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Is Nepal's Renewable Energy Subsidy Reaching Poor People of Rural Areas? A Study of Biogas and Solar Home Systems

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Abstract

The Government of Nepal has been providing financial support to promote biogas technology since the 1970s and Solar Home Systems (SHS) since the 1990s. This paper analyse data from the Nepal Living Standard Survey for the year 2010/11 to determine the extent to which these programs have reached the poor.

Only 5 percent of households eligible for a biogas subsidy have adopted biogas. Only 2 percent of biogas adopters are below the poverty line, as compared to a poverty rate of 19 percent in all of Nepal. The probability of biogas adoption is increasing in annual per capita consumption.

The adoption rate is much higher for SHS with 27 percent of the households eligible for a subsidy having adopted Solar Home Systems. About 25 percent of adopters are below the poverty line, as compared to a poverty rate of 19 percent in all of Nepal showing that the SHS subsidy program reaches many more of the poor than the biogas subsidy program. The proportion of SHS adopters increases some what with an increase in annual per capita consumption upto the median and then falls steeply. The findings suggest that the government's subsidy for biogas has not reached the low-income population and to do so, the existing subsidy delivery mechanism would have to be rethought. The SHS subsidy has done much better in this regard. The paper discusses the reasons behind the differences

Keywords

Biogas, Solar home system, Subsidy targeting, Renewable energy, Energy economics

Is Nepal's Renewable Energy Subsidy Reaching Poor People of Rural Areas? A Study of Biogas and Solar Home Systems

1. Introduction

Globally, 1.3 billion people have no access to electricity and 2.8 billion still rely on solid cooking fuel (IEA, 2012). Moreover, 85 percent and 78 percent,respectively,of the total population without electricity access and using solid cooking fuel reside in rural areas (SE4ALL, 2013). Access to modern energy services is a primary prerequisite for poverty reduction and sustainable human development(Practical Action, 2010). The Sustainable Development Goal number 7 sets the target to ensure universal access to affordable, reliable and modern energy services by 2030.

In Nepal, firewood, agricultural residue and cow dung have been the primary energy sources for cooking (Bhandari and Stadler, 2009; Gurung *et al.*, 2011). According to census reports, 66 percent of households (33 percent of the urban households and 72 percent of the rural households) were using firewood as their main source of cooking fuel in 2001. After a decade, in 2011, 64 percent of households (26 percent of the urban households and 73 percent of rural households) were still using firewood for cooking (CBS, 2012, 2002).

With regard to lighting, the proportion of households using electricity as their major source of lighting had increased from 40 to 67 percent between 2001 and 2012. When disaggregated by area, the increase in usage was from 83 to 94 percent in urban areas and from 32 to 60 percent in rural areas.

The Government of Nepal has been promoting renewable energy technologies (RETs) for a long time. However, the agressive promotion of RETs started when the Government provided a subsidy for biogas in 1992 and Solar Home Systems (SHS) in off-grid areas in 2000, the objective behind the subsidy programs being the provision of clean energy to the poor (Government of Nepal, 2000a).

The Renewable Energy Subsidy Delivery Mechanism 2000 had clearly stated that the goal of the subsidy policy is to provide clean and renewable energy to poor households of rural areas. Similarly, the Subsidy for Renewable (Rural) Energy Arrangement, 2006, clearly states that the rationale of the Arrangement is to make the RETs delivery to the rural poor more effective. The subsidy policy was amended in 2009 and 2013. The 2009 policy has the same poverty agenda as in 2006 but the Subsidy Policy for Renewable Energy, 2013, has the major focus of having RETs reach the rural poor households with the added aim of using the RETs as a means of poverty eradication.

This paper asks to what extent the policy goal of providing clean cooking and lighting technologies to the rural poor has been reached. In the case of biogas, the results are not encouraging. Only 5 percent of the households that are eligible for the biogas subsidy had adopted biogas as of 2011 when the last Nepal Living Standards Survey was conducted. Only 2 percent of biogas adopters were below the poverty line. Solar home systems have been more effective in reaching the poor. 27 percent of the households eligible for the subsidy had adopted it by 2011. Around 25 percent of SHS adopters were below the poverty line.

2. Renewable Energy Scenario in Nepal: the Background

Since the early seventies, RET projects have been promoted in Nepal to reduce rural poor people's dependency on firewood for cooking and fossil fuels for lighting (Gurung ***et al.***, 2011; Pokharel, 2003). These efforts gathered momentum in the early 1970s consequent to the following: the inclusion of RET promotion in the Government's national program; the establishment of the Water and Energy Commission Secretariat (WECS) as the lead body for the development of energy in 1980 (Pokharel, 2003); the inclusion of RET in the Eighth Five Year Plan (1992-1997); the formation of the Alternative Energy Promotion Centre (AEPC) in 1996 as the lead body to promote RETs in Nepal (ESAP, 2010); and the introduction of subsidies for RETs in the Rural Energy Policy in 2006. The goal of the Rural Energy Policy was the reduction of rural poverty through the provision of clean and reliable energy technologies. One of their strategies for this purpose was to classify VDCs based on poverty, remoteness, and caste/ethnicity. The policy thus is of utmost importance for the rural poor.

This is not the first time that attempts have been made to provide RETs to rural poor communities. Biogas was promoted in Nepal before 1975; Solar-PV-based rural electrification was first started in 1988. But, in both instances, dissemination progressed only after subsidies were provided: for biogas, through the Biogas Support Program (BSP) in 1992 (Pokharel, 2003); for electrification, through the AEPC and the Energy Sector Assistance Programme (ESAP) in 1996 (Piya and Rai, 2003).

Subsidies for biogas dissemination started with the provision of an interest-free loan in 1975. From the inception of the programs, only households with at least one cow or buffalo have been eligible for the subsidy. This has the effect of excluding the poorest households who do not own cattle from the scope of the program but it also has the effect of excluding urban households who are generally richer than rural households. In 1996, larger subsidies were given to remote hill areas, and in 1999 the subsidy was modified so that smaller biogas plants received larger subsidy allocations compared to larger-sized biogas plants. In 2006, the Government of Nepal revamped its biogas subsidy policy to focus on smaller biogas plants[1], specific geographic areas, and a specific type of biogas technology. Under this policy, as in all previous policies, households were eligible for a subsidy if they owned at least one cow or buffalo. However, districts located in the *Tarai* (Southern belt) that are accessible by road get a lower subsidy than mid-hill districts that are not connected to a road network. Furthermore, subsidies are provided for the GCC 2047 dome model biogas units, which can be operated using either cow or buffalo dung.

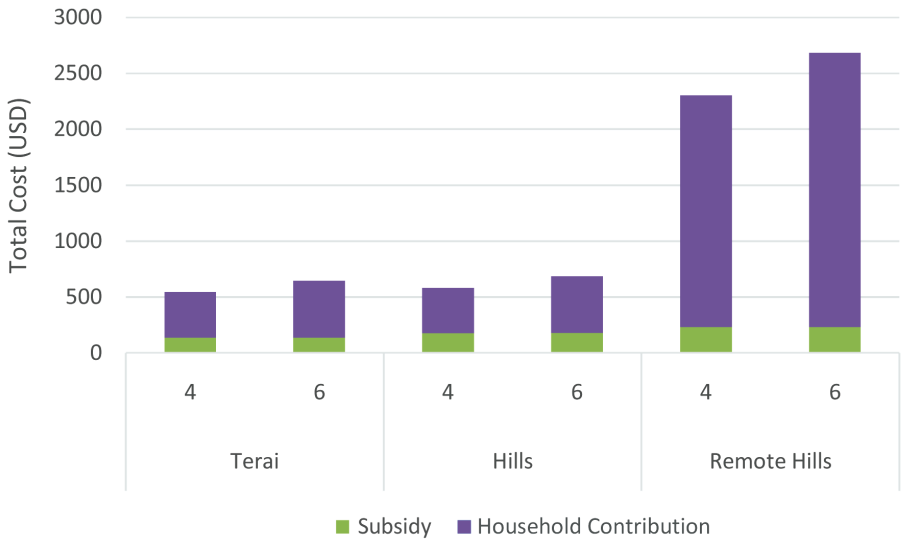

Figure 1: Total Cost, Household contribution and subsidy for biogas plants in year 2010

[1] These were classified by size into the following categories: 2 m3, 4 m3, 6 m3, 8 m3, 10 m3 and above 10 m3.

Taking the price reference of the year 2010 and considering only 4 and 6 cubic meter of biogas plant[2], it is found that a household pays around USD[3] 400 to USD 500 in the Terai and Hill region whereas households residing in the remote hill pays USD 2,000 to USD 2,400 for same size of biogas due to additional cost incurred in transportation. The cost of biogas for same size in Terai and hill varies from USD 500 to USD 700, whereas in the high hill it costs USD 2,300 to USD 2,700 (AEPC, 2010). If we calculate the percentage of subsidy on biogas, then it would be around 20-25% of total cost of biogas.

Solar Home Systems began to be subsidized in the 1990s and the policy currently geographically targets remote Village Development Committees (VDCs) or households located in these VDCs (Government of Nepal, 2069). Thus, VDCs listed as "very remote" receive more subsidy than those listed as "remote;" the latter, in turn, receive more subsidy than those listed as "not remote"[4]. Within targeted VDCs, the subsidy provided depends on the size of the SHS, with 10- to 18-Watt-peak systems receiving a smaller subsidy than those with a peak output that is higher than 18 Watts. Households that are not connected to the national or local grid are eligible for these subsidies.

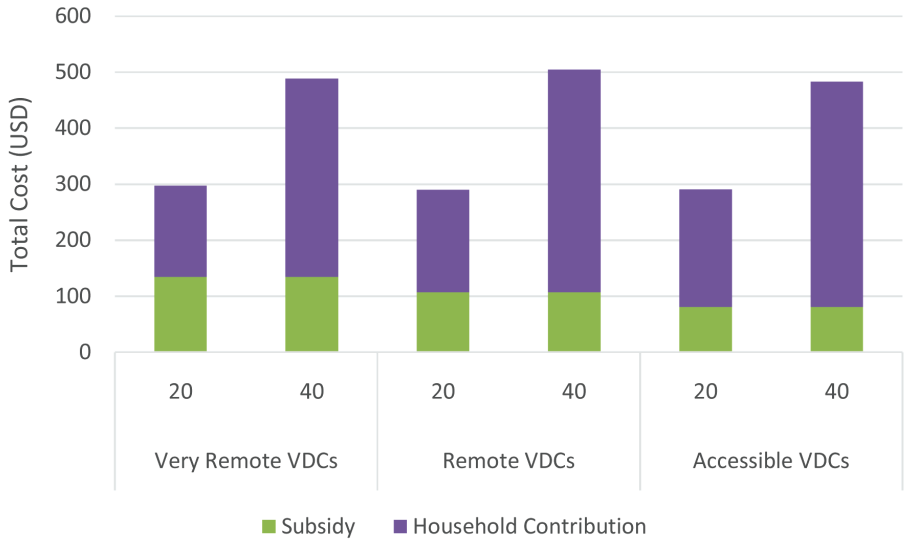

Figure 2: Total Cost, Household contribution and subsidy for solar home system in year 2010

Taking the price reference of the year 2010 and considering only 20 and 40[5] watt of solar home system, it is found that a household pays around USD 163 to USD 210 in the very remote VDCs, remote VDCs and accessible VDCs for 20-watt system. Similarly, USD 340-400 is paid for 40-watt system. Household residing in the very remote area pays less compared with the household residing in accessible VDCs. The cost of 20-watt and 40-watt solar home system varies from USD 293 to USD 300 and USD 490 to USD 500 respectively (AEPC/ESAP, 2011). If we calculate the percentage of subsidy on solar home system, then it would be around 28-45% for 20-watt system and 17-27% for 40-watt system.

The biogas and solar subsidies are channeled through the Alternative Energy Promotion Centre (AEPC), which is under the Ministry of Science, Technology and Environment. The subsidy is not given directly to households. Rather, it is given to Pre-qualified Companies (PQCs) which are either biogas plant construction or solar home system supplier companies. These companies can obtain the subsidy if they are able to provide the required paperwork showing that they have delivered the technology to an eligible household. The companies also need to submit subsidy application forms (signed by the consumer), photographs and other supporting documents after they have finished their installation work. If everything is in order, the companies receive the appropriate subsidy from the government.

[2] 4 and 6 cubic meter of biogas plant are popular

[3] 1 USD= NPR 74.36 (Annual Average of the year 2010 from www.onda.com)

[4] The categorization of the VDCs is done by the Ministry of Federal Affairs and Local Development.

[5] 20 and 40 watt solar home system are popular in rural area

As evident from the above, the Government's renewable energy and subsidy policy has undergone some revisions over the years. However, its primary focus remains the same: to have RETs reach the rural poor households with the added aim of using the RETs as a means of poverty reduction. Given these policy emphases, the study undertook an evidence-based rigorous research in order to see if the policy goal of providing clean cooking and lighting technologies to the rural poor has been successful or not. In addition, it sought to analyze the factors influencing the adoption of these technologies in order to understand the adoption economics of rural households.

3. Data

This study is based on secondary data obtained from the Nepal Living Standard Survey III 2010/11 (CBS, 2011a), which adopted the methodology of the World Bank's Living Standard Measurement Survey (LSMS). This national level survey involved a nationally representative sample of 5,988 households drawn from 499 primary sampling units (PSUs). For this purpose, Nepal was divided into 14 different strat a based on geographical and ecological regions. The PSUs were selected from 14 different strata using Probability Proportional to Size (PPS) sampling, where size was based on the number of households. From each PSU, 12 households were systematically selected (CBS, 2011a).

62% of all households owned at least one cow or buffalo, thus making them eligible for the biogas subsidy. Likewise, 19% of households were not connected to grid electricity because they resided in an off-grid rural area, thus making them eligible for the SHS subsidy.

The analysis of biogas and SHS technology was carried out using two sample groups: the total sample (5988) and the subsidy-eligible sample (3,279 for biogas and 1,008 for SHS, respectively). The rationale behind the use of the total sample in the analysis was to survey the distribution from an eagle's eye view, that is, to determine whether the RET has reached the poor section or not. Similarly, the rationale behind the use of the eligible sample is to zoom into the poor section of the population residing in the rural areas and to determine if the subsidy has reached them or not. By looking at both samples, a clear picture of RET distribution can be drawn at the national as well as the rural level. We compute summary statistics and carry out a regression analysis using a subsidy eligible sample in order to examine the adoption of RET among the poor in rural areas.

In this study, we investigate the adoption for two different renewable energy technologies: biogas and SHS. Biogas is used for cooking meals and requires animal dung to produce flammable gas whereas SHS is used for lighting and requires sunshine to recharge the battery. Biogas is adopted by households having at least one cow or buffalo for the animal dung which is used as input material. Therefore, we estimate two models separately for biogas and SHS[6]. The dependent variable for biogas is a binary variable which equals 1 if the household adopts biogas and 0 otherwise. Similarly, the dependent variable for SHS equals 1 if the household adopts SHS and 0 otherwise. Independent variables include observable variables as well as spatial fixed effects that control for unobservable variables, which are explained below. The observable independent variables include *household poverty, subsidy category, ethnicity, remittance, and credit and household demographics*.

Household poverty is a policy variable to determine whether the subsidy targets poor households or not and is determined based on whether a household falls under the official definition of the poor. It is equal to 1 if the household is poor, that is, the household's annual per capita expenses are less than NPR 19,261 (USD 259), and 0 otherwise[7]. According to CBS (2011b), the estimation of poverty is done through the Cost of Basic Needs approach. The approach defines the poverty line based on the expenditure value required by an individual to fulfill

[6] 20 and 40 watt solar home system are popular in rural area

[7] This is a national average. We used the region (stratum)-specific poverty lines provided by the Central Bureau of Statistics.

his/her needs in terms of both food and non-food items. The CBS (2011b) had estimated the poverty line at NPR 19,261 where the food poverty line is NPR 11,929 (USD 160) and the non-food poverty line is NPR 7,332 (USD 98). It was expected that the rural poor household would adopt both biogas and SHS since the subsidy policies focus on providing RETs to rural poor households.

Subsidy category: there are separate subsidy categories for biogas and SHS. The subsidy for biogas is categorized into three categories, i.e., 15 remote districts without road access (1 if the household resides in these districts, 0 otherwise), 20 districts of the Tarai (1 if the household resides in one of these districts, 0 otherwise) and 40 accessible districts (1 if the household resides in one of these districts, 0 otherwise). Similarly, for SHS, the subsidy is categorized as not remote subsidy category area (1 if the household resides in one of these districts, 0 otherwise), remote subsidy category area (1 if the household resides in one of these districts, 0 otherwise) and very remote subsidy category area (1 if the household resides in one of these districts, 0 otherwise).

Ethnicity is an important variable not only because, the *Dalit* and backward communities reside in rural areas and are poor (Pattanayak and Lewis, 2012) but because the subsidy policy has prioritized these ethnic groups for RETs delivery. There are hundreds of ethnic groups in Nepal but for the purpose of our analysis we have categorized ethnicity into five major categories: *Brahmin* and *Chhetri* (1 for yes and 0 otherwise) as higher castes and *Dalit*, *Janajati, Madhesi* and other ethnicities as lower castes. It is expected that the *Dalit* and backward ethnic groups will receive subsidies for RETs.

Remittance refers to money received by a household when a member works abroad who may send back money for particular expenses such as construction of biogas or purchase of SHS. Given this possibility, the study investigates if remittance has some role to play in the adoption of RET or not. It is a dummy variable which is defined by the remittance received by a household (1 if the household receives remittance and 0 for no remittance).

Credit plays a vital role in the adoption of RETs since some households do not take loans whereas other households take loans from two major sectors: informal and formal. In the research, the informal sector is defined as friends, relatives and landlords (1 for yes, 0 otherwise). The other dummy variable is for households taking loans from NGOs and cooperatives (1 for yes, 0 otherwise) which is defined as the formal sector. Since there are households who have access to national banks, these households are represented by the variable "households taking loans from banks" (1 for yes, 0 otherwise), which too come under the formal sector. It was expected that the credit support will help poor households to adopt the RETs.

Household demographics include the household size, sex of household head (1 for male and 0 for female), age of household head, number of school-going children, and the maximum education level among the household members.[8]

Fixed effects are used to control for spatial unobserved effects in order to correct for the omitted variable bias. The Central Bureau of Statistics reduced 14 strata to 12 analytical domains by merging mountain areas of the mid-and far-west regions and merging the *Tarai* area of the mid-and far-west regions (CBS, 2011b). We use fixed effects at the level of the analytical domain.

We use, in this research, the maximum likelihood estimation method to estimate the Logit model specified in Equation (6) for biogas and SHS.

[8] If any member of a household has 15 years of education, which is the highest for all members of the household, then that household is giventhe 15 number

4. Results

The empirical results are presented and discussed in Section 4.1 for biogas and in Section 4.2 for SHS.

4.1 Results for biogas

In this subsection, we present our analysis of the distribution of biogas among the rich and poor households, descriptive statistics, regression analysis, and the results from focus group discussions.

4.1.1 Distribution of biogas adoption among rich and poor households

Household data show that, overall, 3 percent of households have adopted biogas. Of these 3 percent that have adopted biogas, only 2 percent are poor households. Looking into the double poverty line[9] it is seen that 47.5 percent of households lie below the double poverty line. 35 percent of the biogas adopters lie below the double poverty line.

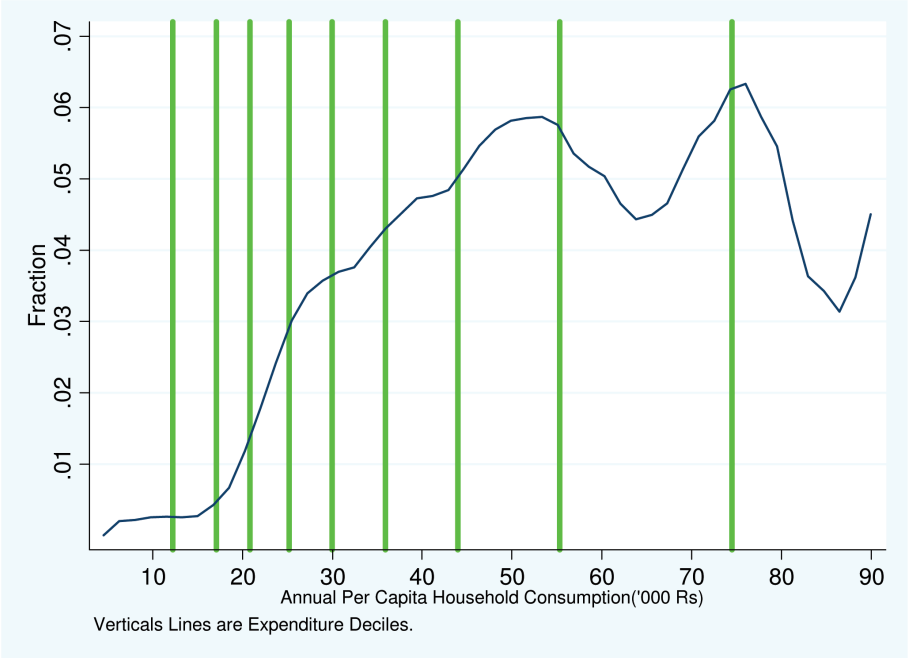

Figure 3: Fraction of households owning biogas[10] (N=5988)

To investigate the distribution of biogas among rich and poor, Figure 3 plots the fraction of households that owns a biogas plant within each decile of annual per capita household consumption. The figure is plotted using the entire sample (5,988), which includes both subsidy-eligible and non-eligible households. The percentage of households with a biogas plant increases as one moves up through the consumption deciles. According to the Figure, less than one percent of households in the 1st decile own biogas though the poorest of the poor households fall in the 1st decile. Similarly, roughly one percent of the households in the 3rd decile own biogas plant while around five percent of the households in the 7th decile own biogas plants. The percentage of households that own a biogas plant tapers off by the 8th or 9th decile. In sum, it is clear from Figure 3 that the proportion of biogas adopters increases as annual per capita consumption increases. This indicates that poor households are not being well targeted for biogas plants.

[9] That is,USD 518, which is twice the poverty line of annual consumption expenditure of USD 259. We used the analytical-domain-specific poverty lines rather than this national average.

[10] The last decile is not reported in the graph as there were very few households adopting biogas and the annual per capita household consumption ranges between 89 thousand and 510 thousand.

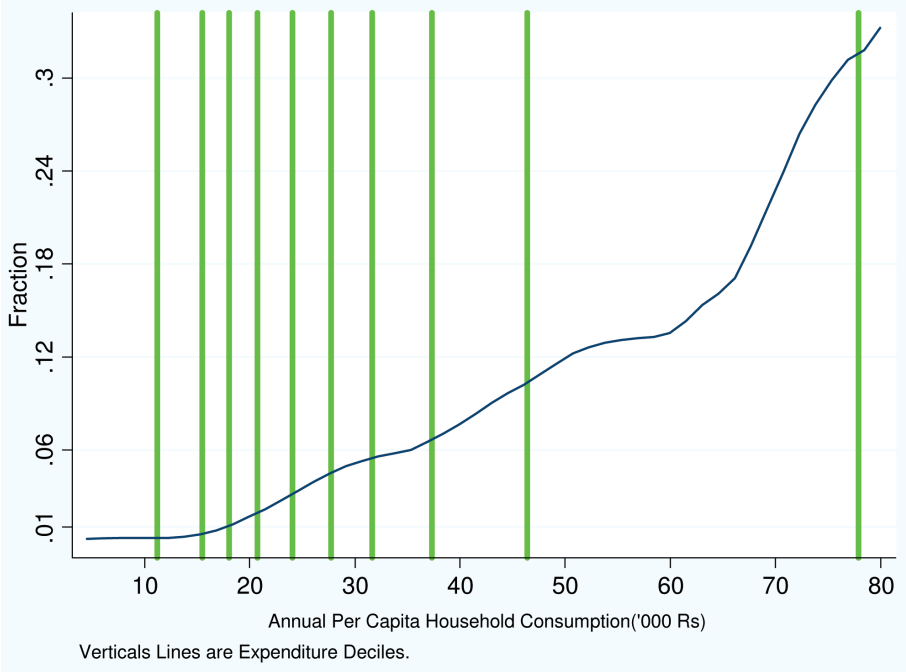

Figure 4: Fraction of Households owning Biogas within the Subsidy Targeted Population[11] (N=3279)

As mentioned above, 5 percent of subsidy-eligible households have adopted biogas (Table1). To investigate its distribution among rich and poor, Figure 4 plots the fraction of the population owning biogas plants within each decile of annual per capita household consumption for the subsidy-eligible households. The graph shows that less than one percent of households in the 1st decile of *subsidy-eligible households* own biogas plants and that this pattern continues with an increase by just two percentage points till the 4th decile whereas the percentage of households with biogas plants doubles between the 6th and 10th deciles so that, by the 10th decile, the number reaches around 16 percent. Within the subsidy-eligible population, it is even more clear that the richer households are more likely to adopt biogas.

4.1.2 Summary statistics for biogas

Table 1 presents the summary statistics of the variables used to examine the adoption of biogas, which is based on data from households that are eligible for the biogas subsidy. Since a household with at least one cattle unit is eligible for the subsidy, there are 3,279 eligible households within the survey data.

The statistics show that 5 percent of these households have adopted biogas. The data also show that around 23 percent of subsidy-eligible households for biogas are below the poverty line.

The national Subsidy Delivery Mechanism specifies that subsidies can only be distributed to those households having at least one cow or buffalo for the animal dung that is used as input material. The Subsidy Policy 2006 grouped the Districts into three major categories for SHS: remote districts without road access, districts of *tarai* (plains), and accessible districts. 16 percent of biogas-subsidy-eligible households reside in remote districts without road access while 50 percent of households live in accessible districts.

The majority of the subsidy-eligible population (40 percent) is from the *Brahmin* and *Chhetri* ethnicity. 30 percent of *Janajati* ethnicity and around 19 percent of the subsidy eligible households belong to the *Madeshi*.

26 percent of the households receive remittances. Forty-six percent of households borrow money from friends and relatives while only 16 percent of households borrow money from national banks for purchasing biogas plants. The

[11] The vertical lines are the mean value of each deciles

average household size is around five members and 76 percent of households are male-headed. The average age of the household head is 48 years. On average, the number of children going to school in a household is two. The statistics show that on average the maximum education level of a member in a household is five years.

Table 1: Summary statistics for households eligible for the biogas subsidy

	Variables	Mean	Standard Deviation
DEPENDENT VARIABLE	Biogas Adoption=1 if household has biogas, 0 otherwise	0.047	0.006
POVERTY	Household poverty =1 if household annual per capita expenses are less than NPR 19,261 (Nepali Rupees), 0 otherwise	0.234	0.0112
SUBSIDY CATEGORY	Remote districts without road access (15 districts)=1 if household resides in the 15 remote districts, 0 otherwise	0.163	0.0193
	Districts of the *Tarai* (20 districts)=1 if household resides in the 20 remote districts, 0 otherwise	0.333	0.0212
	Accessible districts (40 districts)=1, 0 otherwise	0.503	0.0256
ETHNICITY	*Brahmin* and *Chhetri* ethnicity=1, 0 otherwise.	0.339	0.170
	Dalit ethnicity=1, 0 otherwise.	0.147	0.009
	Janajati ethnicity=1, 0 otherwise.	0.298	0.016
	Madhesi ethnicity=1, 0 otherwise.	0.196	0.014
	Other ethnicity=1, 0 otherwise	0.017	0.004
REMITTANCE	Household receiving remittance = 1, 0 otherwise.	0.264	0.0129
CREDIT	Household with no credit =1, 0 otherwise	0.301	0.459
	Household taking loan from friends, relatives and landlords=1,0 otherwise	0.465	0.012
	Household taking loan from NGO and cooperative=1, 0 otherwise	0.077	0.006
	Household taking loan from banks=1, 0 otherwise	0.158	0.008
HOUSEHOLD DEMOGRAPHICS	Household size	5.271	0.0564
	Sex of household head = 1 if male, 0 otherwise	0.761	0.009
	Age of household head in years	47.788	0.274
	Number of school-going children	1.867	0.0323
	Maximum education years in the household	5.145	0.112
	Number of Analytical Domains	11	
Number of Observations	3279		

4.1.3 Fixed effect regression results for biogas

In this section, we discuss the results of the regression to investigate the factors that influence the adoption of biogas. Table 2 shows the marginal effects of the Logit model estimated with analytical domain fixed effects. The model is estimated using data on households that are eligible for the biogas subsidy. The Pseudo R-square, which measures the goodness of fit of the model, is 0.18.

Household poverty, one of the policy explanatory variables, is negative and statistically significant at the 1 percent level. The probability of a household adopting biogas decreases by around 46 percent if the household is below the poverty line.

The results show that the sex of the household head is statistically significant at the 10 percent level and that the sign of the coefficient is positive. Thus, if the household head is male, then the probability of adoption increases by 11.5 percent compared to a female-headed household. The education level, measured as “maximum household education”, is statistically significant at the 1 percent level. The results show that if the education level of a household is increased by one grade, the probability of the household adopting biogas increases by 1.4 percent. The coefficient on a household receiving remittance is positive and statistically significant at the 5 percent level. The probability of a household adopting biogas increases by around 12 percent if the household receives remittance.

Table 2: Fixed effect logit regression results for biogas adoption

	Variables	Marginal Effect
POVERTY	Household poverty (below poverty line)	-0.460***
		(0.094)
SUBSIDY CATEGORY	Remote districts without road access	0.260***
		(0.063)
	Districts of the Tarai	-0.058
		(0.058)
ETHNICITY	*Dalit* ethnicity	-0.381***
		(0.079)
	Janajati ethnicity	-0.179***
		(0.054)
	Madhesi ethnicity	-0.424***
		(0.074)
	Others	-0.398***
		(0.112)
REMITTANCE	Household receiving remittance	0.122**
		(0.048)
CREDIT	Household taking loan from friends, relatives and landlords	-0.048
		(0.057)
	Household taking loan from NGO and cooperative	0.098
		(0.080)
	Household taking loan from banks	0.124**
		(0.055)
HOUSEHOLD DEMOGRAPHICS	Household Size	-0.012
		(0.014)
	Sex of household head	0.115*
		(0.059)
	Age of household head	0.002
		(0.002)
	Number of school-going children	0.024
		(0.022)
	Maximum household education	0.014***
		(0.005)
	Observations	3,275
	Number of Analytical Domains	11
	Analytical Domain FE	YES
	Pseudo R-squared	0.182

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The regression results show that the castes *Dalit*, *Janajati* and *Madhesi* have a negative and statistically significant impact on biogas adoption in comparison with *Brahmin* and *Chhetri* castes. The probability of the household adopting biogas decreases by 38, 18, and 42 percentage points if the household belongs to the *Dalit*, *Janajati* and *Madhesi*, respectively.

All of these results show that an increase in the socio-economic status of the household increases the probability of adoption of biogas.

The subsidy classification has shown that the probability of adopting biogas increases by 26 percentage points if the household falls under remote districts without road access compared to the accessible districts. This is because the accessible districts have other better cooking solutions such as LPG and electricity.

Access to finance is also a widely discussed issue in the renewable energy sector (Pattanayak and Lewis, 2012; Glemarec, 2012). The probability of a household adopting biogas increases by 12 percentage points if the household takes a loan from a bank in comparison with a households that do not take a loan from any sources. One reason for this is that the interest rate is comparatively low in banks in comparison with other financing mechanisms such as NGO, cooperative and landlords. This shows that the adoption of biogas is high if the interest rate is low.

4.1.4 Targeting the right households - analyses from focus group discussions for biogas

In order to better understand the results from the secondary country-wide data on renewable energy technology adoption, a set of focus group discussions was held with biogas technology suppliers, and biogas adopters and non-adopters in March and May 2014. These discussions were held in Kathmandu, Ilam, Jhapa and Dhangadi with suppliers and in Ilam, Jhapa, and Dhangadi with adopters and non-adopters.

Supply-side strategies for biogas

For biogas, AEPC is the government agency that is responsible for identifying biogas technology suppliers. It is also responsible for offering subsidies to encourage the use of these this technology. As explained above, these subsidies are offered to supply companies rather than directly to households.

To encourage the supply and delivery of biogas, AEPC first selects qualified companies to construct biogas plants. These construction companies are responsible for promotional activities, plant installation and after-sales services. At the beginning of every fiscal year, each company presents a plan that outlines the districts it intends to target and the number of biogas plants that it intends to build. If a company fails to construct at least 70 percent of the number of plants set out in its annual plan, then it is disqualified for the next fiscal year. These biogas plant construction companies provide skilled manpower, pipes and fittings, as well as appliances and accessories. They also provide details of all the installations they undertake to the AEPC and claim the subsidy they are eligible for after the installation has been completed.

While individual companies have their own promotional strategies, there are a few common ones that every company adopts in order to select households for biogas plant construction. First, companies select locations based on information provided by local residents or by their staff. Then, they do a walk through visit using bikes or bicycles. During the walk through, they try to identify households that could afford biogas. Their basic criteria for selecting households relate to the size of livestock stalls, house types and the size of the rice straw stacks. When they find around 10 or more potential households, they then identify an influential person or a household in the locality and try to convince that person or household to construct a biogas plant. This is often done by going to the common meeting places in a village where local leaders gather. Biogas construction companies also ask lead households or individuals to gather 10 more households that they think might be interested in having a biogas plant; if a lead household is successful in doing that, then, they are normally offered some discount on the price of their plant. After households have been selected, a biogas expert from the construction company visits them and explains the costs and benefits of biogas plants and outlines the available subsidies. The companies also offer to construct demonstration biogas plants at a discounted rate if this is required to convince households to act. If a household commits to getting a biogas plant installed, they are asked to provide a minimum of a thousand rupees as an advance.

University students and students from rural areas who are studying in cities are an ideal conduit through which biogas use can be promoted and propagated as such students often see the benefits of biogas plants in their adopted locales and motivate their parents back home to install one. Another way in which companies generate demand for biogas plants is by nominating an agent who will get a bonus if he/she recruits households for biogas plant installation. Such agents are often local school teachers, lower-level Village Development Committee officials, the representatives of local political parties and local traders. Such people are selected as agents because of their social status and powers of persuasion.

Non-adopters for biogas

Although biogas non-adopters were from subsidy eligible area and had heard about biogas technology and the biogas subsidy scheme, they were not certain about the actual price of biogas and the amount of subsidy provided. Non-adopters mentioned that it would be easier for them to use biogas if they could rear cattle. However, they noted that they did not have enough land and human resources to both rear cattle and operate a biogas plant. In addition, it was noted that LPG was easily available. Smaller 'new generation' families reported that they found it easier to use LPG than biogas even though LPG was costlier. These families said that they were too busy with jobs and other activities to get involved in the operation of a biogas plant.

4.2 Results for SHS

This section presents the analysis of the distribution of SHS among the rich and poor households, descriptive statistics, regression analysis and the results from the focus group discussions.

4.2.1 Adoption of solar home systems among rich and poor households

In Nepal, 19 percent of total households are poor and around 6 percent of all households have adopted SHS. Of these 6 percent of households that have adopted SHS, about 25 percent are poor households. This shows that the SHS subsidy does reach poor households to a much greater extent than the biogas subsidy. Looking into the double poverty line it shows that 46 percent of all households lie below double the poverty line. Out of the 6 percent of all households that have adopted SHS, 57 percent of them are below double the poverty line.

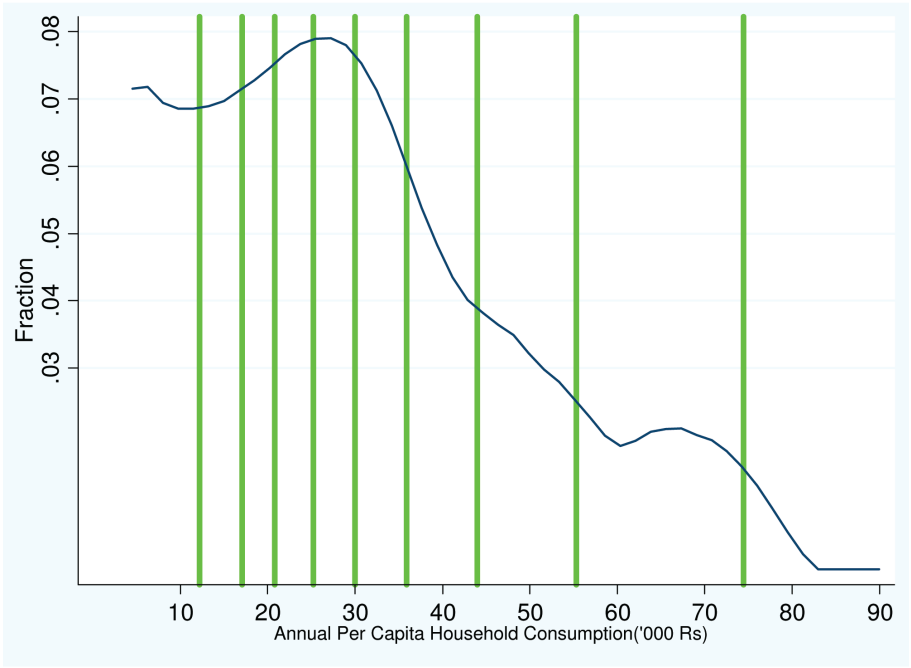

Figure 5: Fraction of households owning solar home system[12] (N=5988)

Since household data show that six percent of households have adopted SHS, to investigate its distribution among rich and poor, Figure 5 plots the fraction of households that owns a SHS within each decile of annual per capita household consumption. The Figure is plotted using the entire sample (5,988) which includes both eligible and non-eligible households. It shows that, while 7 percent of households in the 1st decile own a SHS, some 8 percent of households in the 4th decile own such a system. But the fraction of SHS adopters decreases from 7 percent

[12] The last decile is not reported in the graph as there were very few households adopting biogas and the annual per capita household consumption ranges between 89 thousand and 510 thousand.

to 3 percent from the 1st to the 7th decile. This result is expected because the percentage of SHS owners in each income/consumption class is expected to decline as consumption increases as richer households residing in urban areas enjoy as table connection to grid electricity.

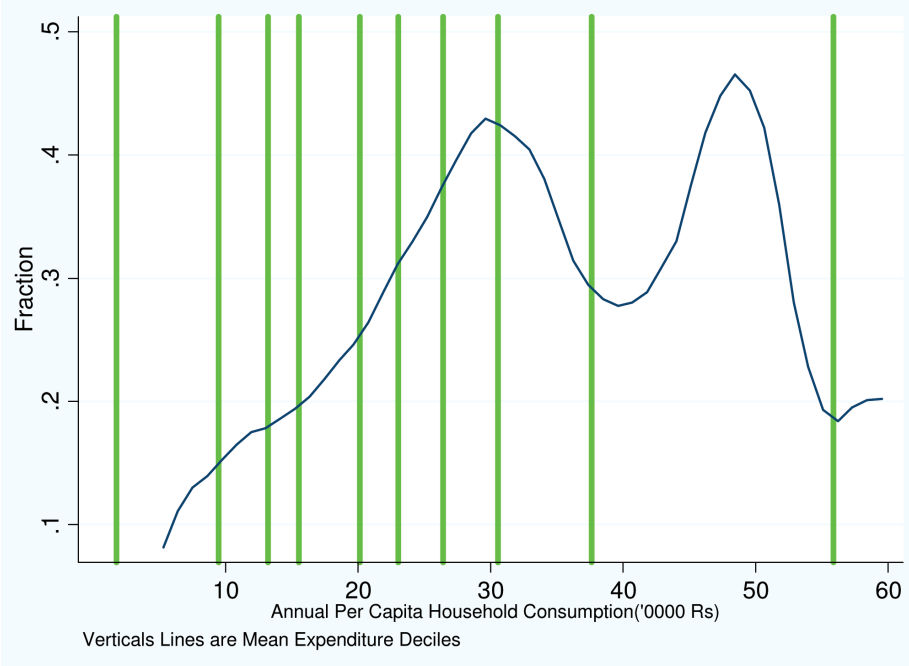

Figure 6: Fraction of households owning SHS within the subsidy eligible population (N=1008)

The data show that, among the households that are eligible for the SHS subsidy (1,008), around 27 percent have adopted SHS (Table 3). To investigate the distribution of SHS among the rich and poor, Figure 6 plots the fraction of households owning a SHS that are eligible for subsidies (i.e., households from within VDCs that are targeted for subsidies which comes to 1,008). The graph shows that SHS adoption among subsidy-eligible households increases sharply with consumption. The graph also shows that around 45 percent of subsidy-eligible households lie below the poverty line. Thus the eligibility criterion of being in an off-grid area effectively targets poorer households, but within the off-grid areas, it is easier for richer households to afford the SHS, even after the subsidy.

4.2.2 Summary statistics for SHS

Table 3 presents the summary of variables that were used to analyze the adoption of SHS, which is based on data from the households that are eligible for the SHS subsidy. The variable "household poverty" indicates whether a household is below or above the national poverty line. It shows that around 35 percent of subsidy-eligible households for SHS are below the national poverty line as compared to 19 percent for the general population. This shows that the eligibility criterion assists in targeting the poor.

The national Subsidy Delivery Mechanism specifies that subsidies can only be distributed to those households that are not electrified (i.e., not connected to the national or local grid). The Subsidy Policy 2006 grouped the Village Development Committees (VDC) into three major categories for SHS: remote VDCs, very remote VDCs and not remote VDCs, on the basis of which higher value subsidies were allocated to very remote VDCs relative to remote and not remote VDCs. 58 percent of SHS-subsidy-eligible households reside in not remote VDCs while 36 percent of households live in very remote VDCs.

The majority of the subsidy eligible population (41 percent) is from the *Janajati* ethnicity which is followed by 37 percent from the higher castes represented here as "*Brahmin* and *Chhetri* ethnicity." Around 16 percent of the subsidy eligible households belong to the Dalit ethnicity while the remaining number is made up of members from the other castes.

Table 3: Summary statistics of solar home system

	Variables	Mean	Standard Deviation
DEPENDENT VARIABLE	SHS Adoption=1 if household has SHS, 0 otherwise	0.273	0.446
POVERTY	Household poverty =1 if household's annual per capita expenses are less than NPR 19,261 (Nepali Rupees), 0 otherwise	0.349	0.477
SUBSIDY CATEGORY	Not remote subsidy category area=1,0 otherwise	0.583	0.493
	Remote subsidy category area=1,0 otherwise	0.0595	0.237
	Very remote subsidy category area =1, 0 otherwise	0.357	0.479
ETHNICITY	*Brahmin* and *Chhetri* ethnicity=1, 0 otherwise	0.373	0.152
	Dalit ethnicity=1, 0 otherwise	0.160	0.011
	Janajati ethnicity=1, 0 otherwise	0.410	0.015
	Madhesi ethnicity=1, 0 otherwise	0.050	0.006
	Other ethnicity=1, 0 otherwise	0.004	0.002
REMITTANCE	Household receiving remittance = 1, 0 otherwise	0.174	0.379
CREDIT	Household not taking loan=1,0 otherwise	0.300	0.458
	Household taking loan from friends, relatives and landlords=1, 0 otherwise	0.578	0.494
	Household taking loan from NGO and cooperative=1, 0 otherwise	0.0704	0.256
	Household taking loan from banks=1, 0 otherwise	0.0516	0.221
HOUSEHOLD DEMOGRAPHICS	Household size	5.160	2.325
	Sex of household head = 1 if male, 0 otherwise	0.751	0.433
	Age of household head in years	46.29	14.64
	Number of school-going children	1.932	1.494
	Maximum education years in the household	4.34	4.58
Number of Analytical Domains		6	
Number of Observations		1,008	

Only around 17 percent of households receive remittances from abroad, the variable for remittance received represented as a household receiving remittance.

Likewise, the variable "credit" is based on whether a household has taken a loan or not. It has four dummy categories: households that have not taken a loan, those that have taken a loan from friends or relatives, those that have taken a loan from an NGO and/or cooperative, and those that have taken a loan from a national bank. The results show that 58 percent of households take loans from friends and relatives while only 5 percent of household take a loan from national banks.

It shows that 75 percent of households are male-headed with the average age of the household head being 46 years. On average, there are two school-going children in a household. The maximum education of a household member is four years on average.

4.2.3 Fixed effect regression results for SHS

In this section, we discuss the results of the regression to investigate the factors that influence the adoption of SHS. Table 4 shows the marginal effects of the Logit regression estimated with analytical domain fixed effects. The model is estimated using data on households that are eligible for the SHS subsidy.

Table 4: Fixed effect logit regression results for SHS adoption

	Variables	Marginal Effect
POVERTY	Household poverty (below poverty line)	-0.184***
		(0.049)
SUBSIDY CATEGORY	Very remote subsidy area	0.039
		(0.049)
	Remote subsidy area	0.008
		(0.075)
ETHNICITY	*Dalit* ethnicity	-0.080
		(0.061)
	Janajati ethnicity	0.045
		(0.034)
	Madhesi ethnicity	0.154**
		(0.067)
	Other ethnicities	0.017
		(0.251)
REMITTANCE	Household receiving remittance	0.102***
		(0.038)
CREDIT	Household taking loan from friends, relatives and	0.019
	landlords	(0.035)
	Household taking loan from NGO and cooperative	0.036
		(0.058)
	Household taking loan from banks	0.021
		(0.074)
HOUSEHOLD DEMOGRAPHICS	Household size	0.030***
		(0.010)
	Sex of household head	0.011
		(0.042)
	Age of household head	-0.000
		(0.001)
	Number of school-going children	-0.001
		(0.015)
	Maximum household education	0.10***
		(0.003)
	Observations	955
	Number of Analytical Domains	6
	Analytical Domain FE	YES
	Pseudo R-squared	0.06628

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

As the main objective of this study is to observe the distribution of RET adoption between rich and poor households, the impact of the household poverty variable on SHS adoption is particularly important. The model suggests that the poorer households are 18 percentage points less likely to adopt SHS than richer households, a result that is statistically significant at the 1 percent level. Remoteness, on the other hand, has no effect on the adoption of SHS, which is positive as it indicates that adoption is evenly distributed among the subsidy category areas.

Households from the *Madhesi* ethnic group are 15 percentage points more likely to adopt SHS technology than households from the *Brahmin* and *Chhetri* ethnic groups.

Households receiving remittances are also statistically significant at the 1 percent level; they are 10 percentage points more likely to adopt SHS than households that do not receive remittances. Likewise, borrowing money from the formal or informal sector also has no impact on SHS adoption. Many in the formal financial sector, such as cooperatives and banks, in fact do not maintain a loan portfolio for SHS.

Households with large family size have a positive and significant effect on SHS adoption at the 1 percent level. With every increase in family member, the household has a 3 percentage point probability of adopting SHS. Although we expected that the number of school-going children would play a significant role in the adoption of SHS, the result indicates no such significance. However, households with family members who have had a higher education have a positive and statistically significant impact on the adoption of SHS at the 1 percent level. For example, if the highest grade of education of members in a household increases, then the probability of adoption of SHS increases by 1 percentage point.

4.2.4 Targeting the right households-analyses from focus group discussions for SHS

In order to obtain a better understanding of the results generated from the secondary country-wide data on renewable energy technology adoption, a set of focus group discussions was held in March and May 2014. These discussions were held in Kathmandu and Dhangadi with suppliers and in Ilam and Doti with adopters and non-adopters.

Supply-side strategies for SHS

For SHS, AEPC is the government agency that is responsible for identifying RET suppliers. It is also responsible for offering subsidies to encourage the use of these technologies. As explained above, these subsidies are not offered directly to households but to supply companies.

The promotion and distribution of SHS technology take place in a manner similar to the promotion and distribution of biogas. First, AEPC identifies companies that are eligible to supply SHS. Eligibility depends on a variety of factors such as the company's experience, its finances and its human resources. Eligible suppliers are then allowed to supply SHS to targeted VDCs. Currently, there are some 71 solar technology suppliers. These are almost all Kathmandu-based. The suppliers import solar photovoltaic systems from countries such as Germany, China, India and the USA.

While most SHS suppliers work all over Nepal, they focus more on the mid- and far-western regions of the country, which are largely un-electrified. While selecting the districts to target, they collect information on the number of households without electricity and the number of VDCs targeted by the AEPC. They also collect information on population numbers. After screening the location, they look for potential distributors. They favor distributors that are financially capable and that have good marketing networks and good transaction reputations. Some suppliers open a branch office or district headquarters and employ staff to cultivate a demand for SHS at the village level. Once the demand for SHS has been fully met in a village or district, they close their branch office and move on to another area. Distributors may also nominate village agents or hire marketing staff to identify potential buyers. The focus group discussions suggest that the first priority of suppliers is often to identify demand from villages near their district headquarters because this helps to mitigate their transportation costs and the overhead costs of their employees.

Most Nepali villages have a "junction point" or a small tea or local beverage shop where people from the village gather for informal discussions about regular village events and national political issues and where they also come to listen to the news on the radio. Most of the people who gather in these tea shops are drawn from the local elite (i.e., they are local political leaders, teachers or comparatively rich household heads). The focus group discussions indicate that the agents or marketing staff of SHS suppliers or distributors first visit these junction points and try to convince the people who are gathered there to adopt SHS. If anyone shows interest, then they ask him to convince ten more people. This person therefore becomes an entry point to a village or someone who can generate demand within an area.

Non-adopters for SHS

The non-adopters of SHS were from the eligible population and they are not much aware of the technology even though they had seen SHS in neighboring households and knew that it provided lighting at night. When asked about solar companies, they said that they had no idea about either the companies or their agents. They also said that nobody had ever visited them to provide information about SHS although they had heard about the presence of a few people in their village who had installed SHS. Some of the adopter households reported that they had bought SHS from a company's district headquarters. In such instances, we found that there had been no discussion or public hearing.

During the focus group discussion, non-adopters showed a high level of interest in buying SHS as they were facing difficulties in using traditional fuels for lighting (not only did they require much effort, they also emitted harmful fumes and smoke). However, since they said that they could not afford to install the system, they thought that smaller and cheaper systems would be more feasible. They also said that they would be able to afford systems priced between NPR 3,000 (USD 30) and NPR 4,000 (USD 40). They specified that such systems should be able to power three lights in addition to providing mobile charging. That said, some non-adopters showed no interest whatsoever in buying SHS as they had easy access to dry-cell torches that were cheaper than SHS and had the added advantage of very low monthly expenses knowing that the operating cost of SHS is very low until the time to replace the battery.

5. Findings

Results of the research can be summarized in Figure 7. The top panel compares the density functions of household consumption for the two subsidy-eligible populations with that of the population as a whole. For both subsidy-eligible populations, the densities are shifted to the left indicating that the percentage of rich people in the subsidy-eligible populations is lower than in the whole population. However, this shift is much less for biogas than for SHS. This shows that the eligibility criteria do tend to remove richer urban households, but much more for SHS than for biogas. This is because the requirement of living in a Village Development Committee without a grid connection targets poorer households in the case of SHS. But the requirement of cattle ownership, although it disqualifies richer urban households,does target relatively affluent households within rural areas.

The pro-poor effect of the eligibility criteria for biogas, is however, reversed within the subsidy-eligible population because adopters tend to be richer than non-adopters. This is seen in the middle panel that shows the density function of adopters shifted to the right of the density function of non-adopters among the subsidy eligible population. This is because investing in biogas is expensive. Even after the subsidy, it may cost a household more than 40,000 NPR, which is double the annual consumption expenditure at the poverty line. Therefore, richer households within the subsidy-eligible population are more likely to adopt biogas.

The bottom panel shows a similar, but much smaller, effect for SHS with the density function of adopters being to the right of the density function of non-adopters. SHS cost less than biogas plants with households paying less than 20,000 NPR in the more favorable locations. So although richer households are more likely to invest in them within the subsidy-eligible population, the effect is less severe than for biogas. It may also be that households find electric light more of a necessity than gas for cooking so that more of the poorer households adopt it. This is also reflected in much higher overall adoption rates for SHS as compared to biogas.

Government subsidy for both the technologies are geographically targeted but the level is different. Biogas is targeted at district level (both rural and urban) whereas SHS is targeted at selected rural VDCs. In addition, the subsidy is distributed through private companies who construct/sell the biogas and or SHS. The companies look for low hanging fruit and thus they target for richer households in the targeted area.

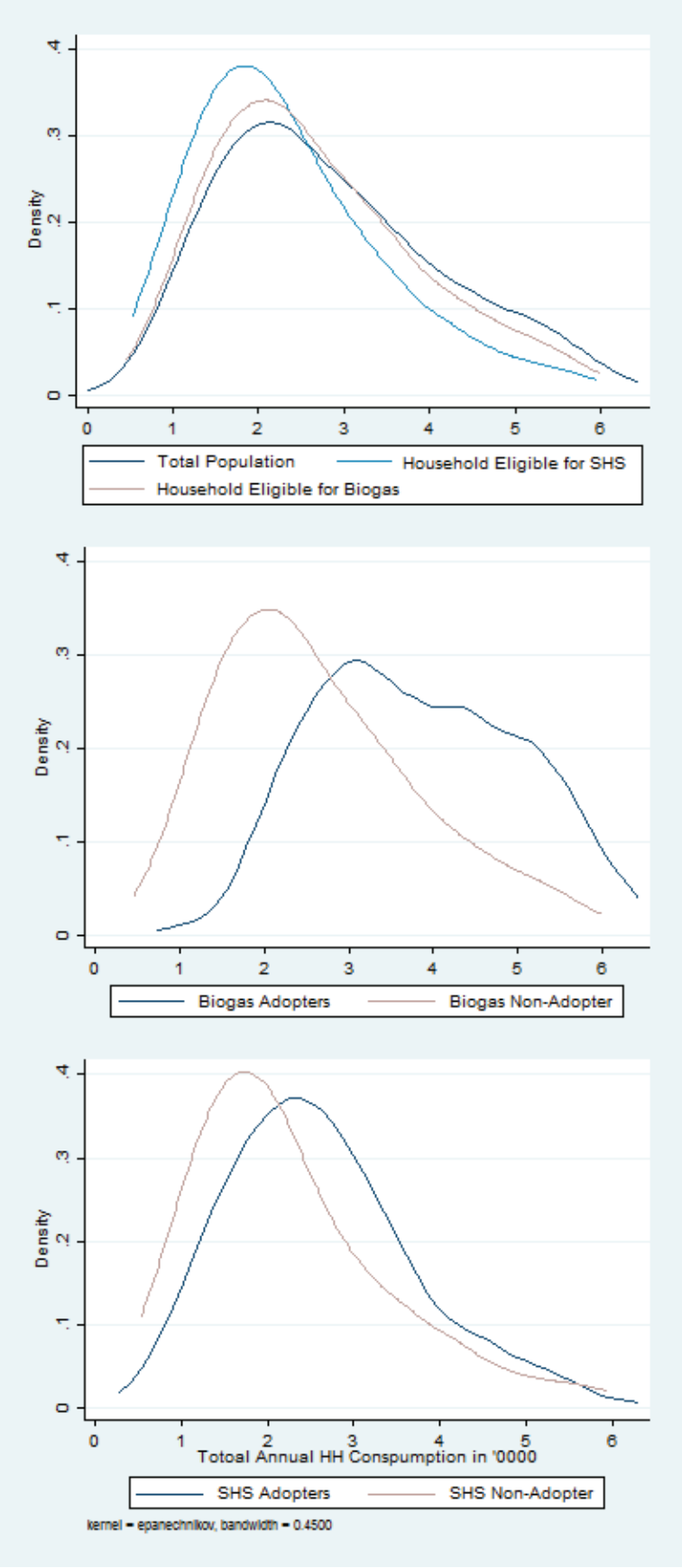

Figure 7: Distribution of subsidy eligible households for biogas and SHS, and the adopters and non-adopters of both the technologies

6. Conclusions and Policy Recommendations

Only 5 percent of households eligible for a biogas subsidy have adopted biogas and only 2 percent of biogas adopters are below the poverty line. There are many reasons why the Government has failed in its objective. A major reason is the public-private partnership model adopted for this purpose. Though highly regulated by the BSP/AEPC, not only do companies experience difficulties in identifying and engaging with the poor, they also have very little interest in the poor. Thus, even when the companies could identify poor households, it was clear that visiting these households was not profitable for them. Given that the biogas subsidy is targeted at the district level (which covers a large area), biogas technology suppliers tend to target families that are easier to reach, thus overlooking poor families that are eligible for the subsidy but are more difficult to reach as the cost afford ability of biogas is also high for poor households. The companies in their turn said that it was difficult to make poor households understand the available technology and subsidy mechanisms. Added to this is its high cost despite the subsidy. The cost of biogas has been increasing day by day despite government regulation of suppliers. All of this suggest the following; the subsidy available for poor households to install biogas has not worked as expected.

With regard to SHS,a somewhat better scenario presents itself compared to biogas as 27 percent of eligible households have adopted SHS for lighting and 25 percent of SHS adopters are below the poverty line. However, though the Government of Nepal has been promoting SHS for more than two decades as a means to increase the energy access of poor and marginalized households, 40 percent of SHS non-adopters are below the poverty line. While the geographical targeting of the SHS subsidy has meant that it has reached its target area and that it is helping to provide off-grid households with access to clean energy to light their houses, once again, the public private partnership model stymies efforts to reach the subsidy eligible poor households. Private SHS companies have a limited interest in investing their time in convincing poor households to take up SHS. Complicating matters is a perception among poor households that they should get government services for free which makes private companies reluctant to visit them. Thus, private companies focus more on richer households because such households are financially more capable of installing RET systems than poor households, which are financially less capable. The results also suggest that geographical targeting would be most effective in helping the SHS technology to reach rural areas where poor households reside if it is done using the lowest administrative division rather than the VDC as is done now.

Our research focused on whether biogas and SHS technologies have reached the poor households of the rural areas or not. It shows that the policy intervention to date has only been successful in serving the off-grid and rural communities while failing to deliver clean energy services to the poor households in these two communities. As discussed above, the PPP business model adopted to deliver clean energy services, while it has been successful in penetrating the rural areas, has failed to reach the poor households in those areas. One of the objectives of the United Nations initiative on Sustainable Energy for All (SE4ALL) is to ensure universal access to modern energy services by 2030. Our study therefore recommends the following policy alternatives to reach the rural poor with such services.

Firstly, since the results clearly show that Nepal's RET subsidies do not work for all groups of the population, a new classification of various groups of poor households and the targeting of these groups with specific programs would be needed to enable Nepal to meet the United Nations'SE4ALL objectives. Secondly, to effectively reach out to the poor, it is imperative to revise the way in which the subsidies are targeted now, targeting instead wards and VDCs where poverty is high. In the case of the biogas subsidy, for instance, it should be targeted at the VDC level where it is currently targeted at the district level. Thirdly, a different subsidy delivery mechanism and business model should be developed in order to provide clean energy to the rural poor; one such mechanism could be the introduction of the battery charging station concept;another would be for private companies to be given some quota to provide biogas to the poor households that have a cow or a buffalo. Fourthly, as there are various governmental agencies already reaching the poorest sections of Nepal's population, the AEPC could collaborate with these agencies to reach the rural poor. For example, the Poverty Alleviation Fund and the Leasehold Forestry Program focus on the rural poor households with a mechanism to identify such households. Collaboration between AEPC and such programs could deliver clean energy services more effectively to the rural poor.

There is potential for further research in this area. It is clear that a different mechanism is needed to reach the rural poor. Our research has not analyzed all the possible mechanisms for reaching the poor. Further research would thus be needed to identify the best way forward. Another avenue of research is how to reduce the cost of the technology since that plays a crucial role in generating interest on the part of a rural poor household in clean and renewable energy. Since the cost of biogas technology, for instance, is increasing day by day, more research should be undertaken on how to reduce the cost. This may entail the replacement of some expensive construction materials or the adoption of a different business model. On the other hand, the fact that SHS costs have fallen means that the outlook is brighter for this technology.

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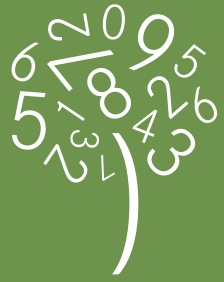

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