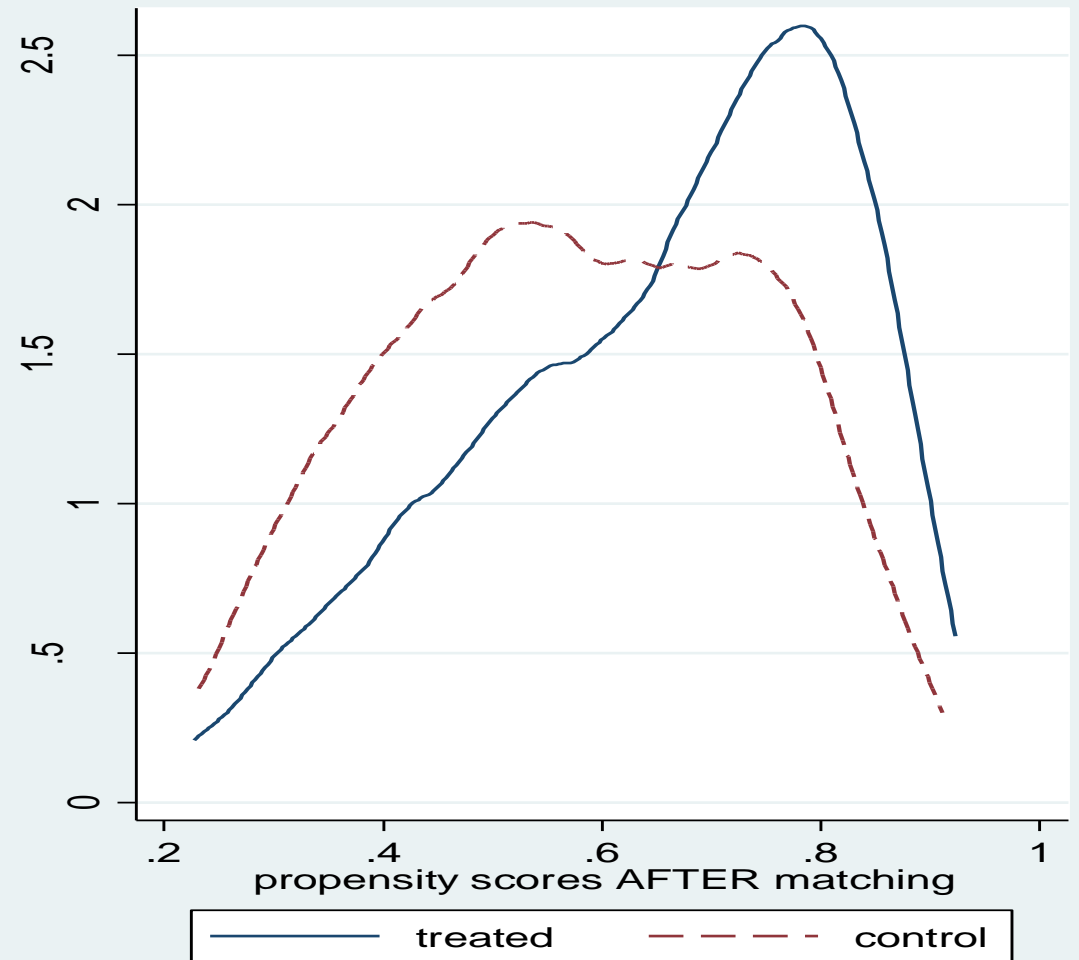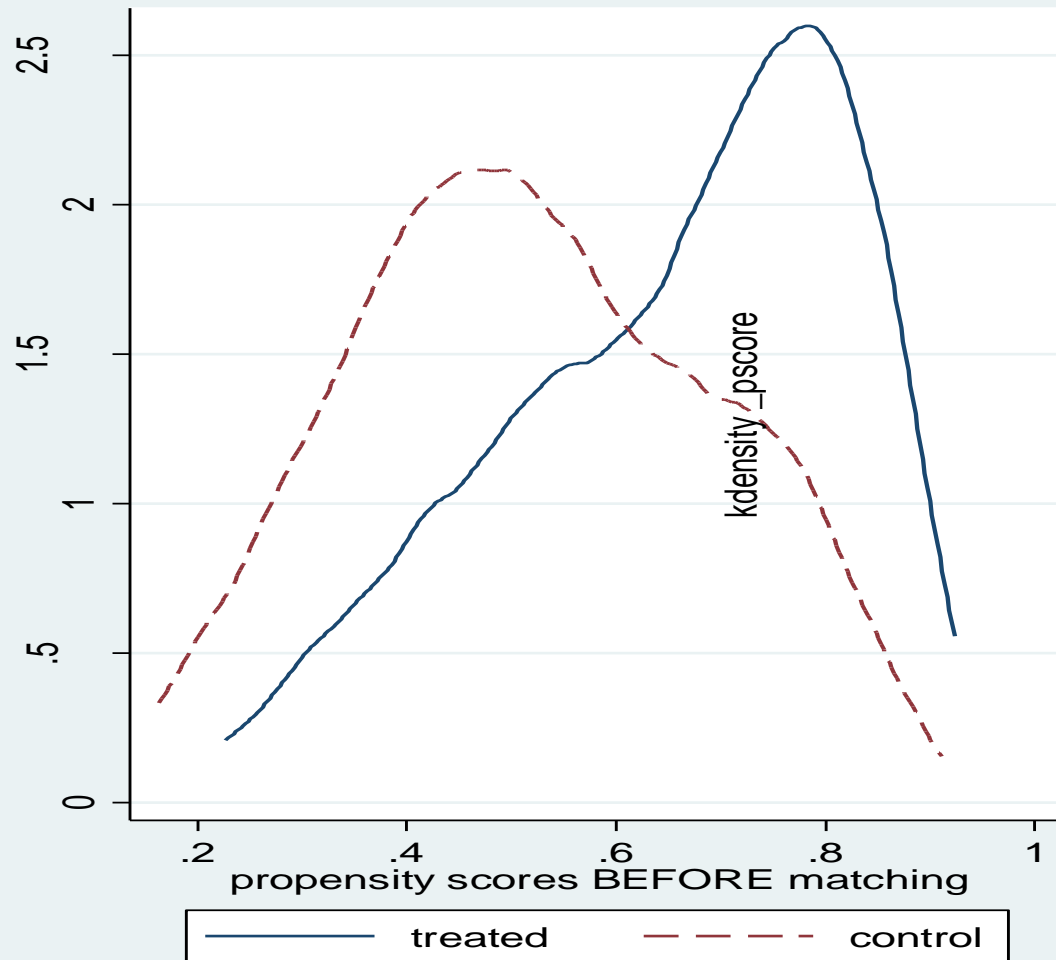
Satisfaction level on the use of Bondhu Chula
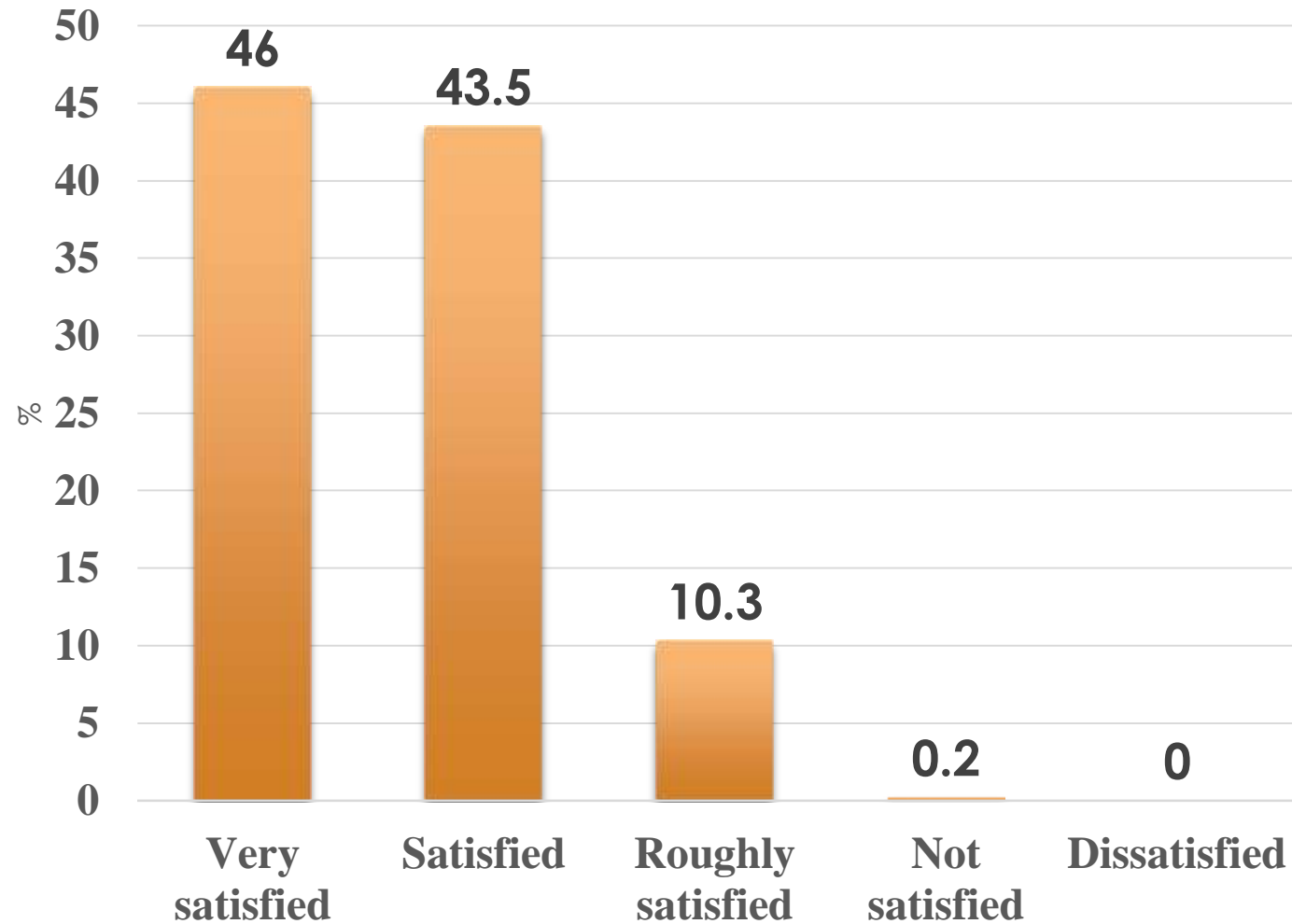
About 46% mentioned that they are very satisfied using the chula (figure 4.3). About 34% Bondhu Chula user said that they are satisfied, followed by 21% users who said that they are somewhat satisfied.

PSM Estimates

Estimates of Common support: Balancing property

Impacts of *Bondhu Chula* on Energy use, cooking time, and health

Indicators	PSM estimates (ATT)	t-value
Biomass Energy use (kg/month)	-11.94	-4.53
Rice cooking time (minutes/ per meal per head)	-1.32	-4.13
Women health: Frequency of visit to a doctor due to respiratory problems (number of times/month)	-1.04	-8.19
Women health: Expenditure for treating respiratory symptoms (Tk/month)	-90.62	-2.27

- The table reports the PSM estimates of the impact of bondhu chula on household energy use, cooking time, and health.
- The estimated results show that having a bondhu has positive impacts in terms of a reduction in biomass energy use, cooking time, and health expenditure (caused by indoor air pollution).

Note: ATT is average treatment effects on the treated, that is, the average effects of bondhu chula compared to traditional chula

Monitoring and Implementation

- The progress of the project was regularly monitored by the CCTF office.

- The Progress of the project was monitored by the project manager of Market development initiative for Bondhu Chula

- CCTF organized monthly coordination meeting at CCTF office where progress and problems of the project were discussed.

- The project is implemented successfully

- The contractors did the good work in selling and installing *Bondhu Chula*. But not much after sale services

- Only Technicians got training; but the beneficiaries did not receive training on installing a *Bondhu Chula*.

- After the project period, there was not much monitoring.

- Did not provide any financial support or loans for the poor household to access to manage the subsidies or to buy *Bondhu Chula,*

Need to lower the price or increase the amount of subsidy to encourage more poor to use this ICS

Need access to finance (loan) for the poor households to buy *Bondhu Chula*

Need more training on marketing

Need to motivate people to expand the use of *Bondhu Chula*

Public Health Department needs to be involved

Local Government should be involved with this type of project

Need to form a committee from the beneficiaries for after project services

To summarize, using household survey data as well as frequency distribution and t-statistics this study finds that the use of a *bondhu chula* contributed to the reduction of household fuel use, fuel expenditure, cooking time, (indicative) indoor air pollution, and health expenditure indicating improvement of the health condition of household members.

Overall, the HHs are satisfied using *bondhu chula*.

Thank You!