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Research Article

Estimation of Willingness to Pay for Family Biogas Plant

Malik Mohammad Hassan¹, Farooq Ahmad^{2*}, Junaid Ahmad Noor³
and Adnan Skhawat Ali²

¹Institute of Environmental Sciences and Engineering, National University of Sciences and Technology, Islamabad, Pakistan

²Sustainable Development Study Centre, GC University, Lahore, Pakistan

³Department of Economics, GC University, Lahore, Pakistan

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Abstract: Biogas plants answers a major search for clean cooking fuels in rural areas of the developing world where a dire need for replacing the existing (traditional) fuel is. Dung and non-dung based biogas plant has a great potential and promise for the future energy requirement. The objective of the current study was to check the feasibility and willingness to pay of biogas plant in sub urban area of district Nankana. The descriptive study was conducted on the basis of questionnaire. The variables such as respondent profile, expenses and income of households, household characteristics, and current status for cooking purposes, social acceptance and willingness to pay were checked through interviews of head of the family. It was answered that they were spending 500-1000 rupees per month on conventional fuel for cooking. As for as the raw material for biogas is concerned, there were 6-7 animal (Cows and Buffaloes) per household on average producing enough manure to install biogas plants for that community but it was noted that about 13.33% household were willing to pay for installation of biogas plant having installation cost 50,000 rupees while 55.33% household were not willing to pay at this cost. There were 31.33% households who answered to think about it. However all the non-willing households were agreed to pay the cost of biogas plant in installments of 200-300 rupees per month. For modeling for willingness to pay, multinomial regression model was conducted which was used for risk assessment and relation of probability of occurrence of an event by appropriate data for legit function.

Keywords: Biogas, Biomass, Renewable energy, Fuel, Regression, Willingness.

INTRODUCTION

The process of biogas production is very simple. It is produced by the decaying of cow dung, field waste, kitchen waste, and organic waste. It can be produced by cellulosic process e.g. biodiesel is produced by the excessive amount of different plant seeds involving *Jatropha*, soya bean and palm oil, bio hydrogen is produced by the transferring methane gas or by the biomass, bioethanol is produced by the crops like maize, cassava, sugar-cane and sorghum¹.

The current situation compels the authorities and concerning institutions to discover the renewable energy resources such as hydro power plant, solar power plant and wind energy, in bio-energy include biogas technology, biodiesel etc. Biogas technology is the most adopting technology of existing era in all over the world. To reduce the combustion and degradation of fossil fuels biogas is the best instrument and technology. It can reduce the deforestation, wastage of time, the cost and use of other fossil fuels such as kerosene, petrol and diesel².

In some regions of the world such as in Africa the biogas fermenters are set in those areas which are rich in provision of cow dung and field waste to get maximum results from the fermenters. The capacity of gas production of these plants from medium and large scale is different in Africa. The gas capability is less than 100 m³/day to greater fermenters with generation of gas capability up to 500m³/day³.

The renewable energy technologies such as, wind energy, tidal energy, solar energy and hydropower plants are working in Atlantic Canada. In case of bio-energy in Atlantic Canada biomass is present in successive amount. The biomass such as animal dung and field waste are necessary for the production of biogas. The region is the most feasible due to presence of raw material for the production of biogas. This biogas and its raw material can full fill the energy requirement of that region. The presence of animal manure in that area has capacity to produce large amount of biogas in Atlantic Canada, and can reduce the depletion of fossil fuels and its utilizations. The anaerobic process of decomposition of animal dung has many advantages such as it reduce the harmful smell produced from the isolated animal dung, it reduce the health effects, it reduce the smoke produced from the burning of dry dung and also reduce the Green House Gas (GHGs) emission. The biogas fermenters decompose all the organic waste and transform it into fertilizers. Its slurry also use as composting and soil nutrition and with rich nutrients of (i.e., P, N, and K), for the rapid growth of plant and high yield⁴.

OBJECTIVES OF STUDY

The objectives of the study were to check the feasibility and willingness to pay for the construction of biogas plant in sub urban area of Nankana. Household characteristics, current status of the cooking purposes, social acceptance, income and expenses and measurement of the spending of the people on conventional fuel were the other parameters taken into consideration.

RESEARCH METHODOLOGY

Study Site: The villages are very suitable for the production of biogas because they have large amount of raw material in the form of animal manure and other organics. The area selected for this study have the quality to produce the biofuel mainly biogas from the raw material that produced there. This study site is situated 10 km west from the District Nankana and has two Union Councils (UCs) Bucheki and Berkhurdar. There are large number of animals and agricultural land so that it is feasible for the construction of On-Farm biogas plant. The villagers have no access to natural gas and other

energy resources except electricity so the study can be very helpful in terms of public awareness and for construction of biogas plant for the residents of that area.

Processing of Biogas Plant: The first biogas plant built in Pakistan in 1959 and with the passage of time it becomes necessary for the energy efficiency and bioenergy due to the rapid depletion of nonrenewable energy resources and its negative impacts on the environment such as carbon emission, global warming, climate change and other health problems. By impressing the services of biogas plant it became popular in the developing countries like China and India. Many nongovernmental agencies and private sectors set their target to construct the biogas plant as many as they can. Biogas plants are categorized into three major types:

- Biogas Plants with floating gasholder
- Biogas Plant with built-in fixed dome gasholder
- Biogas plant with low cost bag / balloon type biogas plant

Willingness to Pay: The basic aim of this study is to check the willingness to pay for the betterment of the energy provision by their productive and less expensive source such as the construction of biogas plant to fulfill their energy need for cooking, heating and lighting. Variables of WTP are acceptance, cost of plant, supply of biogas, monthly installment based payment of biogas plant, and the reasons of not paying of biogas plant.

Modeling for Willingness to Pay:

Multinomial Logistic Regression: It generalizes linear model used for binomial regression. It is used for specific condition such as it applies when those dependent variables in which the independent variable's dummy coding is very frequent, has above two nominal or unordered classes of dependent variable. This method tells us that the variables exist for all classes except single, so we can say that if the M category exists there the dummy variable will be in the form of dummy variable M-1. That class which is not including in multi variable analysis has dummy variables of its own and all the other classes have not its own dummy variables. Their sequence is in such form that all dummy variables of a class have value of 1 for their own and for all other dummy variables the value is 0. There is one class that does not require possess dummy variable that is also called reference class, its identification can only be appeared by the 0 value of all else variables. As we mention above that the dual logistic regression model is also used for risk assessment, and by using this model the risk forecasters use this model to measure another dual logistic regression for all dummy variables. In this case the results will be appearing in dummy variable of M-1 in the model of dual logistic regression. The very important aspect to judge in this entire model's process is that all dummy variables describe the consequences of risk analyst on the possibility of results achievement of that class as we compare it to the reference class.

Preference of Multinomial Logistic Regression on other Techniques: Most of multivariate analysis techniques require the basic assumptions of normality and continuous data, involving independent and/or dependent variables. These assumptions are also in the application of Multinomial Logistic Regression (MLR) data collection and measurement steps in risk analysis, but to varying degree. So much stronger interval and ratio scales provide a good basis for a more broad multivariate analysis, normally used risk measurement scales such as five-point likert, ordinal, and nominal scales are usually considered inappropriate for multivariate analysis techniques, due to various assumption. Due to this, multinomial logistic regression was used where the above assumptions violated. This is obvious in one way in MLR analysis. Thus, it has unusual data distribution assumptions, which suggesting that it generates more suitable findings in terms of model fit and correctness of the analysis

apart from any assumption. A multinomial logistic regression model is a form of regression where the outcome variable is binary and the independents are continuous variables, categorical variables, or both. The use of multinomial logistic regression in risk analysis arises when we analyse relationships between a nonmetric dependent variable and metric independent variables. It compares multiple groups of risk processes such as risk alleviation, planning, monitoring, through a combination of binary logistic regressions. The evaluation is equivalent to the evaluation for a dummy-coded dependent variable, with the group with the highest numeric score used as the reference group. Further, it gives a set of coefficients for each of the two comparisons. Multinomial logistic regression is present to handle the case of dependents with more classes. This is known as the multivariate case. Thus, it is expected that multinomial logistic regression approach would do better when there is sign of very much departures from multivariate normality as is the case where distributions are highly skewed or heavy-tailed especially in dynamic settings. In MLR however, hypotheses on significance of explanatory variables cannot be tested in quite the same way as say linear regression.

Questionnaire Design: Open and close ended questions were designed in the questionnaire to get maximum respondent response and to get satisfactory answer by expressing his views without any hesitation such as

After hearing about its benefits, are you willing to pay for family biogas plant?

a) Yes b) No c) We will think about it

Total household income per month:

Respondent demographic and socioeconomic characteristics: Respondent demographic and socioeconomic characteristics are very important for effective results of research. The location of households, urban, rural or suburban also have a great matter on effective results, the number of households, their living style and social activities decide the feasibility of developmental projects and provide the suitable environment for it. For this purpose these questions were set; Location of House Hold, area the house is occupied? (In kanals or marlas), rooms in house, kitchens in house and having cattle's or not.

RESULTS AND DISCUSSIONS

The cost of biogas plant was proposed as Rs.50, 000. This cost was told to the respondent to check their willingness for the construction of biogas plant. There were 13.33% households who had their monthly expenses between 500 and 1000 on fuels and they gave the positive response to the adoption of biogas plant and spend on such alternative energy source of biogas. 55.33% households of same expenses of fuel were not willing to pay for the construction and use of biogas plant. They were not willing to pay on such cost of the plant. 31.34% households said that they will think about it.

This table and graph show that after elaborating them the benefits of biogas plant they were still not agree to pay for biogas plant. Very small amount of people were agree on it. And 46 households were saying that we will think about it (**Figure-1, Table-1**).

There were some reasons that are why they were not willing to pay; they wanted some incentives from the government side such as the monitoring and management, reduction in plant cost and also low monthly installment cost should be responsibility of government. And illiteracy was also the major issue because they have not experience to use such type of project which makes them confused. Majority of the people needs incentive based mechanism that also provides them opportunity for profit. These types of incentive based mechanism encourage the community in perspective of clean

environment and energy production. Comparison with the other study conducted⁵ shows that the incentive from the government is the first preference by the rural households that's why they demand for government incentive to launch the project of biogas plant because they were experiencing of it first time. Another study⁶ was conducted to check the willingness to pay for the utilization of bioenergy and evaluate the ratio of surcharges which consumer was willing to pay for bioenergy in Alabama. The results of the research showed the positive results that consumers were paying the best price for the utilization of bioenergy but there were also a group of people who were not paying sufficient cost the reason of not paying was unawareness the clean energy⁶.

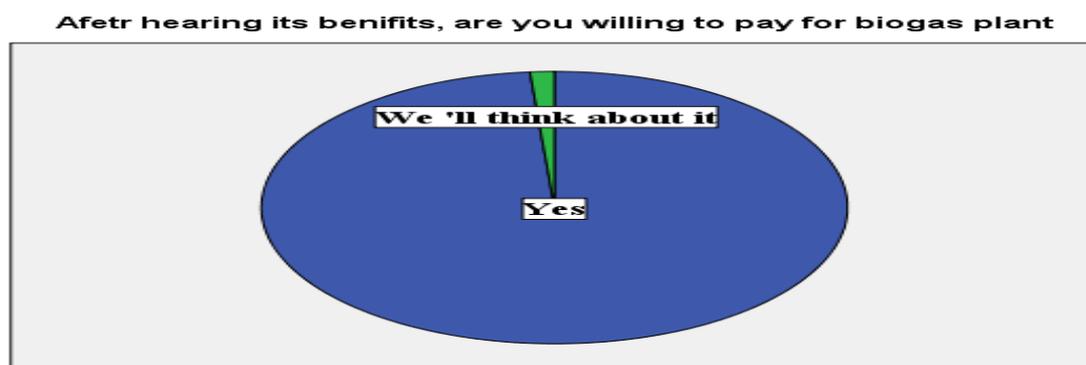


Figure-1: The benefits of biogas plant attract them to agreeing on paying for biogas plant.

Table-1: If the plant cost is 50,000 will you pay for it? (uses 2 cows or buffalos)
 * After hearing about its benefits, are you willing to pay for family biogas plant?

	After hearing about its benefits, are you willing to pay for family biogas plant?			Total
	Yes	We 'll think about it	No	
If the plant cost is 50,000 will you pay for it? (uses 2 cows or buffalos)	Yes	20	0	20
	No	82	1	83
	We "ll think about it	46	1	47
Total		148	2	150

Study of willingness to pay for construction of biogas plant, there was male dominated society that's why 100% heads of households were male and also earning member of the households. 56% were located in rural areas earned a monthly income between Rs.20,000 to Rs.40, 000, those households living in suburban areas were 29% and their monthly income was between Rs.15,000 to Rs.30, 000. 15% were in urban area of the village (**Figure-2, Table-2**). Gender arrangement, geographical location and monthly household income earning designs were parallel between urban, suburban and rural area's non-users of biogas plant. On average, biogas non-users owned a larger area of land and spent more on kerosene for household lighting purposes. They linked to the profession of agriculture. They had also excessive amount of raw material cow dung, crop residue, field waste, leaf litter, kitchen waste, and organic waste than the small area owners.

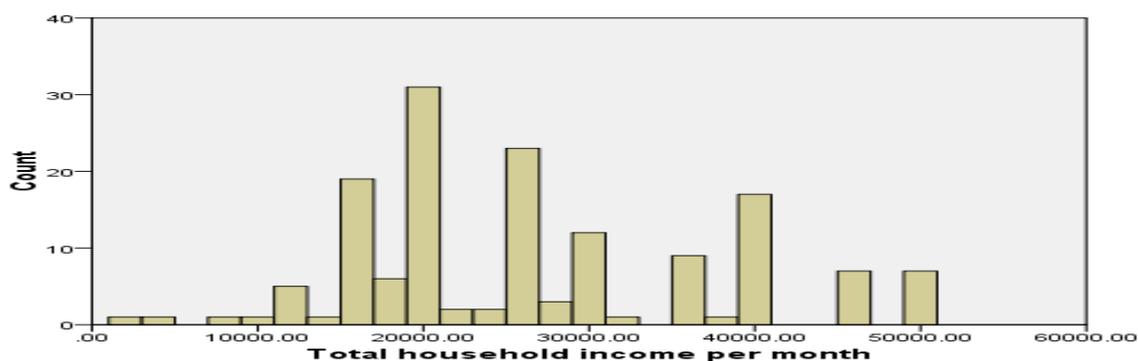


Figure-2: The total income of a household per month

Table-2: If the plant cost is 50,000 will you pay for it? (Uses 2 cows or buffalos)

* Total household income per month

		Total household income per month in thousands																				Total		
		20	30	80	10	12	14	15	16	17	18	20	22	23	25	28	30	32	35	38	40		45	50
If the plant cost is 50,000 will you pay for it? (uses 2 cows or buffalos)	Yes	0	0	0	0	0	0	1	0	0	0	3	1	1	5	0	2	0	1	0	3	2	1	20
	No	0	0	1	1	4	1	15	1	2	2	22	1	1	5	2	4	1	6	1	8	4	1	83
	We "ll think about it	1	1	0	0	1	0	2	0	1	1	6	0	0	13	1	6	0	2	0	6	1	5	47
Total		1	1	1	1	5	1	18	1	3	3	31	2	2	23	3	12	1	9	1	17	7	7	150

There were 13.33% households who were willing to pay for biogas plant if they were supplies of biogas at home. Most of them include the educated households. 55.33% households were not willing to pay for the supply of biogas at home. They were not willing to pay on such cost of the plant. Those who were paying for biogas were happy because they were supplying of biogas at home and there fuel collection time and other wastage of money were reduced. They were provided the best and clean source of energy to their homes. 38 households did not give any answer about that question. On the cost of 50000 there are 31.33 households who say “We will think about it” (Figure-3).

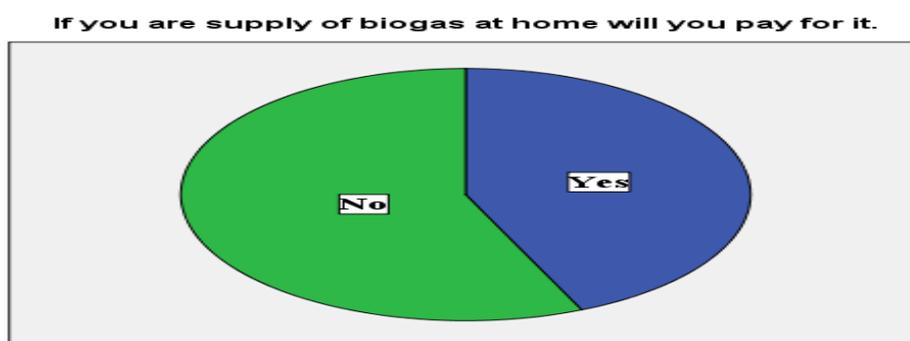


Figure-3: To check their willingness if the biogas is supplied in their houses.

The graphical representation shows that those households which were not willing to pay for the biogas plant and when we asked them for installments then they were agree to pay for biogas plant construction the amount only 100 to 300 rupees individually and monthly (Figure-4).

If you have to pay monthly installments based on your expenses for fuels will you pay for it.

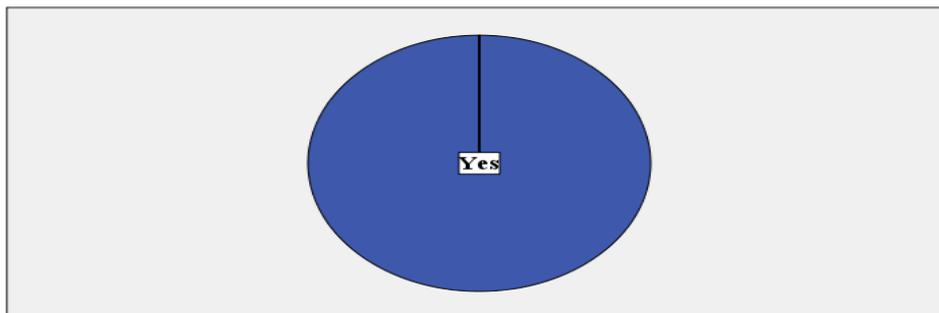


Figure-4: Their willingness on monthly installment based payment same as their current fuel cost.

In this table 57 people were willing to pay for the construction of biogas plant at the cost of 50000 but on installments not at a time collectively. 27 people said that we will think about it. But the figure shows only those who are willing to pay in installments without binding of the other parameter of plant’s cost (Table-4).

Table-4: If the plant cost is 50,000 will you pay for it? (Uses 2 cow or buffalos)

* If you have to pay monthly installments based on your fuel expenses then will you agree to pay?

		If you have to pay monthly installments based on your fuel expenses then will you agree to pay?	
		Yes	Total
If the plant cost is 50,000 will you pay for it? (uses 2 cows or buffalos)	No	57	57
	We "ll think about it	27	27
Total		84	84

The reason of not paying or paying of very small amount for biogas plant is ignorance, illiteracy, confusion, and demand for government incentive. They were not known that what is biogas and how it works etc. Small numbers of people were saying “Yes” they are willing to pay for biogas plant after that they were paying 500 to 1000 on conventional fuels. But there were large numbers that were paying 500 to 1000 but they were still not willing to pay for biogas plant. The same amount was those people whose answer was we will think about it and they were spending same (Figure-5, Table-5).

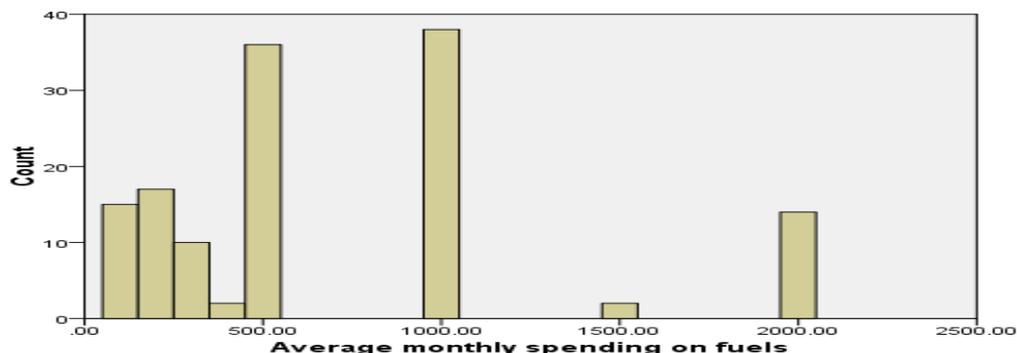


Figure-5: The households average monthly spending on fuels.

Table-5: If the plant cost is 50,000 will you pay for it? (Uses 2 cows or buffalos)

* Average monthly spending on fuels

		Average monthly spending on fuels								Total
		100.00	200.00	300.00	400.00	500.00	1000.00	1500.00	2000.00	
If the plant cost is 50,000 will you pay for it? (uses 2 cows or buffalos)	Yes	2	3	2	0	5	6	0	2	20
	No	11	12	6	1	15	17	2	4	68
	We "ll think about it	2	2	2	1	16	15	0	8	46
Total		15	17	10	2	36	38	2	14	134

There were 14 households whose frequency of getting fuel in a month was one time and they were willing to pay for biogas plant. Instead there were majority of people whose frequency was greater but 13 people for 2 time in month and 13 people for one time in a month but they were not willing to pay for the biogas plant. 35 households whose frequency was one time in a month and 11 people were whose frequency was two time in a month and their answer was we will think about it. In case of figure 7 almost 75% households frequency of getting fuel ignoring the plant’s cost. Only approximately 25% were getting fuel 2 times in a month (**Figure-6**).

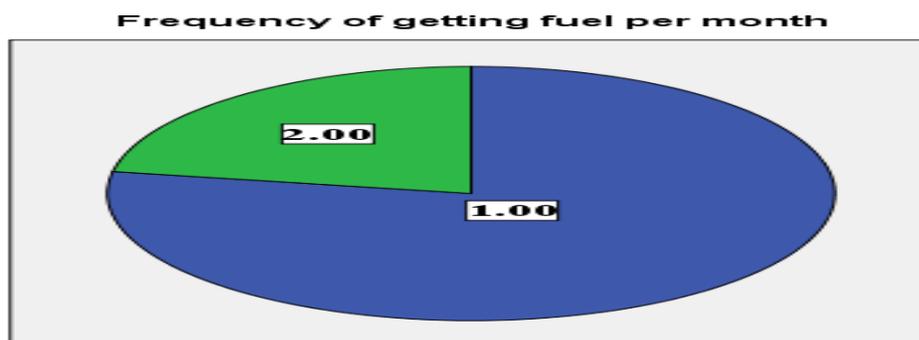


Figure-6: Their repetition of getting fuel in a month

The **Table-6** shows that there were 8 households of intermediate who were not willing to pay for biogas plant and 21 numbers were of matric and 12 were of middle class of same answer. Majority of 28 were uneducated. There were very small amount of educated people such as bachelor and master who were willing to pay for biogas plant. There were 25 uneducated and small amount of people who were of primary educated their answer was we will think about it.

There were 8 households of intermediate who were not willing to pay for biogas plant and 21 households were of metric and 12 were of middle class who were agree after telling them the benefits of biogas. Majority of 28 households were uneducated. There were some high educated households such as bachelor and master who were willing to pay for biogas plant. There were 25 uneducated households who were of primary educated their answer was “We will think about it.”

20% households adopted the biogas technology in their area independently out of 100% households. 55% households were primary school education to intermediate (Figure 4.8). This education should be sufficient to take the decision for adaptation of modern renewable and clean energy technology. The adoption of biogas as an independent variable was the choice of 90.4% households of the total observations of 220. The average of 11.3 years of schooling involve that on average, the households

head get the secondary education. This should be enough standard education to take an initiative concerning to the renewable energy technology⁷⁻¹⁰.

After elaborating them the benefits of biogas plant they were still on the statement of “No”. Very small amount of households were agree on it. And 46 people or households were saying that we will think about it. The biggest reason of not accepting the biogas plant was the uneducated households, illiteracy and easy to collect the conventional fuels. They were not aware of the environmental and health benefits of biogas plant and also for their crops.

Table-6: If the plant cost is 50,000 will you pay for it? (Uses 2 cows or buffalos)

* Education of respondent

		Education of respondent								Total
		Uneducated	Primary (1-5)	Middle (5-8)	Matric	Technical Diploma	Intermediate	Becholar	Masters	
If the plant cost is 50,000 will you pay for it? (uses 2 cows or buffalos)	Yes	11	5	0	0	0	0	2	2	20
	No	28	12	12	21	1	8	1	0	83
	We "ll think about it	25	8	7	5	0	1	1	0	47
Total		64	25	19	26	1	9	4	2	150

Most of the respondents were linked with the profession of agriculture. They were belonged to rural area. Small numbers of households were linked with the occupation of self-employed and self-employed business (Figure-7).

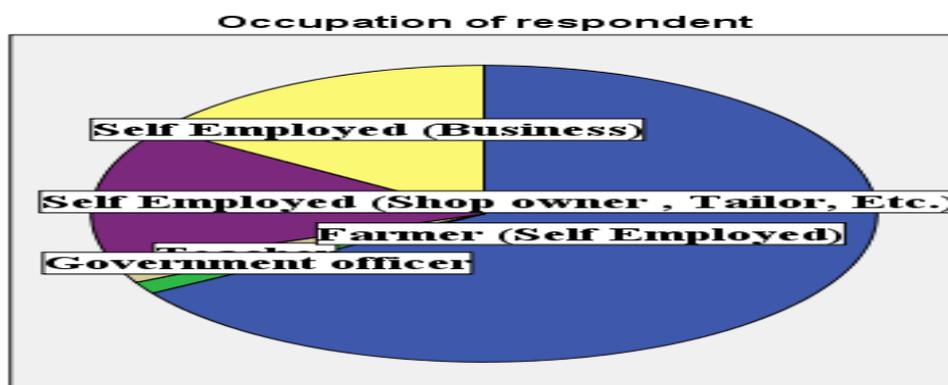


Figure-7: They have adopted different occupation but the farming is dominated there.

The maximum expenses were about 20,000 of more than 25 households. These are the average expenditure of households of both Union Councils. Their families were large so that the expenses are high (Figure-8).

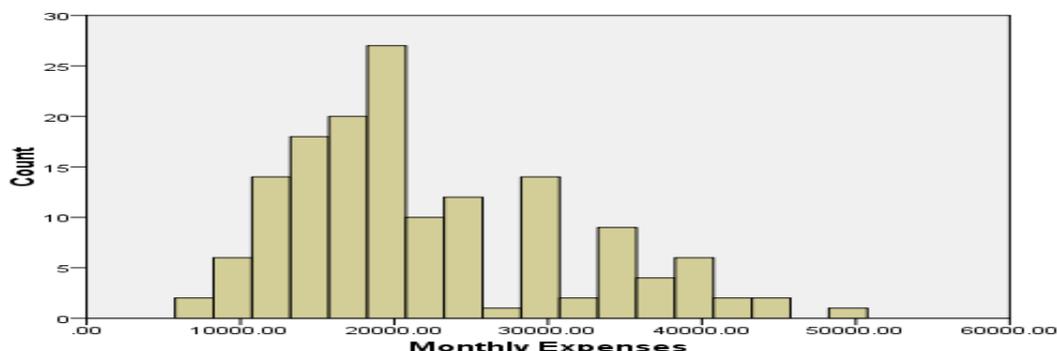


Figure-8: The monthly expenses of households

The selected sites is comprise on rural area. Small part shows the urban area. The numbers of households were large in rural area than in urban and suburban area. They are linked with the profession of agriculture. The population of rural area is larger and scattered in large fields (Figure-9).

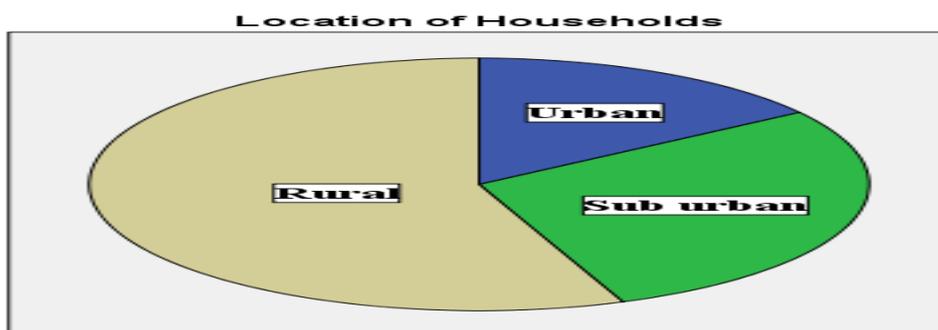


Figure-9: The location at which household is situated.

Maximum households were satisfy with their current and traditional source of energy but it had a reason that the tradition fuels were free for the large land owners the paid nothing to anybody for their use. They were not aware of the hazardous environmental consequences like deforestation by cutting down the trees, emission of GHGs and other toxic smoke (Figure-10).

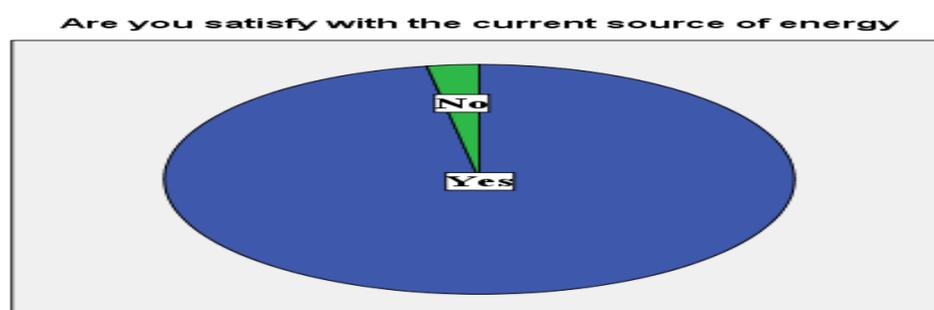


Figure-10: Their satisfaction with their current source of energy.

When we elaborate them the benefits of biogas they were compelled to think on it seriously. All the households were agreed and willing to construct biogas plant and use the biogas in their homes. The results were almost 100% after getting aware of its benefits (Figure-11).

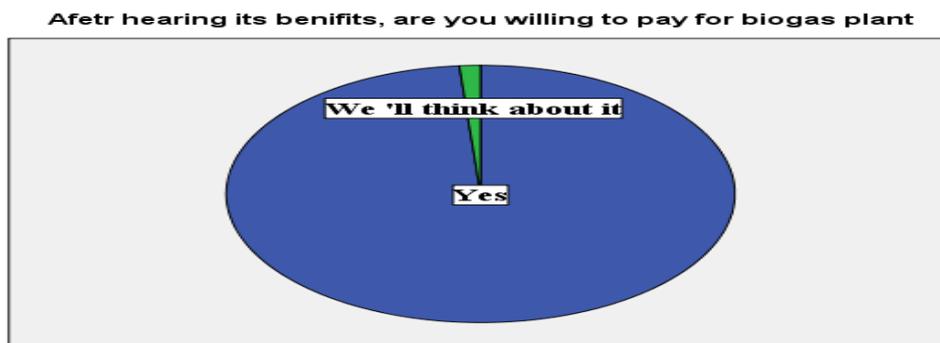


Figure-11: The benefits of biogas plant attract them to agreeing on paying for biogas plant.

The results of the questionnaire after run the model of Multi Logistic Regression Model:

	(1) cost	(2) cost	(3) cost	(4) cost	(5) cost
No					
Income	0.0000499* (2.17)	0.0000581* (2.24)	0.0000704* (2.23)	0.0000727* (2.26)	0.0000695* (2.14)
Education		0.0930 (0.73)	0.0913 (0.71)	0.0945 (0.73)	0.0774 (0.59)
expense			-0.0000108 (-0.61)	-0.0000106 (-0.61)	-0.0000106 (-0.59)
cattle				-0.0220 (-0.30)	-0.0154 (-0.21)
satisfaction					1.385 (1.25)
_cons	-2.768*** (-3.93)	-3.164*** (-3.47)	-3.226*** (-3.50)	-3.042** (-2.66)	-3.073** (-2.65)
We Will Th~k					
Income	0.0000381* (2.19)	0.0000244 (1.27)	0.0000535 (1.01)	0.0000562 (1.01)	0.0000538 (1.00)
Education		-0.190 (-1.57)	-0.197 (-1.60)	-0.201 (-1.63)	-0.193 (-1.57)
expense			-0.0000318 (-0.52)	-0.0000380 (-0.58)	-0.0000334 (-0.53)
cattle				0.0262 (0.46)	0.0225 (0.40)
satisfaction					-37.06 (-0.00)
_cons	-1.570** (-3.14)	-0.934 (-1.50)	-0.964 (-1.49)	-1.197 (-1.43)	-1.185 (-1.42)
N	150	150	150	150	150

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Results of multinomial logistic regression model: The multinomial logistic regression model is used to check the willingness to pay for family biogas plant. The results of research are shown in below table. These results are interpreted as, that the income is showing the positive relation of income and

their negative behavior, because when income increase the negative behavior about acceptance will also increase. In case of theory it should be negative. The response of we will think about it should be positive and in results it resulted same as theory. So the results are accurate for we will think about it.

If their income increases the reasons of increase in their negative behavior are: The selected site's households major expenses are on food items and secondly on the transportation. If income increases then they will spend maximum on food because now they are spending maximum on food for their families which are large. They do not spend much amount for their energy resources from their income. They can pay that amount which they pay for current energy source which is 200 to 500 rupees that is very low. If we collect their paying amount then it will take 25 to 30 months for completing the amount 50,000 rupees the cost of biogas plant. After applying the multinomial regression model the results are showing the positive relation of education acceptance and negative behavior. Negative behavior will increase because any decision they will take should be long term and gaining maximum utility. But in real, if the education will increase the acceptance of biogas will also increase. People will be aware about surrounding environment. The negativity will decrease with the increase of education. In case of thinking that we will think about paying for biogas plant, in theory it increases because they think more to take good decision for long term in future. But in results it is opposite and there is negative relationship among thinking and willingness to pay for biogas plant. The reason is that they will have no time to much think about it. Any decision they want to do will be pending due to shortage of time.

The results after application of model show that if the expenses will increase the negative behavior of people about willingness to pay for biogas plant will decrease. The reason is that if their expenses increase they demand for alternatives to reduce their expenses then they will realize the effectiveness of biogas plant and cheap energy source. Theory tells us that if the expenses of households will increase they will be agreeing to pay for biogas plant. In case of we will think about it, results show that thinking will be reduced. Its reason is that they will not more think to decrease their expenses and to adopt biogas technology. Theory also describes the same results.

The results show that increase in the no. of cattle will decrease the negative behavior of people. They will construct more plants. So there is negative relationship between no. of cattle, acceptance of biogas plant and their negative behavior. The reason is that due to increase in cattle the animal dung will be maximum and they will search for such technique through which they can utilize their waste efficiently so then they adopt biogas technology. The same description and rule is of theory. In case of we will think about it results show the positive relationship of thinking about acceptance and increase in no. of cattle. Theory shows that they will more think about construction of biogas plant. The reason is that more raw material of animal manure will be utilized efficiently and they will think more for best results and utilization. So these are same results.

Satisfaction is also a significant parameter to consider in all research. Result tells us that if the satisfaction will increase by whatever the source of energy is except biogas their negative behavior will also increase. The reason is that they need maximum satisfaction whatever the source of energy is. They do not experience of biogas plant. That's why they rejecting the paying for biogas plant. In theory it is same with the results. In case of we will think about it results shows the negativity that if satisfaction will increase the thinking of people decrease. There is negative relationship among thinking and increase in satisfaction. Its reason is that they will not think about construction of biogas plant if it provides them maximum utility the people. Theory tells that there is negative relationship so the theory and results are same and accurate.

CONCLUSIONS

There were 13.33% households who were willing to pay for biogas plant and use the biogas on the cost of 50,000 rupees. 55.33% households were not willing to pay. 20 households said that they will think about it. It contains some reasons such as illiteracy, ignorance, easy access of traditional fuels and demand of incentives from government. This negativity can be reduced by convincing them about such green technology and realize them the harmful effects of climate change, deforestation, global warming, and their health problems which are produced by their use of conventional fossil fuels excessively. There were majority of those households who were educated primary to master. They were willing to adopt biogas after getting aware of its benefits.

The selected rural area was rich in production of biomass and that make it more feasible for the production of biogas plant. In existing situation of energy crisis rural area has best sources and raw material for adaptation of biogas plant. This is the only way to fulfill the energy need of households in such rural areas.

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*** Corresponding Author: Farooq Ahmad**

Sustainable Development Study Centre, GC University, Lahore, Pakistan