Chapter 13
What Influences Rural Poor in India to Refill Their LPG?

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Key Messages

- Rural income generation schemes, female literacy, positively influence LPG refills.
- While male work force participation increases LPG refills, female workforce does not.
- Vicinity to forest has heterogeneous effects depending on type of forest.

13.1 Introduction

Under the Nationally Determined Contributions (NDC) in the Paris Agreement (2015) India has committed to reduce emission intensity by 33–35%; increase the share of non-fossil-based energy to 40%; and improve its forest and tree cover to create an additional carbon sink of 2.5–3 GT-CO_2e (UNFCCC, 2018). Meeting these

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carbon-mitigation commitments requires the adoption of cleaner and more efficient alternatives. Liquefied petroleum gas (LPG) and natural gas have been internationally recommended as a mitigation measure to reduce black carbon emissions (IPCC, 2018). A push towards cleaner cooking technologies like LPG would help in achieving targets under five of the 17 SDGs, namely SDG 3—Good health and well-being; SDG 5—Gender equality; SDG 7—Affordable and clean energy; SDG 13—Climate action and SDG 15—Life on land (Rosenthal et al., 2018). This chapter examines the impact of rural employment generation programmes along with various socio-economic and local environmental factors on LPG use.

LPG is a naturally occurring, unavoidable by-product of oil and natural gas extraction and crude oil refining. Earlier, LPG was vented or flared at sites, wasting valuable fuel and spewing black carbon into the atmosphere (Van Leeuwen et al., 2017). Utilizing it instead has been recognized as beneficial for both environment and human health in comparison with alternatives such as solid biomass fuels as it releases lower levels of black carbon and methane (Bruce et al., 2017).

A 2016 report states that as many as 819 million people (nearly 60% of the population) in India use traditional biomass such as fuelwood, cow dung, and coal, for their daily cooking needs, sourced primarily from nearby forests and wooded areas (IEA, 2016). Widespread use of these fuels poses serious risk to both human and environmental health (Junaid et al., 2018). Incomplete combustion of the fuels on inefficient stoves, and other devices used for cooking, lighting and heating, leads to household air pollution (HAP). High levels of HAP include health-damaging pollutants such as fine particles and carbon monoxide and contribute to about 4–6% of the burden of disease in India (Smith, 2000). Since women and children spend most time at home, they are the most adversely affected (Kankaria et al., 2014; Smith & Sagar, 2014). Mitigating the ill-effects of HAP is crucial not just to achieve targets of improved health (SDG 3) but also gender equality (SDG 5). In addition, shifting to cleaner fuels like LPG reduces the burden of fuel wood collection and reduces cooking time, thus allowing for empowerment of women (Rosenthal et al., 2018). Studies have estimated that HAP contributes to between 22 and 52% of ambient PM2.5 exposure in India also adding to the climate crisis (Conibear et al., 2018).

Burning fuelwood emits climate pollutants such as black carbon, methane, carbon monoxide and other ozone-depleting gases. In South Asia, over half of black carbon comes from cook stoves, disrupting the monsoon and expediting the Himalayan–Tibetan glacier melting (Chung et al., 2012). In rural areas of developing countries, emission from biomass-based cooking alone was 49.0 $GtCO_2$-eq (recorded in 2004) (IPCC, 2007). Though LPG has been criticized as a fossil fuel, till such time as there are renewable alternatives, LPG could be promoted as the available cleaner solution with the potential of reducing emissions from 49.0 $GtCO_2$-eq to 0.70. This would directly help meet NDC commitments of reduced emission and targets under SDG 3 (Good health and well-being) and SDG 13 (Climate action).

In addition, fuelwood extraction for fuel and energy is also a major contributor to deforestation and threatens the health of forests and other wooded areas. Global estimates indicate that about 30% of wood fuel harvesting is unsustainable (Bailis et al., 2015). In 2010–2011, the annual fuelwood consumption by India was 216.4

million tonnes per year (FSI, 2011). By protecting forests from fuelwood and charcoal extraction, LPG use could reduce the pressure on local resources and thereby enable carbon sequestration.

13.1.1 Policy Evolution Towards Cleaner Cooking: LPG

The rural poor in South Asia are heavily dependent on natural resources and thus directly influenced by extreme weather events (IPCC, 2014). In the wake of the warming temperature and decreasing precipitation, studies have projected an increased risk of climate disasters in India (Bisht et al., 2019). At the household level, this would translate to reduced availability of food, fodder, water and fuelwood in the short term and ecological and socio-economic consequences in the long term. When faced with such shortages, disadvantaged groups are likely to be most affected. In this context, adapting and promoting innovative cleaner energy sources such as LPG could potentially increase the resilience of rural communities to changing climate. Shamin and Haque (2021, Chap. 14 this volume) examine a similar question with respect to the adoption of solar systems in Bangladesh.

Realizing this, India has made many attempts to introduce improved cooking technologies that provide "triple benefits"—reduction in HAP and time-saving for households (health benefit), reduction in forest dependence (local environmental benefit) and reduced emission of carbon (global benefit) (Bhojvaid et al., 2014; Jeuland & Pattanayak, 2012). Since 2009, the government has attempted to promote the use of LPG as a fuel choice for households in remote and rural areas.

Starting with the Rajiv Gandhi Gramin LPG Vitarak Yojana (RGGLVY) (Sankhyayan & Dasgupta, 2019), the scheme evolved into the Pradhan Mantri Ujjwala Yojana (PMUY) in May 2016. This intervention aimed at bringing the benefit of efficient and low-emission fuel options to households that could not afford it because of their income status (Dabadge et al., 2018). The initial aim was to provide 50 million women belonging to poor (below the poverty line, BPL) families with gas (liquefied petroleum gas, LPG) connections. The scheme aimed to provide financial support for new LPG connection (installation).

Apart from RGGLVY and PMUY, the government has introduced other schemes like Pahal and complementing campaigns like "Give it Up" that have been crucial in ensuring that subsidies for LPG reach those who need them most (Gould & Urpelainen, 2018). While Pahal Consumers Scheme, launched in June 2013 aimed at directly transferring LPG subsidies to the bank accounts of consumers, the 2015 "Give it Up" scheme focused on motivating LPG consumers who can afford to pay full price for the cylinders to give up the LPG subsidy voluntarily.

Over the past decade, there has been steady progress towards the adoption of clean fuels in India. The number of LPG connections in the country has more than doubled, from 106 million households in 2009 to 263 million in 2018; total household consumption of LPG has increased from 10.6 million tonnes to 20.4 million tonnes during the same period (PPAC, 2018). With a push towards the adoption and use of cleaner cooking fuels, nearly 90% of Indian households now have LPG connections, making it the world's second-largest consumer of LPG (PPAC, 2019). However, sustained use of this fuel remains a challenge (Kar et al., 2019).

13.1.2 Factors Limiting Sustained Use of LPG

While there is general acceptance that the adoption of cleaner fuels like LPG has the potential to deliver health, social and environmental benefits including positive climate impacts in the short term, there has been mixed success on their sustained use despite state-subsidized efforts (Bruce et al., 2017; Rosenthal et al., 2018). Earlier studies suggest that there is a wide heterogeneity of factors influencing its use (Jain et al., 2018; Kumar et al., 2017; Singh et al., 2017). This includes; price (Sankhyayan & Dasgupta, 2019), women's participation in household decision-making (Gould & Urpelainen, 2018), seasonality (Kar et al., 2019) and household characteristics like house type and household size, and ease of access (Giri & Aadil, 2018).

Households with irregular income and easy accessibility to biomass fuel are less likely to use LPG for all their cooking needs (Mani et al., 2020). Forested areas and shared land resources in and around villages have been the primary source of this fuelwood (Pandey, 2002). Households that have traditionally depended on fuelwood for cooking purposes continue to do so, especially for heating water and large-scale cooking. In rural areas, the annual average fuelwood consumption per capita was estimated at 796 kg (Pandey, 2002). With continued population growth, demand for fuelwood is only likely to grow in the future resulting in the degradation of the forests in the vicinity of villages and the formation of barren lands. With improved access to LPG connections, households have started practising fuel stacking, wherein they stack both traditional biomasses such as fuelwood along with LPG, to meet requirements. However, in Bangladesh, Bari, Haque and Khan (2021, Chap. 14 of this volume) found that better supply of LPG reduced forest dependence of rural migrant communities.

There is a recognized need for a policy push to offset the use of biomass fuel by cleaner cooking technologies such as LPG. This shift could help India to meet NDC commitments as well as five of the Sustainable Development Goals, 2030.

13.1.3 MGNREGA a "Window of Opportunity" to Improve LPG Use?

Affordability has been recognized as one of the crucial barriers in LPG use (Khandker et al., 2012). This can be ensured either by making money available to rural households through more work and better wages or by extending higher subsidies. In the long run, increasing the disposable income of rural households to buy refills is more sustainable than providing subsidies. We examine the potential of the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), which guarantees 100 days of wage employment per year to rural households, in influencing LPG use in India. We expect that a district that has a higher per capita MGNREGA expenditure presumably has employed more people and/or for longer days and hence gives the rural poor of that district a better income status. It is contended that by utilizing the otherwise untapped labour potential in rural areas, the programme effectively increases the purchasing power of rural households.

While testing this expectation, the chapter also examines other socio-economic and environmental factors that could influence LPG use in India. LPG use can be inferred not from the number of connections but from the frequency of refills. We, therefore, test the relationship between the frequency of refills and various socio-economic and environmental factors.

In rural areas, households still primarily depend on rain-fed agriculture. Therefore, rainfall in a district would strongly predict the agricultural income of a region, *ceteris paribus* (Gadgil & Gadgil, 2006; Krishna Kumar et al., 2004; University of East Anglia Climatic Research Unit (CRU) et al., 2019). Supply and cost drive fuel choice, i.e. village communities who live in the proximity of forests are likely to choose fuelwood over LPG as the relative shadow price of fuelwood is much lower than LPG. The economic status of households would be reflected by the extent of poverty in the district. While poverty rates are a direct way to understand the income distribution of a region, the economic well-being can also be gauged by the participation of the population in the workforce. This would directly indicate income generation opportunities—we expect that the higher the workforce participation rate in a district, the better off the households of that district due to available income from employment.

Given the demographic structure of Indian societies, women's empowerment through education could have significant implications for family decision-making (Sen, 2000) which includes decisions on expenditure on fuel and women's health. Education is a known tool for empowerment within and outside the household (Walker, 2005). People (especially women) of a more literate society are likely to choose cleaner fuel even if it costs more as they would value their health and make more informed choices. Economic deprivation in India is closely linked to social categories. Scheduled Tribes (ST) and Scheduled Castes (SC) have, for long, been known to be historically deprived (Deshpande, 2011). We, therefore, use SC and ST proportions in rural populations to understand the extent of deprivation at the district level.

13.2 Material and Methods

We have used data available from government sources on LPG connections and refills (PMUY, 2018); MGNREGA expenditure for the year 2017–2018; forest survey data (FSI, 2019); district-level rainfall data (IMD, 2015, 2016, 2017, 2018; University Of East Anglia Climatic Research Unit (CRU) et al., 2019); poverty data (Chaudhuri &

Gupta, 2009); and demographic data (Census, 2011). After matching LPG data with all the above data, we were left with complete data for 582 districts across 29 states and three union territories.

We use a formal regression model for our analysis. Our dependent variable is the proportion of LPG refills to the number of LPG connections registered under the PMUY scheme in each district. This we have treated as an indicator of LPG adoption. We anticipate, as stated above, that this would be dependent on multiple factors.

$$\begin{aligned}\text{LPG refills in 2019} = f\ (&\text{amount of per capita expenditure per capita}\\ &\text{on MGNREGA in 2018 [preceding year], the extent}\\ &\text{of rainfall in 2018 [preceding year], rural female}\\ &\text{literacy rate, the proportion of SC and ST}\\ &\text{in rural areas, the proportion of the rural}\\ &\text{population in the workforce, percentage of poor}\\ &\text{in rural districts and extent of different types of forests)}\end{aligned} \tag{13.1}$$

The specific model using the ordinary least squares (OLS) multiple regression method is discussed below.

$$\begin{aligned}Y_i = \beta_0 &+ \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i}\\ &+ \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i} + \beta_9 X_{9i} + \beta_{10} X_{10i}\\ &+ \beta_{11} X_{11i} + \beta_{12} X_{12i} + \beta_{13} X_{13i} + \beta_{14} X_{14i} + \varepsilon_i\end{aligned} \tag{13.2}$$

where

Y = Proportion of refills four times from among those who got LPG connection under PMUY.

X_1 = MGNREGA expenditure per capita (ratio of MGNREGA expenditure to state population).

X_2 = Square of MGNREGA expenditure per capita (X_1).

X_3 = Total rainfall in 2018 (in millimetre).

X_4 = Square of total rainfall in 2018.

X_5 = Rural female literacy rate.

X_6 = Proportion of ST in rural population.

X_7 = Proportion of SC in the rural population.

X_8 = Female workforce participation rate.

X_9 = Male workforce participation rate.

X_{10} = Per cent of rural population under the poverty line.

X_{11} = Area under very dense forest (in hectare).

X_{12} = Area under moderate dense forest (in hectare).

X_{13} = Area of open forest (in hectare).

X_{14} = Area under scrub (in hectare).

ε_I = Stochastic error.

We use Stata 15.1 "*regress*" command to estimate OLS results (see Table 13.2) and the post-estimation commands to confirm that the data fulfils the OLS assumptions to validate our estimated coefficients. We conducted three post-estimation tests for (1) normality, (2) heteroskedasticity and (3) influential observations. We found that for all three tests, the null hypothesis of normality, homoscedasticity and non-influential observations holds.

(1) Heteroskedasticity: We did a Breusch–Pagan test which has a chi-square value of 1.879 (with *p*-value: 0.170).
(2) Normality of residuals: We did a Shapiro–Wilk W normality test which has a "*z*" value of 1.242 (with a *p*-value: 0.107).
(3) Influential observations: We did a Cook's distance test, which is less than 1.00, and there is no distance which is above the cut-off.

While most of these variables are used commonly as independent variables, the case of forests is not self-evident. LPG adoption is expected to reduce demand for wood fuel and therefore forest dependence. There are two points to be noted here. First, many researchers have noted that fuelwood use does not reduce the density and canopy cover of trees. The fuelwood demand for forest-dependent communities is met by loping of lower branches and dry wood. Second, the impact of fuel wood collection on forest quality is not necessarily dependent on access to the forest or the density of forest-dependent population but on the availability of wage labour and local markets (Davidar et al., 2010). Third, LPG adoption is unlikely to show results in the very short run and is more of a long-term intervention.

13.3 Results

The summary statistics of the above variables is presented (in Table 13.1) below. Our findings indicate that around 48% of all those who got an LPG connection reported refilling the LPG four times a year ranging from a low of 6% to a high of 92%. The distribution nearly approximates a normal distribution (see Supplementary information, Graph S.G1). The average per capita expenditure on MGNREGA in 2017 was INR754. The reported average rainfall in 2018 in India was 1103 mm, ranging from 804 to a high of 5065 mm. The wide range in rainfall is a reminder of the 15 agro-climatic zones in the country. The heterogeneity is not just in geography, but also in social characteristics. Female literacy on average was 55% and varied between a low of 12% to a high of 89%. The districts differed in terms of marginalized groups (SC and ST populations). While the average ST population was 19% (minimum 0 to a maximum of 99%), the SC population on average was 16%, with a smaller range of 1–53%. The female workforce participation, which is an indicator of the presence of women in the paid workforce, had a national average of 32% (from a low of 5% to a high of 65%).

Table. 13.1 Summary statistics of variables

Variable	Unit	Obs	Mean	Std. dev	Min	Max
Proportion of PMUY beneficiaries who refilled four times	Number	610	47.74	17.67	5.92	91.53
MNREGA expenditure per capita	Rs. lakh (INR)	597	0.008	0.01	0	0.11
Rainfall in 2018	Mm	577	1103.35	804.67	0	5065.9
Female literacy rate	%	633	0.55	0.12	0.24	0.89
Proportion of ST in rural population	Number	624	0.19	0.28	0	0.99
Proportion of SC in rural population	Number	624	0.16	0.1	0	0.53
Female workforce participation rate (rural)	%	624	32	13	5	65
Rural poverty rate	%	509	28.25	19.71	0	88.4
Very dense forest	Ha	634	156.31	407.51	0	4699.29
Moderately dense forest	Ha	634	483.44	742.04	0	5881.18
Scrub forest	Ha	633	72.52	159.91	0.26	1520.19
Open forest	Ha	634	475.23	522.35	0	3538.63

Source Authors' calculations from multiple sources

Variables influencing these refills were—MGNREGA expenditure, rainfall, female literacy, the proportion of SC and ST populations, female workforce participation rate, percentage of poor in a district, extent of density of forest, prevalence of open and scrub forests (see Table 13.2). Female literacy rate, the proportion of SC population, as well as prevalence of very dense forest and scrub forest, influence the refills positively. On the other hand, the proportion of the ST population, female workforce participation and percentage of poor and open forest negatively impact refills. The negative relation with female workforce participation may seem odd because the greater this value the more likely it is to have greater family income, and therefore potentially a cause for LPG adaption. However, we are aware that the official statistics on female workforce participation may be underreporting the value. A large proportion in the female rural workforce may not be part of the paid workforce but participate in productive activity. This could be a possible reason for this result.

There is a nonlinear relationship between refills and its two determinants, MGNREGA and rainfall (U-shaped). Both of these variables influence the income of rural households. An initial increase in MGNREGA expenditure or rainfall reduces refills. However, as these values—MGNREGA expenditure or rainfall (below a calamity level)—rise, the increased household income positively impacts on refills after a threshold level. It comes as no surprise that refills are low in areas of high poverty.

Table. 13.2 Results of ordinary least squares regression (robust standard errors)

Dependent Variable: Proportion of PMUY beneficiaries who refilled four times	
Independent variables	*Coefficient (t-value)*
MNREGA expenditure per capita	-2677.2 *** (-7.03)
Square of MNREGA expenditure per capita	103,518.7 *** (-5.76)
Total rainfall in 2018	-0.0094 *** (-3.66)
Square of total rainfall in 2018	0.0000017** (2.75)
Female literacy rate (rural)	13.34* (1.85)
Scheduled Caste population (rural)	12.75* (1.65)
Scheduled Tribe population (rural)	-20.79*** (-4.84)
Workforce participation (male, rural)	1.17 (0.07)
Workforce participation (female, rural)	-13.23** (-1.99)
Very dense forest in 2019	0.005* (2.41)
Moderately dense forest in 2019	-0.0004 (-0.29)
Open forest in 2019	-0.004** (-2.24)
Scrub area in 2019	0.008** (1.95)
Constant	65.2*** (9.67)
N	445
R-square	0.4939
adjusted R-square	0.4775
F (14, 430)	29.98
Prob > F	0.0000
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$	

Source Authors' calculations

We have four measures of forest types—very dense, moderately dense, scrub and open. Refills are higher in areas with very dense forest and scrub areas. The reasons for this could be that in very dense forests fuelwood collection would be difficult and regulated by the forest department. Therefore, there is a higher adoption of alternate fuels. In scrub areas, there is a lower availability of fuelwood which, again, leads to a higher number of refills. However, in open forests, there is scope for fuelwood availability and so refills are less frequently observed.

Information on forest category indicates higher instances of refills in dense and scrub forests for reasons given above, the relationship with moderately dense shows as insignificant. In moderately dense forests, state monitoring is relatively less. There is also relatively greater availability of fallen branches and dry wood. Harvesting of fuelwood from this category of forests can be significant. However, this relationship needs to be more closely studied. Vidanage et al., (2021, Chap. 15 of this volume) and Devi et al., (2021, Chap. 8 of this volume) have shown that state support for programmes could elevate outcomes to being more sustainable.

13.4 Conclusion and Policy Implications

Today, about three-fifths of India's households rely on fuelwood and other solid fuels. Continuing these consumption patterns could lead to significant environmental impacts, especially considering India's high population growth and increasing fuelwood extraction. India will need to move away from fossil fuels gradually to meet sustainable development targets and carbon-mitigation targets. Increasing household LPG use is one of the several pathways to achieve this.

However, projections of the International Energy Outlook report suggest that in 2030, 580 million people in India will still be using traditional fuels and India would then fall short of its target under SDG 7 (Affordable and Clean Energy) (IEA, 2017). This is despite government efforts to improve access to subsidized connections through various schemes. The main reasons cited for this gap in meeting targets are poor implementation, supply shortage and lower affordability. While two of these issues need to be addressed from the supply side, this chapter focused on the push needed from the demand side to improve LPG uptake.

Our analysis indicates that poorer households are more likely to switch fuels if their disposable income increases through employment generation schemes. The expenditure on MGNREGA is a policy-determined variable, and the decision-makers could ensure a win–win situation of triggering the triple benefits of reduced household air pollution, reduction in forest dependence and reduced emission of carbon, in turn promoting affordable and clean energy (SDG 7) for rural households.

Switching to cleaner cooking fuels such as LPG has the potential to deliver extensive health, social and environmental benefits, including positively affecting climate in the short term (Bruce et al., 2017; Rosenthal et al., 2018; Singh et al., 2017). It can further support achieving a few of the targets under SDG. Since India is committed to achieving the Sustainable Development Goals by balancing economic, social and environmental goals, the wide use of LPG would be a small but sure step towards achieving these objectives.

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