FACTORS DETERMINING THE ADOPTION OF INDUCTION STOVE FOR HOUSEHOLD COOKING IN BHAKTAPUR

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Abstract

The current global warming trend is unequivocally the result of human activities and is proceeding at an unprecedented rate over the millennia. About 6.7 percent of global greenhouse gas emissions are caused by household cooking. It is essential to expand the use of clean fuels and technologies to reduce household emissions. Most households in urban areas use LPG for cooking purposes along with a gradual introduction of electric induction stoves. The main objective of this paper is to identify the factors determining the choice of induction stoves for household cooking. Primary data were collected from 300 households of Bhaktapur and Madhyapur Thimi Municipalities in March, 2021. Binomial Logit regression was performed to examine the determinant of induction stove adoption by household. LPG is the primary source of cooking for household. Sixty seven percent of households use electricity partially for cooking purposes. Forty five percent of total households use an electric rice cooker and 27 percent use an induction stove. Twenty six percent of households do not know about induction stoves. The family's education level, particularly the cooking member, is the primary determinant of adopting an induction stove. The probability of adoption of induction stoves increases with an increase in income. Families living in their own houses are more likely to use induction stoves than those living in rented houses.

Keywords: Induction stoves, Energy ladder, Household cooking, Binomial logit

1. Introduction

Greenhouse gases (GHG) emissions due to human activities have unequivocally caused global warming, with the global surface temperature reaching 1.1°C above 1850-1900 in 2011-2020, dominated by carbon dioxide (CO_2) and methane (CH_4), partly masked by aerosol cooling (IPCC AR6). About 6.7% of global greenhouse gas emissions are caused by household cooking activities and thus it is of significance to identify research gaps between current studies and future directions in the context of carbon neutrality (Jia et al., 2022). Nearly 3 billion people cook or heat their homes with polluting fuels, like wood or other biomass, resulting in indoor and outdoor air pollution that causes widespread health impacts (WorldBank, 2020).

Household energy choice is a product of active decision-making, which involves taste and preferences, culinary norms, social relations, and other considerations deeply ingrained in the tradition of society (Atanassov, 2010). In this context, it becomes increasingly important to identify various factors affecting the choice of energy sources used by households.

The energy ladder is a concept that has been used to describe the transition of households from utilizing traditional energy carriers for their energy service needs to utilizing more modern, technologically sophisticated energy carriers to meet those needs. Households using modern, commercial fuels such as Liquefied Petroleum Gas (LPG), natural gas, or electricity are assumed to be poised on the upper rungs of that ladder (Hosier, 2004). The objective of this paper is to analyze factors determining the adoption of induction stoves for household cooking in Nepal.

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Firewood is still a major source of cooking fuel in Nepal as more than half (52.4 %) of the households are using it. In 2016/17, in urban areas, 54.1 % of households were using LPG and 35.4 % were using firewood (CBS, 2016). According to the census, a total of 51% of household uses wood and 44.3 % of household uses LPG but only 0.5% of household use electricity as fuel usually used for cooking (CBS, 2021).

Also, imports of petroleum products accounted for 15.2 % of the country's total import bill of Rs1.41 trillion in fiscal 2018/19 (MOF, 2019) . The import of LPG was 181411 MT in 2011/12 which reached 536028 MT in 2021/22 (NOC, 2022). So LPG import has increased by 2.95 times in the last decade.

Nepal is progressing in the production of Hydropower in recent years. Till mid-March of FY 2018/19, 77.8 % of the total population has access to electricity and total electricity production was 1,142 Mega Watt (MW) (MOF, 2019). Till Mid-March of 2022, 94 % of the total population has access to electricity and production has reached 2205 MW which shows great progress in electricity use in the last few years(MOF., 2022).

Induction cooking is one of the solutions for reducing the health hazard from traditional cooking and also increasing the consumption of electricity and reducing LPG imports. The total number of imports of induction stoves by customs offices in 2076/77 is 10,435 (DoC, 2022). According to the Department of Customs (DoC), the number increased to 84,512 units of induction stoves and 2,001 units of infrared cookers during the period between mid-July 2022 and mid-February 2023.

2. Review of Literature

Various studies have been carried out on household cooking energy consumption by different researchers.

The monthly income of households or household welfare, in general, has a significant effect on energy choices (Özcan et al., 2013). Modern fuels would probably be adopted as household income increase. Modern fuels were perceived as being most desirable, whereas firewood and charcoal were least desirable(Atanassov, 2010).

Families with a higher education had a higher probability of using electricity for lighting, and lighting and cooking concurrently. Rural households and households further away from the market were less likely to use electricity for both lighting and lighting and cooking. In developing countries supply constraints were considered the major hurdles for the household use of electricity(Mottaleb et al., 2017). The same result obtained by Alem et al. (2016) that shows the higher the education level, the larger the probability of using clean fuel sources and the smaller the chance of using biomass fuels such as firewood and charcoal.

Preference for certain fuel types among the fuel alternatives was significantly affected by the number of employed people in the household, availability of ICT (Information and Communications Technology) systems in the home premises, location of the dwelling, number of family members, formal education level, type of housing, and the use of alternative sources of energy. ICT system ownership of households greatly affects the substitution of fuel types and has a positive direction following the energy ladder going from traditional and dirtier to more modern and cleaner fuel types (Acharya and Marhold, 2019).

Education attainment too has a positive and significant effect on modern fuel use. Notably, the impact of female education attainment is more than males. It means the education gap between genders hinders the uptake of modern fuels (Ahmad and De Oliveira, 2015).

The study found that younger individuals were more likely to use sustainable cooking systems than older individuals. The age of the main cook was found to be a barrier to the use of sustainable clean cooking systems (Vigolo et al., 2018). The higher the age of the household member, the more common the transition from cooking systems to modern systems (Özcan et al., 2013).

Electric cooking could be a desirable option for household cooking. Tariffs on electricity need to be structured accordingly to make electrical energy look more attractive than LPG or traditional cooking fuels for all (Vaidya, 2020). From the literature, we can summarize the variables of household cooking transition are household income, health (smoke, emission, and exposure), easiness, literacy, household size, age of household head, land holding and livestock, house ownership (rent or house owner), location (rural or urban), access of ICT, access of renewable energy (fuel availability) and price of modern fuel (relative fuel cost and price).

To identify the factors affecting the adoption of household cooking, Sharma (2019) used a log-level regression equation using ordinary least squares. Fuel wood share in household cooking with various other socio-economic and access variables indicated that the size of large ruminant units, the household size, literacy status of a household, presence of biogas or LPG stoves, price of firewood, ecological belt, and total landholding were several factors determining the demand for firewood.

3. Research Methodology

This study uses the primary data collected by the author. Primary data on household cooking, such as types of fuel and cooking methods, daily operation hours, and year of acquisition were collected from the questionnaire. The structured questionnaire is developed in the Kobo toolbox web application. Primary data were collected from all wards of Bhaktapur Municipality and Madhyapur Thimi Municipality on March 2021.

The population of Madhyapur Municipality was 83036 in 2068 B.S. and that of Bhaktapur Municipality was 81748. So, the total number of households was 37114 and the average household size was 4.4 (CBS, 2017). A total of 300 households were surveyed from the study area. The number of samples collected from each ward was proportional to the population in the ward.

Binomial Logit regression was performed to find out the significance and odd ratio of variables that are assumed to be the determinant of household energy transactions.

The central mathematical concept that underlies logistic regression is the logit—the natural logarithm of an odds ratio. In the simplest case of linear regression, for one continuous predictor X and one dichotomous outcome variable Y, the plot of such data results in two parallel lines, each corresponding to a value of the dichotomous outcome (Peng et al., 2002).

The simple logistic model has the form of Equation (1)

$$Logit(Y) = ln(odds) = ln\{\pi/(1-\pi)\} = a + bX \quad (1)$$

where a is the Y-intercept and b is the regression coefficient. X can be categorical or continuous but Y is always categorical. And is the probability of the outcome of interest or "event". The value of b determines the direction of the relation between Y and X. When b is greater than zero, larger X values are associated with larger logit of Y.

The logistic model for this study is shown in Equation (2)

$$Logit\{p(Induction)\} = \frac{ln\{p(Induction)\}}{(1-p(induction))}$$
$$= b_0 + b_1 Log(Expenditure) + b_2 MaxEducation$$
$$+b_3 CookEducation + b_4 CookAge + b_5 HeadAge$$
$$+b_6 FSize + b_7 ResidenceType \quad (2)$$

where,
Expenditure: monthly expenditure of family
MaxEducation: maximum education level of the family
CookEducation: education level of cooking member
CookAge: age of the cooking member
HeadAge: age of the family head
FSize: family size
ResidenceType: type of residence i.e. rented house or own house.

4. Findings

4.1. General demographic information

A total of 300 households were surveyed for the study. The total number of members of the sample household is 1459. About 51 % of the total population was male and 49 % of the total population was female in the study area. The total household size was 4.86. Only 22 households out of 300 households had a female household head.

The education level of sampled households showed that each household had at least one member who completed school level education. About half (50.7 %) of total households have members who completed bachelor-level education.

During the survey, the respondents were asked about their expenditures. The minimum monthly expenditure was Rs. 4000 and the maximum was Rs. 80,000. The mean value of monthly expenditure was calculated to be Rs. 22471. About half of the household's expenditure was between Rs. 10,000 to Rs. 20,000. A total of 17.3 % of households had expenditures more than Rs. 30000.

4.2. Cooking member

Only 7 households had male cooking members. The age of a cooking member ranged from 18 years to 82 years. The mean value of the age of the cooking member was 42.7 years.

Education statistics of sampled household showed that 17% of household cooking members did not complete school-level education. A total of 56.3% of households had cooking members who completed school level only. A total of 5.4% of households had cooking members who completed post-graduate education.

Cooking is mostly done by the female members of the family. According to the survey, in 87.6% of households, the wife of the household head is the main cook of the house. In 6.3% of sampled households, a daughter-in-law was the one who cooked for the family.

4.3. Energy use pattern in household cooking

LPG was the first choice of source of cooking in 272 households. Electricity was the first choice of fuel for cooking in 26 households. The first choice of fuel for cooking is shown in the Figure 1.

Electricity was the second choice of fuel for cooking in 206 households. A total of 26 households used LPG as their second choice of fuel for cooking. 68 households used other fuels like kerosene, firewood, biomass, etc. as their second choice of fuel for cooking (Figure 2).

4.4. LPG for cooking

LPG was the main source of cooking. One LPG cylinder of 14.2 Kg was consumed in an average of 41.6 days. The average year of acquiring of LPG stove was 14 years.

4.5. Use of electricity for cooking

Electricity was the second main choice of fuel for cooking. An electric appliance used for cooking and their oper-

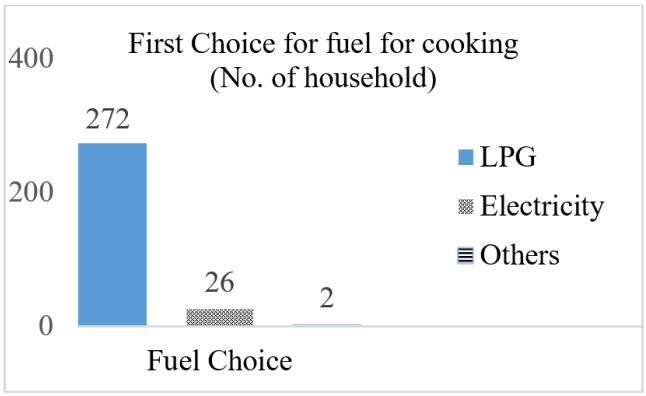

Figure 1. First choice of fuel for cooking

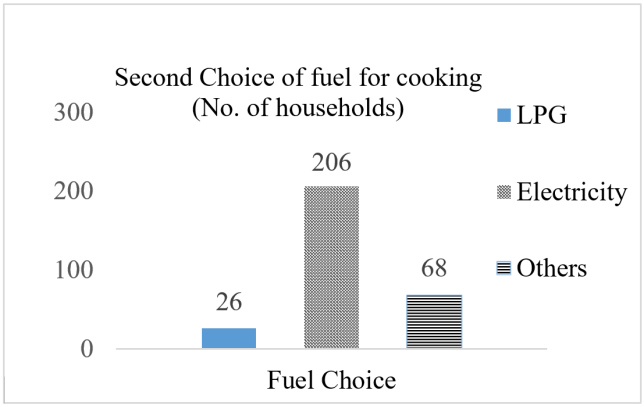

Figure 2. Second choice of fuel for cooking

ation duration is shown in the Table 1.

Table 1. Electric appliances for cooking purpose

Electric Device	Percentage of Households	Average Operating Hours per day
Rice Cooker	45	1.37
Induction Stove	27	1.99
Microwave	17	0.38
Traditional Heater	8	0.60
Water heater	33	1.06
Infrared cooker	1.7	1.40

4.6. Induction stove for cooking

Induction cooking is a newer technology for the Nepali community. There is a lack of knowledge about induction stoves. Only 27% of households had induction stoves and 26% of households did not even know about induction stove. About 47% of households knew about induction stoves but they did not acquire induction stoves (Table 2).

4.7. The factor determining different fuel choices

Different socio-economic factors play an important role in the selection of household cooking fuel. Many research have been carried out in past to identify such factors that have major impact on the selection of household cooking fuel.

Table 2. Knowledge of induction stoves in households

	No.of Household	%
A. Acquiring Stove	81	27
B. Not Acquiring and:		
i. Known about it	142	47
ii.Not Known about it	77	26
Total	300	100

4.7.1 Education level and adoption of induction stove

Education level is one of the major factors determining fuel choices. Table 3 indicates that as maximum education level of household increases, the percentage of adoption of induction stoves also increases.

Table 3. Education level and adoption of induction stove

Induction	No	Yes	Total	%
Education:				
School	61	5	66	7.5
Graduate	113	39	152	25.6
Postgraduate	45	37	82	45.1
Total	219	81	300	27

The education level of family members who spend maximum time cooking is also an important determining factor for the adoption of induction stoves. As their education level increases, they know the benefit of a cleaner source of cooking. Table 4 shows the higher education level of members who cook and adoption of induction cooking:

Table 4. Education level of cooking members and adoption of induction stove

Induction	No	Yes	Total	%
Education:				
Class 10 or less	42	9	51	17
SLC	132	37	169	21.8
Graduate	38	26	64	40
Postgraduate	7	9	16	56
Total	219	81	300	27

The table shows that only 17% of households had induction stoves where the education level of the cooking member was below the School Level Certificate. In total 21.8% households with education level of cooking members above school level had induction stoves. The percentage of households acquiring induction stoves increased to 40% and 56% when their cooking members had bachelor's and master's level education.

4.7.2 Average expenditure and induction cooking

Expenditure is taken as one variable for the adoption of induction stoves. The average expenditure of households having induction stoves was Rs. 26514 whereas that of households without induction stoves was Rs. 20909. Hence, it can be seen that the higher income group tends to acquire induction stoves.

4.8. Logistic model for the determinant of factors affecting the choice of induction stove

The impact of variables for the use of induction stove was analyzed using binomial logistic regression. The empirical model is given in Equation (2). The dependent variable is the use of an induction stove where the value 1 indicates the household having an induction stove and 0 indicates the household without an induction stove.

In Equation (2), b_0 is a constant term and b_1 , b_2 , $\ldots . b_7$ are the coefficients. This study hypothesizes the relation between the major variables discussed in the literature with appropriate contextualization in the local context (Table 5).

The family head of gender is coded 0 for female and 1 for male. Household with induction stove is coded 1 and household without induction stove is coded 0. The electricity bill of a household is calculated by subtracting the amount charged to rented rooms from the total electricity bill. MaxEduation is coded 0 for the households with maximum education level of less than graduate level and coded 1 for the maximum education of household greater than bachelor's level.

Present study also hypothesizes that expenditure of household and education level have a positive relation with the adoption of induction stoves. The previous literature showed wood, charcoal, and kerosene utilization declined with increasing levels of education, and electricity utilization increased gradually with rising levels of education. LPG, electricity, and solar energy utilization increased gradually with an increase in income; although with some fluctuations. Rented dwellings tend to use higher fuels (such as kerosene and LPG) because they are compact and do not require large space for storage (Bisu et al., 2016).

Another hypothesis of this study is that age has negative coefficients. The average age of household heads was negatively associated with the share of modern cooking fuels; enumeration areas with younger household heads on average exhibited higher shares of modern cooking fuels, similar to transitional cooking fuels (Tootle, 2015).

Binary logistic regression is performed in SPSS with dependent variable induction and other specified explanatory variables. The result is shown in Table 6.

Here, we are testing the null hypothesis that there is no difference in the logarithm of odds of adoption of an induction stove with the variables given. If the p-value value is less than the given significance level, we can reject the null hypothesis. The log of expenditure is significant at 1%. The maximum education level of the family is significant at 5% and the education level of the cooking member is significant at 1%. Residence type is significant at a 5% level. The age of the cooking member and family head is insignificant. Moreover, the size of the family is insignificant for the adoption of an induction stove.

The regression coefficients are interpreted as the predicted change in log odds for every one-unit change in the predictor. There is a positive predictive relationship between expenditure, maximum education level, and education level of cooking members with the adoption of induction stoves. The probability of adoption of an induction stove increases by 2.785% when expenditure is increased by 1%. A household with a bachelor's level of education increases the probability of the log of adoption of an induction stove by 1.297 times and a household with a bachelor's level of education of a cooking member increases the probability of the log of adoption of an induction stove by 1.682 times.

Controlling the other variables in the model, for a household with a family member with a maximum education level of bachelor's degree, the odds of using an induction stove for cooking purposes is increased 3.658 times compared with the household with members without a bachelor's level of education. When the education level of the cooking member is bachelor's, the odds of using an induction stove increased 5.378 times than the households without bachelor level education of cooking member. Odds of using an induction stove increased 3.242 times when the households have their own house when compared with households living in rent.

5. Discussions

Findings from the primary survey show newer and more efficient cooking methods are begin adopted in households in recent years. A study in 2014 showed that the typical household LPG lasted 47.39 days (Bajracharya, 2015), but this study shows that it has decreased to 41.9 days indicating the energy use pattern is shifting towards the upper level of the energy ladder. But energy stacking is the major phenomenon where a household does not completely switch to efficient fuel. Nevertheless, the ratio of cleaner and modern fuel is in increasing trend. In this context, the analysis of the fuel used by households indicate that Nepal has stepped into the energy transition ladder but is still at its very bottom (Sharma, 2019) . Sharma (2019) carried out the study in rural areas and the authors found the rural areas of Nepal at the lower side of the energy ladder. On the contrary, this study focusses in urban areas where society is in the the upper level of energy transition ladder.

Many literature reviews were performed to identify the

Table 5. Explanatory variables and their expected signs in the empirical model

S.N.	Explanatory Variable	Explanation of Variable	Hypothesis
1	Expenditure	Avrage Expenditure of Family	+ve
2	MaxEducation	Highest Education Level of Family	+ve
3	CookEducation	Education Level of Cooking Member	+ve
4	CookAge	Age of Cooking Member	
5	HeadAge	Age of Family Head	-ve
6	Fsize	Family Size	-ve
7	ResidenceType	Rented or Own House	

Table 6. Result of binomial logistic regression

S.N.		Coefficients	S.E	Sig.	Odd ratio(Exp B)
1	LOG_exp	2.785	0.829	0.001	16.197
2	Max_Education	1.297	0.581	0.026	3.658
3	Cook_Education	1.682	0.404	0.000	5.378
4	Cook_age	0.035	0.022	0.103	1.036
5	Head_age	-0.026	0.019	0.168	0 .974
6	Family_size	-0.078	0.079	0.327	0.925
7	Residence_type	1.176	0.600	0.050	3.242
8	Constant	-15.492	3.709	0.000	0.000

factors determining different fuel choices. The highest education level of the family and the education level of cooking members have a significant role in the adoption of induction stoves. Families with higher expenditure are more likely to adopt induction stoves for cooking. Household size, age of household head, and cooking members do not have a significant role in the adoption of induction stoves.

6. Conclusion and Recommendation

From the results of the field survey conducted for this research, it can be concluded that the energy use pattern in urban areas is very much different from the national average and rural areas. Households that are in the upper level of the energy ladder have LPG as major sources of energy. Electricity, on the other hand, is the second main source for cooking.

Binomial logistic regression shows that the education level of the family significantly affects the adoption of an induction cooker. The income level of the household is also one of the major variables that determine the use of household cooking. The age of the family head, the age of the cooking member, and household size do not have a significant impact on the adoption of induction stoves.

An awareness program should be launched to penetrate the use of induction stoves in Nepalese society. The concerned authority of the government needs to encourage people to go for higher education as education level is one of the major determinants of household energy choice. The income level needs to be raised so that people will move from a lower energy level to a higher energy level in the energy ladder for cooking purposes. This will ensure that the indoor air quality is improved and and the increasing trade deficit due to the import of fossil fuel is reduced at least to some extent.

7. A Way Forward

A promising path forward to encourage the widespread adoption of induction cooking over traditional LPG cooking involves a multi-faceted approach that combines awareness, affordability, and efficiency. Firstly, raising awareness among consumers about the benefits of induction cooking on energy efficiency, can play a pivotal role in shifting preferences. Secondly, making induction cooktops more affordable through government subsidies can break down economic barriers and make this technology accessible to a wider range of households. Lastly, emphasizing the environmental advantages of induction cooking, including reduced greenhouse gas emissions and decreased reliance on fossil fuels, can resonate with eco-conscious consumers. By improving the quality of electricity supply through upgrading transformer capacity, and addressing both practical and environmental concerns, a concerted effort to promote induction cooking as a way forward has the potential to revolutionize cooking practices and create a more sustainable future.

Promoting induction cooking in Nepal is vital to lower LPG imports and alleviate the trade deficit with India. According to the Department of Customs, the import of LPG in 2021/22 is Rs. 65.5 billion. If the import of LPG can be reduced by 50% in 2025, the import deficit will be reduced by Rs. 32.75 billion each year. By encouraging this transition, the authors believe that Nepal can foster economic stability

and enhance its self-sufficiency in energy production.

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