Rayat Shikshan Sanstha's

Yashvantrao Chavan Institute of Science, Satara (Autonoums)

Lead College of KBP University, Satara

Research Project on

"A Comparative Analysis of Bio-gas and LPG Utilization in Rural Households."

Submitted to,

DEPARTMENT OF STATISTICS

By

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M.Sc. I (Sem - ll)

2023-24

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Lead College of Karmaveer Bhaurao Patil University, Satara

CERTIFICATE

Department of Statistics

Date:

This is to certify that, **Miss. Gade Ketaki Sanjay**, UID No.:- 202301200011 partial fulfilment of curriculum of M.Sc. I (Sem – ll) students has successfully completed the research project work in the statistics entitled **"A Comparative Analysis of Bio-gas and LPG Utilization in Rural Households"** as prescribed by the Karmveer Bhaurao Patil University, Satara during the academic year 2023-24.

Teacher in charge **Examiner** **Head,**
Department of statistics

ACKNOWLEDGEMENT

In our efforts towards realization of our project work, we have drawn on the guidance of many people, whom we wish to acknowledge.

I am thankful to our **Principal Dr. B. T. Jadhav** and Head of the Department of Statistics **Dr. H. P. Umap** for their support and cooperation towards successful completion of this project also obliged to P.G. Co-ordinator of Department of Statistics **Dr. D.S. Jadhav** for continuous encouragement.

We are also extremely thankful to our beloved teachers **Dr. S. M. Nimbale, Mr. P. H. Mahadik, Ms. D. S. Tanpure, Mr. K. A. Ghorpade, Ms. A. V. Shinde, Ms. D. S. Sabale, Mr. P. M. Bhosale, Mr. R. B. Ade and Ms. A. V. Kambale** for their support and guidance for this project.

We would like to extend our profound and deep sense of gratitude to all those who helped us by filling out the questionnaire.

Last but not the least we would like to thank all those who helped us directly and indirectly in our endeavor.

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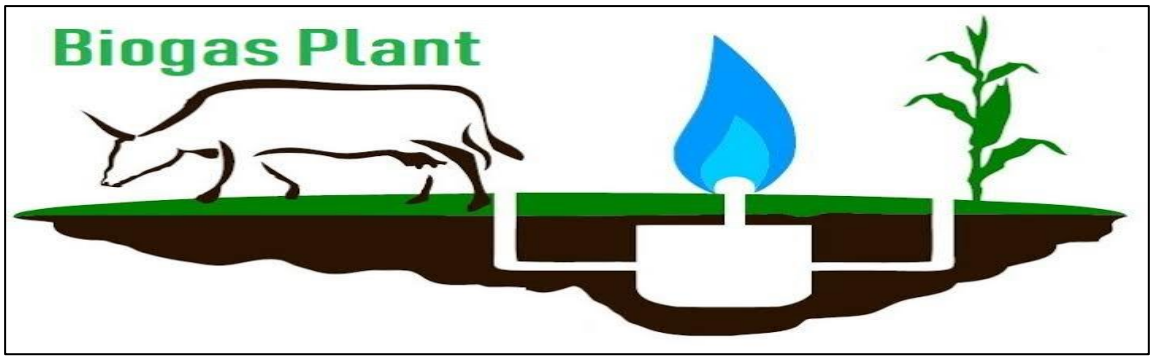
TITLE

"A Comparative Analysis of Bio-gas and LPG Utilization in Rural Households."

ABSTRACT

In this project we are going to analyze the usage and preferences towards Bio-gas and LPG/Cylinder as a Domestic fuel among the households in Kaulage village. The aim of this study is to understand factors influencing choice of fuel, benefits received by users and impact on household budget. Through the data collection and its analysis, we investigate the percentage of households in Kaulage village that have adopted biogas, LPG, or both fuels as their Domestic cooking fuel, reasons for dual usage, and the effectiveness of government support programs. Findings reveal the predominant sources of household income and their association with fuel preferences. Insights into preferred bio-gas generation materials, reasons for dual-fuel usage, and attitudes towards fuel switching are provided. These findings shed light on the dynamics of energy usage in rural settings and offer implications for policy interventions and future research endeavors.



INTRODUCTION

In rural areas, it is somewhat difficult for people to have energy that's both clean and affordable which is really important for people's day to day life. This project, "A Comparative Analysis of Bio-gas and LPG Utilization in Rural Households," is basically conducted in Kaulage village. This study looks at two different types of energy that rural households might use as a Domestic fuel, that are biogas and liquefied petroleum gas (LPG).

Biogas is an environmentally-friendly, renewable energy source produced by the breakdown of organic matter. Biogas is a renewable fuel which is produced when organic matter, such as food or animal waste, is broken down by microorganisms in the absence of oxygen. This process is called anaerobic digestion. For this to take place, the waste material needs to be enclosed in an environment where there is no oxygen. Biogas plants utilize a wide variety of raw materials, including manure, fertilizers, bio waste, energy crops and residues. It is primarily contains methane (CH_4) and carbon dioxide (CO_2). The Indian government has been providing subsidies for the installation of bio gas plants for several years now, as part of its efforts to promote renewable energy and sustainable development.

Liquefied Petroleum Gas (LPG) is a common household fuel used for cooking, heating, and any other purpose. It is a mixture of gases, which are compressed into a liquid form for storage and transportation. LPG is widely available and convenient to use, as it can be easily transported and stored in cylinders or tanks. In India, LPG is distributed to households through government-regulated companies. The government of India has implemented various schemes and subsidies to promote the use of LPG as a cleaner alternative to traditional cooking fuels like wood, coal, or kerosene.

So in this study, we are going to study, How many people in rural areas use biogas or LPG? What factors influence their decision? Which one is cheaper or better? And how does using biogas or LPG affect people's lives.

OBJECTIVES

- To determine the count of households in Kaulage village using different Domestic fuels along with the factors influenced to choose that fuel.
- To examine the income sources among households.
- To analyse the distribution of biogas plant installations in Kaulage village based on the source of assistance.
- To check the impact of significant changes in LPG prices on household budgets.
- To check whether there is any relation between choice of Domestic fuel and income source.
- To determine the difference between annual expenditure on Domestic fuels.
- To develop a predictive model for estimating the annual expenditure for Domestic fuel.

METHODOLOGY

As our research project objectives are related to rural area, here we have considered the total household population of Kaulage village. To get the appropriate information firstly I visited the Gram panchayat, Kaulage. Then I got the total household population. In this village there are total 448 houses. Whenever we are dealing with population, the first thing comes in our mind that which part of population should be considered. So to draw an appropriate sample from the population here I used simple random sampling. The appropriate Sample size (known population) is determined by using Yamane formula, which takes into account the population size and desired level of confidence.

- Sample size : n = $\frac{N}{(1+Ne^2)}$
- N : Population size = 448
- e = 0.05
- Sample size : n = 208

After getting adequate sample size, we circulated a questionnaire among village people through a google form regarding to the research topic. Through this form we collected the required data for analysis purpose.

Statistical Tools:

- MS-Excel
- Python
- R Software
- Diagrammatic Representation
  - Pie chart
  - Column chart
  - Bar chart
  - Doughnut chart

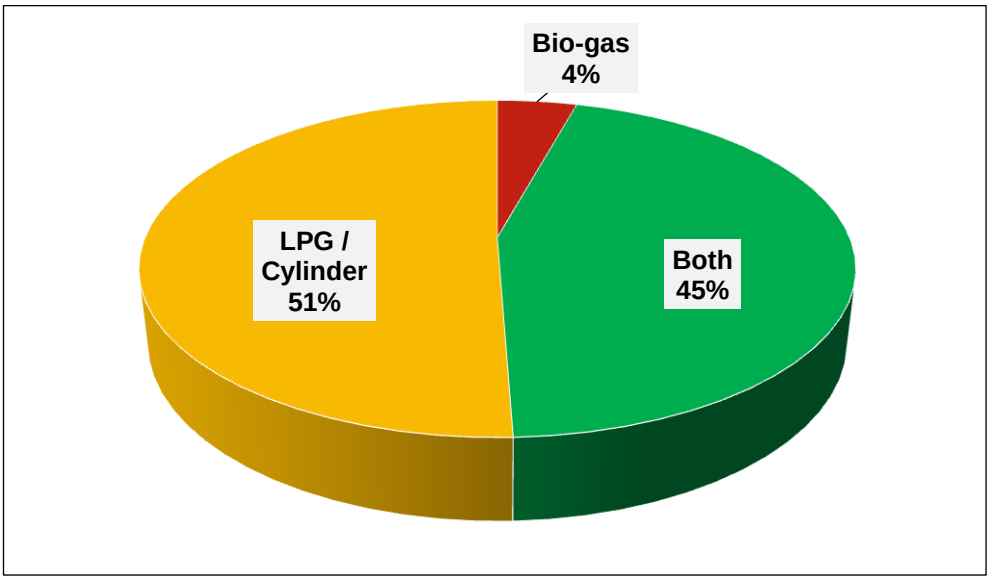
Statistical Tests:

- Chi-square test (Fisher exact test)
- Kruskal-Wallis
- Regression Analysis

DATA ANALYSIS

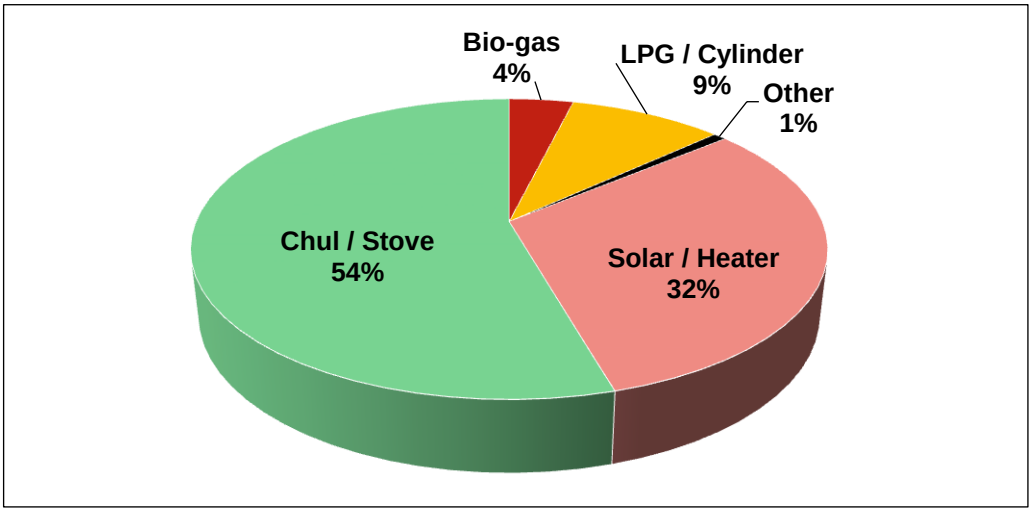
GRAPHICAL REPRESENTATION

❖ **The count of households using different Domestic fuels for cooking:**



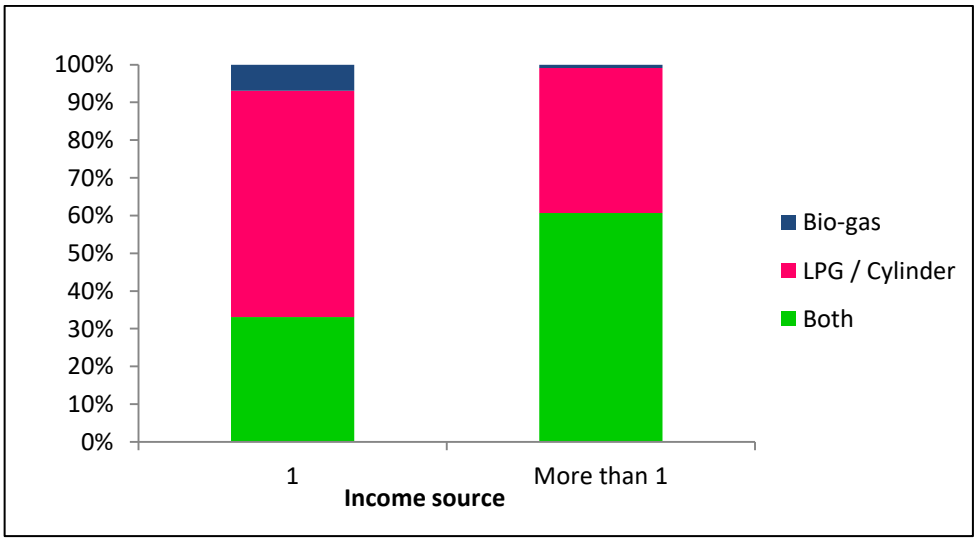
Interpretation: Here it is observed that 51% households prefer LPG/Cylinder as a Domestic cooking fuel and very less of them that is only 4% use Bio-gas. While 45% households give preference to Both fuel that is Bio-gas and LPG/Cylinder.

❖ The count of households using different fuels for water heating :



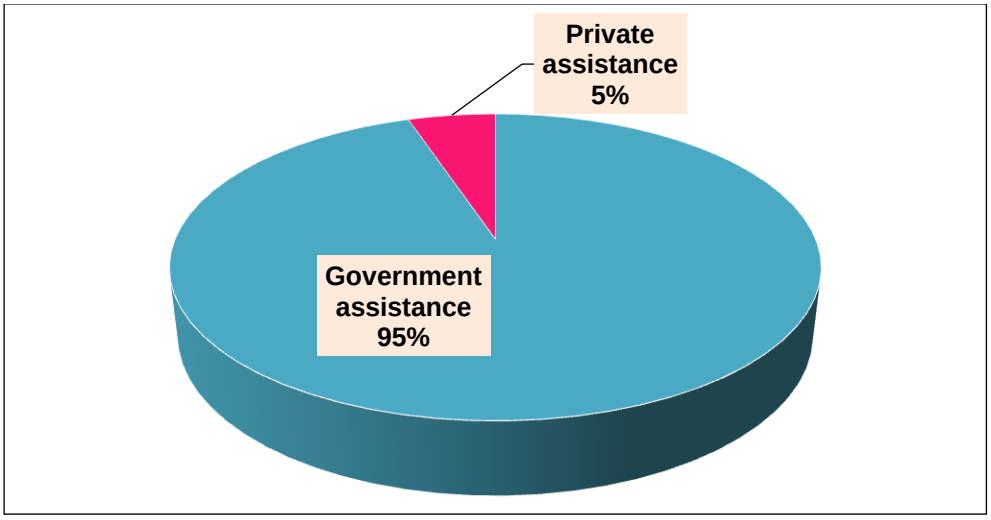
Interpretation: From the above chart we can see that most of the households, that is 54%, use Chul / Stove for water heating while 32% of them use solar / heater. Only few, that is 9% , 4% , 1% households use LPG/Cylinder, Bio-gas and other fuel respectively for the purpose of water heating.

❖ Count of number of income source with respective fuel users:



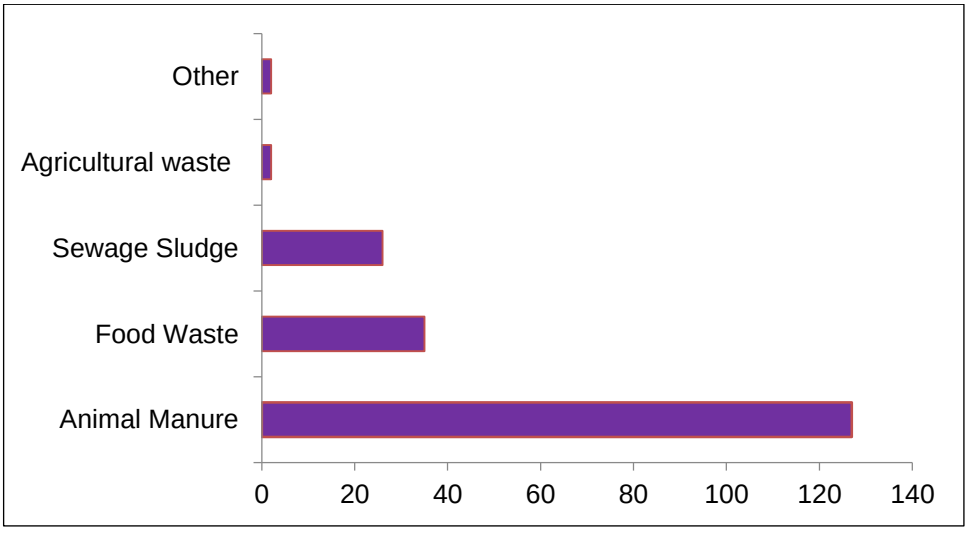
Interpretation: Here we interpret that, in households with only 1 income source, there are 35% users which use both fuels, 60% use LPG/Cylinder, and only 5% use only bio-gas. On the other hand, households with more than 1 income source show that around 60% use both fuels, 38% use LPG/Cylinder, and only 2% use bio-gas.

❖ Distribution of Biogas Plant Installations by Source of Assistance:



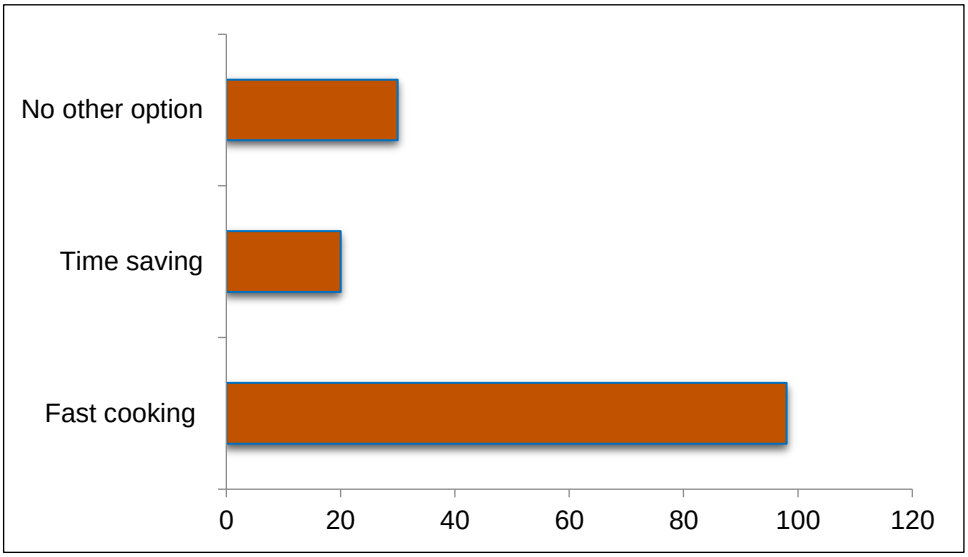
Interpretation: From this chart it is observed that, in Kaulage village most of the bio-gas plants installed through the government assistance while very few are privately funded. That is 95% and 5 % respectively.

❖ Material used to generate Bio-gas:



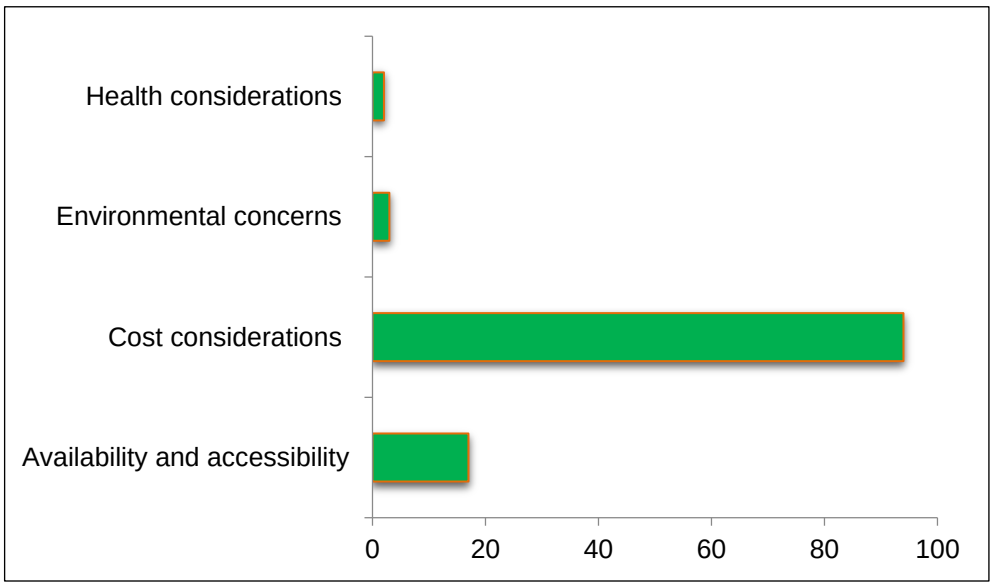
Interpretation: Most of the users use animal manure as a Domestic material to generate bio-gas which is followed by food waste and sewage sludge on small scale. There is very less use of agricultural waste or any other material for generation of bio-gas.

❖ Factors influenced to choose LPG/Cylinder :



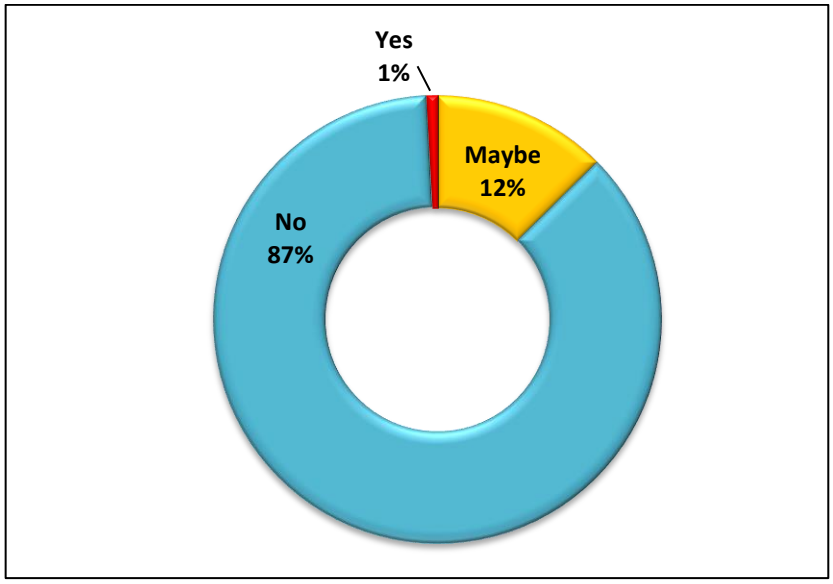
Interpretation: Most LPG users choose this fuel due to its fast cooking capabilities. But few of them use this fuel because they have no other option. Also, another one reason behind use of this fuel is time saving.

❖ Reasons for Using Both Fuels:



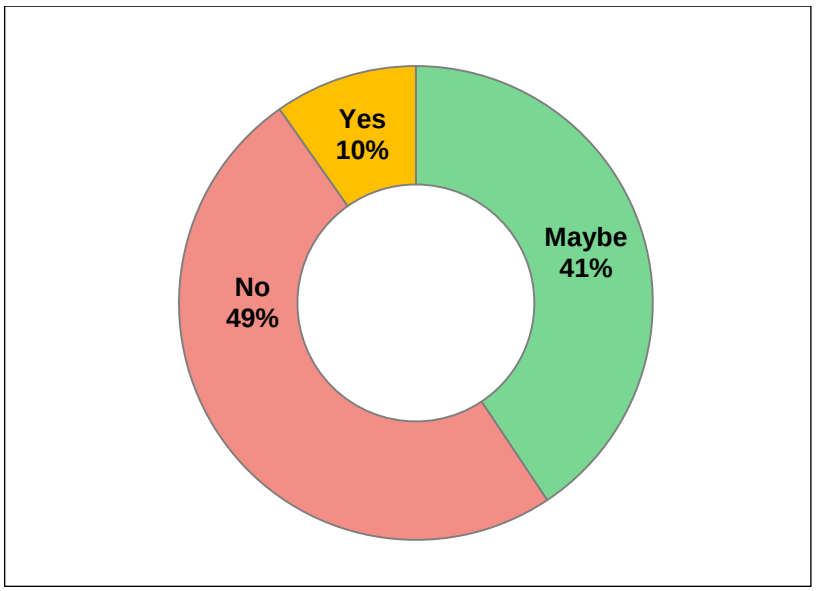
Interpretation: Among the both users, many of the households prefer both fuels primarily due to cost considerations while remaining users prefer due to Availability and accessibility , Environmental concerns , Health considerations.

❖ Bio-gas users that will switch to LPG/Cylinder in future :



Interpretation: Here out of total bio-gas users, 87% users will not switch to LPG/Cylinder while 12% responded as maybe. Very few that is only 1% of bio-gas users will switch to LPG/Cylinder in future.

❖ LPG/Cylinder users that will switch to Bio-gas in future :



Interpretation: Here out of total LPG/Cylinder users, 49% users will not switch to bio-gas while 41% users responded as maybe. Very few that is only 10% of LPG/Cylinder users will switch to bio-gas in future.

STATISTICAL ANALYSIS

Chi square Test

1) Aim : To check the dependency between Domestic fuel usage and the impact of significant changes in LPG prices on household budgets.

Hypothesis:

H0 : Domestic fuel usage and the impact of significant changes in LPG prices on household budgets are independent of each other.

v/s

H1 : Domestic fuel usage and the impact of significant changes in LPG prices on household budgets are dependent on each other.

Table :

Domestic Fuel	Any significant changes in LPG prices on household budgets	
	No	Yes
Both	62	54
LPG/Cylinder	23	107

Calculations :

α (L.O.S.) = 5% = 0.05

Test statistic:

χ^2 statistics = 33.0937

P_value = 8.782269766757862e-09

Result :

Here, P_value < α = 0.05.

Hence ,H_0 is rejected.

Conclusion :

There is dependency between Domestic fuel usage and the impact of significant changes in LPG prices on household budgets.

2) (Fisher Exact Test)

Aim : To check the association between Income source and type of Domestic fuel.

Hypothesis:

H0 : There is no dependency between type of Domestic fuel and number of income source.

v/s

H1 : There is dependency between type of Domestic fuel and number of income source.

Table :

No. of income source	Type of Domestic fuel		
	Bio-gas	Both	LPG/Cylinder
1	10	48	87
More than 1	1	68	43

Calculations :

α (L.O.S.) = 5% = 0.05

P_value = 1.034e-05

Result :

Here, P_value < α = 0.05.

Hence H_0 is rejected.

Conclusion :

There is dependency between type of Domestic fuel and number of income source.

Kruskal-Wallis Test

Aim : To check whether there is difference between medians of the 3 groups namely, Annual expenditure on biogas , Annual expenditure on LPG/Cylinder , Annual expenditure on both fuels.

Hypothesis:

H0 : There is no significant difference in the medians of the groups.

v/s

H1 : At least one group's median is different from the others.

Calculations :

α (L.O.S.) = 5% = 0.05

Test statistic:

H_statistic = 135.74078342174923

P_value = 3.343977875247248e-30

Here, P_value < α = 0.05.

Hence, reject H_0.

Conclusion :

At least one of the group's median is different from the other group.

So, there is significant difference between annual expenditure on biogas, LPG/Cylinder and Bio-gas.

Regression Analysis

Response Variable : Y = Annual expenditure of Domestic fuel.

Explanatory Variables : X1= Family members,

X2 = Domestic fuel.

Here,

	coef	std err	t	P>|t|
Const	1779.2654	1037.477	1.715	0.088
Family members	-83.7527	118.106	-0.709	0.479
Domestic fuel Both	663.2412	973.156	0.682	0.496
Domestic fuel LPG / Cylinder	7436.1906	988.646	7.522	0.000
0	340.9456	213.045	1.600	0.111

R-squared = 0.560

Adj. R-squared = 0.553

Durbin-Watson = 1.427

Mean of predicted annual expenditure is 5424.1245

Conclusion :

The predicted model is,

$\hat{Y}$ = 1779.2654 - 83.7527 * Family members + 663.2412 * Domestic fuel Both + 7436.1906 * Domestic fuel LPG / Cylinder + 340.9456 * Domestic fuel Bio-gas

1779.2654 : This is the intercept term or the value of $\hat{Y}$ when all independent variables are zero.

-83.75, 663.24, 7436.19, 340.95 : These are the coefficients corresponding to the independent variables (Family members, Domestic fuel Both, Domestic fuel LPG / Cylinder and Domestic fuel Bio-gas, respectively). They indicate the change in $\hat{Y}$ for one-unit change in the corresponding independent variable, holding all other variables constant.

MAJOR FINDINGS

The comparative analysis of bio-gas and LPG utilization in rural households is conducted in Kaulage village. It aims to reveal the primary factors for fuel choice and usage patterns. Here are some major findings from this study :

- This study shows that the domestic fuel source preferred by households is LPG / Cylinder. Most of the households also prefer both fuels while there are very least users of Bio-gas.
- This study suggests that households with multiple income sources rely more on both fuels (bio-gas and LPG/Cylinder), while those with a single income source mainly use LPG/Cylinder for cooking.
- The study shows that most of the households got help from the government to install bio-gas plants, while very less was privately funded . This suggests that government assistance might play a big role in encouraging people to use bio-gas.

* To generate bio-gas, people mostly use material like animal manure along with lesser quantity of any other material.
* This analysis reveals the main factors influencing the decision of choosing LPG/cylinder and reasons for using both fuels (like cost considerations) among households.
* Most bio-gas users are not interested to switch to LPG/Cylinder, with only a small percentage users are considering to switch.

  On the other hand, the majority of LPG/Cylinder users are unlikely to switch to bio-gas, with a significant portion considering the possibility to switch, while a small amount of users are open to switching.
* The Domestic fuel used by households is associated with the effect of significant changes in LPG prices on their budgets.
* There are significant differences in the annual expenditure on biogas, LPG/Cylinder, and both fuels combined.

FUTURE SCOPE

- We can stay in touch with families to see how using biogas or LPG impacts their lives over time.
- This study helpful for the further investigation into fuel preferences and usage patterns in rural areas.
- By examining long term effects of switching to bio-gas or LPG in rural areas can be useful for promoting cleaner energy use.

LIMITATIONS

- This study only focuses on the population of Kaulage village, which may not be representative of broader regions or populations.
- The study may fail to get the changes in household fuel usage and preferences over time because it is collected only once.
- External factors such as government policies or economic conditions could influence household fuel choices, which may not be fully accounted for in the study.
- The data collected relies on self-reporting from participants.

REFERENCE

1) Fundamental of mathematical statistics by S.C. Gupta.
2) "Think Stats: Exploratory Data Analysis in Python" by Allen B. Downey.
3) https://link.springer.com/article/10.1007/s42452-023-05408-6
   Rahul Biswas, Arifa Sharmin, Md. Ashaduzzaman and Md. Akramul Islam. "Assessing rural households' biomass consumption patterns in three Upazilas in Khulna district of Bangladesh.", 15 June 2023.

QUESTIONNAIRE

Section 1 :

1) Number of family members _____

2) Occupation / income source
   a) Farming b) Service c) Business
   d) Pension e) Other

3) Annual family income_____

4) How many cattle do you have?
   a) 0 b) Other….

5) Which type of fuel do you use for water heating purpose? (e.g. Bathing, Other)
   a) LPG / Cylinder b) Bio-gas c) Chul / Stove
   d) Solar / Heater e) Other

6) Which type of fuel are you currently using as a Domestic cooking fuel?
   a) LPG / Cylinder b) Bio-gas c) Both

Section 2 :

LPG / Cylinder users :

7) How long have you been using LPG as a cooking fuel?(In years) _____

8) What factors influenced your decision to choose LPG over other cooking fuels?
   a) Fast cooking b)Time saving c)No other option

9) How available is LPG / cylinder in your area?
   a) Extremely available b) Highly available c) Moderate availability
   d) Limited availability e) Not available at all

10) Do you face any problems while getting LPG?
   a) Yes b) No c) Sometimes

11) Have you experienced any significant changes in LPG prices affecting your household budget?
   a) Yes b) No

12) How much annual cost do you spend on LPG? _____

13) Have you been facing any problem due to use of LPG?
   a) Yes b) No

14) Would you consider switching to biogas as cooking fuel in the future?
   a) Yes b) No c) Maybe

15) What factors would influence your decision to switch fuels?

a) Cost Savings b) Health and Safety

c) Long-Term Sustainability d) Other

16) Overall Satisfaction Level

a) Very Satisfied b) Satisfied c) Neutral

d) Dissatisfied e) Very dissatisfied

Section 3 :

Bio-gas users :

7) How long have you been using Bio-gas as a cooking fuel?(In years) _____

8) Was the Biogas system installed with government assistance or privately funded?

a) Government assistance b) Privately funded

9) Are you satisfied with the installation process?

a) Yes b) No

10) How much annual cost do you spend on bio-gas? _____

11) Which type of material is used to generate bio-gas?

a) Animal Manure b) Food Waste c) Sewage Sludge

d) Agricultural waste e) Other

12) How would you rate the efficiency of the Bio-gas system in terms of cooking compared to traditional methods?

1 to 5

1 . Much more efficient 2 . Much less efficient

13) Have you facing any problem due to use of biogas?

a) Yes b) No

14) Would you consider switching to LPG / cylinder as cooking fuel in the future?

a) Yes b) No c) Maybe

15) Overall Satisfaction Level:

a) Very Satisfied b) Satisfied c) Neutral

d) Dissatisfied e) Very dissatisfied

Section 4 :

Both Bio-gas and LPG users :

7) Which type of fuel is more beneficial?

a) LPG / Cylinder b) Bio-gas

8) Reasons for Using Both Biogas and LPG :

a) Cost considerations b) Availability and accessibility

c) Environmental concerns d) Health considerations e) Other

9) How much annual cost do you spend on bio-gas and LPG? _____

10) In future, are you thinking about to switch to use of only one fuel?

a) Yes b) No c) Maybe

11) How long have you been using LPG as a cooking fuel?(In years) _____

12) Which factors are influenced to choose LPG / Cylinder fuel :

a) Less availability of Bio-gas b) Backup

c) Availability d) Energy intensity

13) How available is LPG / cylinder in your area?

a) Extremely available b) Highly available c)Moderate availability

d) Limited availability e) Not available at all

14) Do you face any problems while getting LPG?

a) Yes b) No c) Sometimes

15) Have you experienced any significant changes in LPG prices affecting your household budget?

a) Yes b) No

16) How much annual cost do you spend on LPG? _____

17) Would you consider switching to biogas as cooking fuel in the future?

a) Yes b) No c) Maybe

18) Was the Biogas system installed with government assistance or privately funded?

a)Government assistance b) Privately funded

19) Are you satisfied with the installation process?

a) Yes b) No

20) How much annual cost do you spend on bio-gas? _____

21) Which type of material is used to generate bio-gas?

a) Animal Manure b) Food Waste c) Sewage Sludge

d) Agricultural waste e) Other

22) How would you rate the efficiency of the Bio-gas system in terms of cooking compared to traditional methods?

1 to 5

1 . Much more efficient 2 . Much less efficient

23) Have you facing any problem due to use of biogas?

a) Yes b) No

24) Would you consider switching to LPG / cylinder as cooking fuel in the future?

a) Yes b) No c) Maybe

25) What are the reasons behind use of both fuels as a Domestic fuel?

a) Availability and accessibility b) Cost consideration

c) Environmental concerns d) Health considerations

26) How much annual cost do you spend on both fuels? _____

27) Overall satisfaction level :

a) Very Satisfied b) Satisfied c) Neutral

d) Dissatisfied e) Very dissatisfied

ANNEXURE

Chi square test:

Python code :

```
df1 = pd.read_excel(r'C:\Users\Genius\Desktop\Clg Activities\Project 2\Sorted
Data.xlsx',sheet_name = 7)
print(df1.head)
df1.columns
contingency_table = pd.crosstab(df1['Domestic_fuel'],
df1['Any_significant_changes_in_LPG_prices_affecting_household_budget'])
print('Contingency_table ; ')
print(contingency_table)
chi2_stat, p_value, dof, expected = chi2_contingency(contingency_table)
print("Chisq statistics = ",chi2_stat)
print("P_value = ",p_value)
print("Degrees_of_freedom = ",dof)
if p_value < 0.05:
    print('Reject Ho')
else:
    print('Accept Ho')
```

Fisher Exact test:

R code :

```
install.packages("readxl")
library(readxl)
data = read_excel("C:/Users/Genius/Desktop/Clg Activities/Project 2/Sorted Data.xlsx",sheet =
2);data
cont_table = table(data$`Income_source\r\n`, data$Domestic_fuel)
print(cont_table)
# Perform Fisher's exact test
fisher_test = fisher.test(cont_table);fisher_test
p_value = fisher_test$p.value;p_value
result = ifelse(fisher_test$p.value < 0.05, "Reject Ho", "Accept Ho");result
```

Kruskal-Wallis test:

Python code :

```
d_f = pd.read_excel(r'C:\Users\Genius\Desktop\Clg Activities\Project 2\Sorted
Data.xlsx',sheet_name = 6)
d_f.head()
from scipy.stats import kruskal
biogas_exp = d_f['Annual_expenditure_on_biogas'].dropna()    # Drop NaN values if any
lpg_exp = d_f['Annual_expenditure_on_LPG'].dropna()
both_exp = d_f['Annual_expenditure_on_both_fules'].dropna()
print(biogas_exp, lpg_exp, both_exp)

# Perform Kruskal-Wallis test
h_statistic, p_value = kruskal(biogas_exp, lpg_exp, both_exp)
print('H_statistic = ',h_statistic)
print('P_value = ',p_value)
if p_value < 0.05:
    print('Reject Ho i.e. At least one groups median is different from the others.')
else:
    print('Accept Ho i.e. There is no significant difference in the medians of the groups.')
```

Regression Analysis :

Python code :

```
DT = pd.read_excel(r'C:\Users\Genius\Desktop\Clg Activities\Project 2\Sorted
Data.xlsx',sheet_name = 15)
print(DT.head())
print(DT.dtypes)
# Specify the independent variables (features) and the dependent variable
X = DT[['Family_members\n','Primary_fuel']] # Features
X_additional = pd.DataFrame(x)
y = DT['Annual_exp']  # Target variable
# Create dummy variables for categorical variable 'Gender'
X_features = pd.get_dummies(X, columns=['Primary_fuel'], drop_first=True)
X = pd.concat([X_features, X_additional], axis=1)
X.fillna(0, inplace=True)
X = X.astype(float)  # Convert all variables to float data type
```

```
print(X)
# Check if there are still any missing values
print(X.isnull().sum())
# Add a constant term to the independent variables matrix
X = sm.add_constant(X)
# Fit the multiple linear regression model
model = sm.OLS(y, X).fit()
# Print the model summary
print(model.summary())
```