Social Economic Impact of Biogas Plant on the Livelihood of People of District Sargodha, Tehsil Sahiwal and Sillanwali.

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CERTIFICATE

This is to certify that this thesis entitled: ***"Social Economic Impact of Biogas Plant on the Livelihood of People of District Sargodha, Tehsil Sahiwal and Sillanwali"*** submitted by Mr. Own Shamsher Ali is accepted in its present form by the School of Public Policy, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in Master of Philosophy in Public Policy.

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Abstract

The global warming and emission of greenhouse gasses pushed the world economy towards renewable sources of energy. Bioenergy is one of the major types of alternative energy source. Pakistan has agriculture economy with significant number of livestock that contribute to economic activities at national level. Historically, Pakistan faced a greater problem with respect to the adoption of biogas energy. This study evaluates the socio-economic impact of biogas plants on the livelihood of two Tehsils of District Sargodha. It is a quantitative study. A structured questionnaire formulated to collect the primary data. Structured Equation Model employed to interpret and analyze the data. Most of the plants were $10m^3$ in size, which used 50-60 Kg of dung daily to produce enough gas to fulfill the requirement of the household. It is revealed that wood consumption decreased from 28,080 to 2,520 kg annually since the Biogas plants are functional. Biogas plats reduced the fuel expenditure as in some of the cases; households are able to save up to Rs10000 per month. It added to save the time of buying and collection of wood as it usually took time between 1 to 2 hours daily. Furthermore, Biogas completely substituted the use of wood or Liquid Petroleum Gas (LPG). However, it is observed that in the month of January and December due to low ambient temperature gas produced from biogas was not sufficient, so wood and dung cakes were used to meet the daily cooking requirement. It is concluded that the impact of biogas plant on the livelihood of people is positive. Involvement of government and public is essential for the expansion of biogas technology throughout the country as a cheap alternative source of energy.

KEYWORDS: Biogas; Livelihood Assets; Social Economic; Livestock; Total Income.

Contents

List of Abbreviations

BG	Biogas
FC	Financial Capital
FP	Farm Productivity
GDP	Gross Domestic Product
GHG	Greenhouse Gases
HC	Human Capital
HH	Household
HS	Household Sanitation
IAP	Indoor Air Pollution
LPG	Liquefied Petroleum Gas
NC	Natural Capital
NGOs	Non-governmental organizations
NRSP	National Rural Support Program
PC	Physical Capital
PCAT	Pakistan Council of Appropriate Technology
PCRET	Pakistan Council for Renewable Energy Technologies
SAV	Savings
SC	Social Capital
SEM	Structured Equation Model
TI	Total Income

Chapter 1

Introduction

Sustainable development is one of the formidable challenges of the present world. The depletion of non-renewable energy resources with the frail economy has led the urgency in search of the sustainable, economic, and environmentally friendly source of energy. In the development process of any country, energy plays an important role. Energy expenditure is a good tool to measure the socio-economic development of a country. For poverty alleviation through income, health, education, environmental improvement, the energy sector has positive impacts (Chen *et al.,* 2009).

Without increasing well-utilizing of energy and energy services, no country has succeeded to mitigate the poverty too significantly. In real, energy sector influences all dimensions of development i.e. social, economic, and environmental (Rae et al., 2009). To achieve economic development, the use of energy sources work as a primary agent for country's development. This is important because economic success and standard of life of a country are directly linked to the level of its per capita energy expenditure (Singh and Smooch, 2004).

The demand for energy is increasing with every passing day. Its provision is not growing proportionately. However, the provision of sufficient, reasonably priced, efficient and consistent energy services with least effects on the environment is important. In many developing countries, the use of animals and crops waste is being used to boost the energy supply (Chen et al. 2009).

The increase of energy expenditure and establishment of suitable energy sources, a country can improve its living standards. The major hurdles to a country's economic development and poverty alleviation are the scarcity of energy and the high prices of

petroleum. In rural areas, to narrow down the space in energy supply, a renewable fuel can play a vital role as a tool of the energy mix, in the rural areas. The installation of biogas plants in Pakistan are limited even biogas technology is old and well known in Pakistan. The cooking in rural areas of Pakistan is mainly on fuelwood, farming residue, and dried animal manure. The country has largely been deprived of the proven benefits of household biogas. The women and children in terms of reduced burden of firewood collection and less indoor air pollution (Ilyas, 2006).

Today's use of energy in the developing countries is heavily represented by the use of conventional fuel that is biomass. Firewood, straw, dung, and crop residue constitutes a large part of the energy consumption. Biofuel is almost fuelwood, used in rural areas of Pakistan. Many people in the rural areas are burning livestock dung and other agricultural residues. These are the source of environmental degradation and disturbing soil fertility in the country. In Pakistan, wood is used as a major source of fuel consumption at HH. This resulted in various problems like deforestation, indoor air pollution leading to health problems, wastage of time, challenging for women, Global warming, soil erosion, abrupt climate change etc. on the other hand, people in the rural areas are burning livestock dung and other agricultural residues. This has been one of the factors in the erosion of environment and soil fertility in the country (Sakhawat *et al.*, 2013).

Being agricultural based country, Pakistan has excellent capability for running biogas plants. In Pakistan, where the total cultivated area is about 22.2 million hectares with accessible crop residue is 69 million tons annually that can generate a great amount of electricity per year. No of animals in Pakistan are almost 65 million those are a source of 650 million kg per day dung and only 50% of this dung can be collected. Pakistan can generate 16.25 million cubic meters of biogas per day with the use of this collectible dung. If this gas might be used to generate electricity, the amount of electricity can be calculated 9885 kWh

per year. Estimated biofertilizer production is 12 million per year. Biogas plants can easily compensate around 20-30 % of fertilizer requirement in the crop fields (Ilyas ,2006).

1.1. Background of the Study

Energy plays a significant role in the economic and social development of any nation. As Farouge and Hameed (2012) state, that energy is necessary for everyday life. It is in the form of heat, light, and electricity. Energy and development go together. With the increase in development, the level of energy consumption also increases (Aqeel & Butt 2001; Murphy & Hall, 2011). Therefore, energy has become one of the fundamental components of better living, growth, and development.

The shortfall of energy supply not only disrupt the economy of the country but also the livelihood of the people. Pakistan faced approximately 4% GDP loss to the economy due to energy shortages in recent years. As for as energy supply is concerned, urban areas are more concerned. Domestic users mostly use natural gas. However, rural areas most people use fuel woods, dungs and crop residue (Shams *et al*., 2014). Whereas other alternative resources like liquefied petroleum gas (LPG) and fuel-wood are becoming expensive, alternative resources of energy and fuel-wood supply are decreasing due to over-cutting. Cutting wood not only causing deforestation but also had a worse effect on the environment. It is the need of the time to adopt these types of energy resources. These are ingredients of sustainable development. These are socially accepted and economically viable and offer the great prospect for development while does not affect the environmental (Khurshid, 2009).

Energy resources are categorized into two type's i.e. renewable and non-renewable resources. Non-renewable energy resources are those, which are consumed completely, and it is almost impossible to refill these resources. Non-renewable resources include coal, natural gas, petroleum, oil shale and tar sands (West and winter; 2010). The disadvantages of burning

these type of resources cause serious consequence for the environment. These fuels emit greenhouse gases (GHG) such as carbon dioxide (CO_2), methane, sulfur dioxide into the atmosphere. GHG gases became greater threats to the environment and cause air pollution, climate change, global warming, and increases the risk of diseases (Pieprzyk et al., 2009). On the other hand, these types of energy are facing a serious challenge in term of long-term sustainability.

Therefore, cleaner and sustainable form of energy is the best possible solution (Asif and Muneer, 2007). The other form of energy is renewable forms of energy which we get from natural resources such as solar power, wind power, biogas, biomass, and hydropower (Omer, 2012). These types of energy resources are environmentally friendly. These types of energy resources can meet the requirement of energy needs without affecting or harming the environment.

Over the years growing demand for energy and depletion of fossil fuels has led many countries to go for the alternative source of energy which is economically feasible, sustainable, and environmentally friendly (lwaro and Mwasha, 2010). International summit such as world future energy summit 2016 and protocol such as Kyoto protocol have made attempt to give awareness about depleting resources and about changes climate conditions. Promoting alternative source of energy is one of an important step toward reducing dependency on fossil fuels (Linaras et al.,2008). The technology advancement in agriculture and in solid waste materials are also playing an important role. Different countries use different types of technology to reduce dependency on fossil fuels as China is working on solar energy, India on waste to make energy and Brazil on sugarcane ethanol in Brazil (Goldemberg & Lucon, 2010). Burgermeister (2009) stated that Germany is also becoming one of the key players in term of renewable energy.

In terms of the renewable sources of energy, hydropower is leading source of energy production and approximately 15% of electricity all around the globe is produced through hydropower (World Energy Report, 2013). Another form of renewable energy resource is bioenergy. It is defined in the broader term as energy generated from feedstock conversion through technology. At present the share of biofuel in transportation in about 2% all around the world, but it is expected to increase to 5% by 2030.The share of bioenergy in total primary energy supplies (TPES) is about 10% in 1990 and about 907Mtoe which has increased and in 2010 it is about 1240Mtoe (World Energy Report ,2013).

Pakistan is facing energy shortages. Pakistan has a wide spectrum of high potential renewable energy sources, conventional and non-conventional as well, which have not been adequately explored, exploited or developed. However, it has significant potential to produce energy through alternative energy resources. It has an agricultural economy. Agriculture plays a vital role in the development of the country. It possesses a great potential for production of biogas energy due to the availability of large population of rural livestock and availability of animal dungs and agriculture waste. These biogas plants provide energy at low cost and environment-friendly (Shams *et al*., 2014). Amjid *et al.* (2011) stated that less availability of energy is one of constraining for development of the country.

Pakistan approximately spends 7 billion US$ on the import of conventional energy. It is equal to 40% of total import of Pakistan. Estimation shows that by 2050 Pakistan energy demand would increase by 3 times more as compared to present but in term of supply is a concern the situation is not very pleasing. To counter these problems, we must think about an alternative form of energy for that one of the potential energy resources in term of availability and renewability is biogas which not only plays an important role in term of reducing energy crises especially in rural areas of the country. Also, to reduce the dependency on fuel woods

which is depleting day by day and helpful for the environment. Furthermore, it reduces the climate change and gave improve chance of economic development (Bajgain *et al.,* 2005).

There is around 16 million small-scale domestic biogas plant all around the worlds. In Pakistan, the first biogas plant was installed in 1959 but the first biogas plant which is used for domestic purposes was fixed-dome chines model was installed in 1974 by Pakistan Council of Appropriate Technology (PCAT), this project fails due to leakage problem (Heedge & Pandey, 2008). With the passage of time, innovation and a better understanding of technology, several successful projects of government, NGOs and regional supports programs have resulted in the installation of thousands of biogas plant. It is reported that almost 2920 domestic biogas plant until August 2013 has been installed. There is also planning to install 0.3million plants in next 10 years (Anonymous, 2013).

There are many benefits associated with biogas plant such as production of energy (heat, light, electricity) and high quality fertilizer and protection of environment through reduction in use of fossil fuel and reduction in greenhouse effect (Osei, 1993; Bajgain & Shakya, 2005; Heegde & Pandey, 2008; Hamlin, 2012).

1.2. Problem Statement

Depletion of natural resources and transformation of industry caused environmental and energy crises. The awareness regarding the environment and energy-related concern demands the development of the sustainable system. A system that meets the basic requirement of human life through natural resources. Development of such sustainable system is not only helpful in conserving natural resources and environment but also contributes to raising living standards of a society. In this context, this research seeks to examine that how much a household can save resources for instance money and time by

using biogas plants. Moreover, what is the impact of biogas plant user on the other aspect of life?

The technical problem statement for this research study is:

"19.125 Million M3 biogas can be produced daily by anaerobic fermentation of dung through the installation of about 3.825 million family size biogas plants, in Pakistan."

1.3 The objective of the Study

The objective of the study is to test the impact of socio-economic indicator on livelihood with respect to a household who installed a biogas plant and who have not installed. Furthermore, this study seeks to examine the impact of socio-economic indicator on livelihood assets through farm productivity, saving, indoor air pollution, time-saving, and household sanitation.

1.4 Research Questions

Following are the key questions that are addressed in this study:

(i) Whether socioeconomic indicator has a significant impact on livelihood with respect to those who install biogas plant and who doesn't?

(ii) Do Farm Productivity, Saving, Indoor air pollution, Time-saving, Household Sanitation play a role in the social-economic indicator and livelihood assets?

1.5. The significance of the Research

Energy has become a prime necessity of modern day life. The renewable energy resources bring social economic development with no negative impact on environment and health are becoming more significant. These resources are very important to improve the social condition of people. The adoption of such resources required social acceptability,

support from society, economic viability and technical feasibility. The alternative energy resources are considered environmentally friendly for the present world. The biogas plant is one of this technology through which affordable energy can be supplied to rural areas in Pakistan.

Chapter 2

Literature Review

A literature review of biogas technology is presented in this chapter. In the first part of the chapter, history of the biogas technology is explained. The importance of biogas plants and its role to mitigate the energy crises and uphold the sustainable development is also discussed based on the assumptions of different studies. It also covers the factor affecting biogas production; its type and design are also reviewed in detail. A review of biogas development around the world and insight about biogas utilization and potential of biogas technology worldwide is also discussed in this chapter.

2.1 History of Biogas Plant

It is stated that biogas is used for heating at Assyria around 10BC but the literature does not support this claim. However, well-documented evidence shows that human usually uses biogas around mid-nineteen in China. 'Guorui' had built 8m^3 biogas plant. Later decade made accompany to popularize this concept. The first largest agriculture bio plant started working in 1950 but the technology started getting popularity after 1970 when the oil pricing started increasing. There was a shift in policymaker toward alternative energy.

With the passage of time, there is a rapid increase in installation of biogas plants while the efficiency of biogas plant is 20-56% but mainly it most dependent on how the plant is being operated. There are more than three billion people around the globe who are using solid fuel to meet energy need this fuel includes wood, animal dungs, agriculture reside etc. In Pakistan the first biogas plant was installed in 1974 in Sindh but not became successful due to gas leakages later on one gas plant is installed in Azad Jammu Kashmir. The benefits of biogas plant are immense it is widely acclaimed that biogas plant saves our resources and also gave us energy in a friendly way (Shahzad& Hanif, 2014).

2.2 Energy Crises in Pakistan

Shahzad and Hanif (2014) stated that country like Pakistan had to take different energy option e.g. biogas and wind energy because they are low cost and helpful for the poor. The huge dependence on imported fuel is one of the reasons for the weakness of economic development of Pakistan it got even worse when the prices of fuel are increases in the international market. The demand and supply gap of electricity is approximately 5000 -8000 Mw in Pakistan. It is increasing up to 6-8% per annum. So in order to reduce this gap, Pakistan had to rely on the source of renewable energy which includes solar, wind and biomass energy through which you can reduce your dependence on fossil fuel and increase distribution of your energy resources (Raheem & Abbas, 2016). Khurshi (2009) stated that Pakistan is facing worse energy and gas shortages and the gap between demand and supply is increasing, therefore, the government of Pakistan had to adopt load management system for electricity and for the supply of gas. As most of the energy development which is happening nowadays in Pakistan to reduce this gap is mostly on the basis of fossil fuel.

This energy is not only finite but also have a bad effect on the environment so to reduce the dependency on the fossil fuel we must adopting the sustainable and renewable form of energy.

2.2.1 Wind Energy.

It is estimated especially in Sindh that approximately 50,000 Mw of wind energy can be produced more over significant wind speed is recorded in different part of the country especially in some part of Baluchistan and some areas of KPK like Swat and some of the northern areas (Sheikh, 2010).

2.2.2 Solar Energy.

Solar energy is one of the significant types of renewable type of energy. Although solar energy can be extracted in both rural area as well as the urban area. Solar terminal and photovoltaic (PV) used to extract solar energy from the sun and convert sunlight into electricity through semiconductor devices called solar cells. (Asif, 2009). Sahir and Qureshi (2006) argue that Pakistan make itself ideal candidate for solar energy due to its geographical location and climate condition. The availability of 1900-2200 kW/m^2 of annual global irradiance makes Pakistan one of the leading candidate for solar energy.

2.2.3 Biomass.

Biomass is drive from plant animal and agriculture waste and you can use it for various purposes like cooking, heat, fuel, electricity mostly in rural part of the country region.it is consist of four different types of waste agriculture waste, animal waste, municipal solid waste, forest waste but mostly animal and plant waste are the main source of biomass (Sheikh, 2010).

2.2.4 Biogas.

Doggar (2011) absorbed that Pakistan is facing huge energy crises approximately 7000Mw shortfall is recorded which causing Rs242 billion per annum loss to our GDP. Bioenergy such as biogas can provide a solution to this problem, especially in rural areas.Biogas is considered one of the important alternative energy around the world especially in case of Pakistan where more than 60% people live in an urban part of the country and there work is related with agriculture and mostly possess livestock.

Meanwhile, Pakistan, where more than 60% of people live in rural areas the social impact of these plants, is very important. Not only these plants can improve the environment of the kitchen but also reduce the fuel consumption by up to 48%. It can also reduce the

working hour spending on the cooking. Bajgain and Shakya (2005); Tsai (2007) stated that biogas is the best suitable for sustainable and renewable energy and has positive and improving effect on the environment. Khurshi (2009) stated that biogas has also got the edge because most household in rural areas processed livestock traditionally in Pakistan cow dung is also used for energy purposes. Pakistan has the potential of developing small, medium, and large-size biogas plants. under the Clean Development Mechanism of the Kyoto Protocol, it not only reducing greenhouse gases effect. A family can also earn Rs 3,150/- per month so the programme is helpful in reducing poverty.

Biogas technology is highly advanced in China and India. More than 6 million plants and 950 units of the different category were installed in China. In case of Pakistan where 159 million cattle from which you can get 652 million kg manure that can produce 96 million m^3 biogas per day and produce 21ton of fertilizer.

Currently, the largest program of biogas is run by Rural Support Program Network (RSPN) approximately 2920 biogas plant installed by them up to 2013. There are many benefits of biogas plants apart from producing energy they can also use for income generation and beneficial for health, they can also improve kitchen environment reduce the cooking hour apart from these benefits most important benefit is that the overall impact on environment which is reduction in the greenhouses effects (Sajjad& Imran , 2014) while Amjid and Bilal, (2011) stated that Developing country like Pakistan is facing huge amount of energy crises, therefore, there is dire need to search different awareness through which sustainable energy can be produced.

For that biogas is become one of the better options for sustainable and renewable energy and through which Pakistan can reduce its spending on the import of fossil fuel .On the other hand not only a household can approximately save Rs92,026 annually while time

saving on cooking and better environment of kitchen lead toward better health. Ali and Zahra (2013) argue that Biogas technology is one of the technology which we can use as a renewable source of energy in rural part of the country now people are using cow dungs and wood to meet energy needs which is harmful to the environment as well as it causes deforestation, also cause health and social problem as well so biogas be best suitable fuel for rural areas.

2.3 Purpose of Biogas Plant

The main purpose of biogas plant is to use manure for compensation of environment and to minimize the risk from increasing energy prices of the fuel. While presently Pakistan which is facing a huge amount of energy gap between demand and supply of electricity and natural gas In Pakistan household uses 2325kg of firewood, 1480kg of dung (Sakhawat*et al.*, 2013).

2.4 Sources of Biogas Plant.

Animal waste, Wood, and agricultural waste are the energy sources for biogas but wood causes deforestation, therefore, it can't be used. Therefore, Biogas technology uses animal dung which is easily available in the rural areas. Agricultural residues are also one of the sources of biogas. Rice hulls, jute straws, water hyacinth, algae, bran leaves etc. can be used to produce biogas. While human waste is also used, but rejected, as mostly biogas is used for cooking purposes and people are not accepting this resource for cooking. While on the other hand human waste is not easily collected.

Following gasses are emitted in the process of biogas. As shown in Table 2.2

The composition of Biogas Table 2.2

Gasses	Percentage
Methane (CH)	50-75%
Carbon dioxide (CO)	25-50%
Nitrogen (N)	0-10%
Hydrogen (H)	0-1%
Hydrogen Sulphide (HS)	0-3%,
Oxygen (O)	0-2%

Source: Sakhawat and Naseem, 2013

2.5 Size and Cost of The Biogas Plant

Depending on the size of the livestock present in the house most of the plant consists of 8m3 three buffalo requires, for 10m3 four buffalo requires and 20m^3 six buffalo and its cost approximately R.s 65000 to 140000 and it is also estimated that most of the investment is recovered in 15 months (Khurshid, 2009).

2.6 Effect of Biogas on Livelihood

Biogas increases 31% of income due to which their livelihood also improves. Subedi and Adhikari (2015) stated that biogas slurry which we use as a fertilizer can also be a sale in the market or use for your land which increases income which had a positive effect on the livelihood of any household. By using biogas, you can give more opportunity to other poor people in the community that they can use traditionally a source of energy. On the other hand,

how, biogas effect the livelihood of women, empower them and their relationship with households. While Biogas is one of the alternative rural programs for proving sustainable renewable energy, which had a positive effect and improves the livelihood of millions of people living in Africa (Heegde & Soder, 2007).

Panta and Lee (2009) try to explain to increase the livelihood of the people living in the rural areas government had to make policies through which reduction in poverty and increase in education has been possible and also the dependence of energy for cooking and for heating is reduced on natural resources like cutting of forest, for that government must give subsidies to the people living in rural areas for alternative resource of energy like biogas through which the deforestation can be reduced and living standard and livelihood of rural people can improve. While on the other hand a significant amount of effect on people lives in rural areas when the traditional type of energy subsidies with modern fuel.

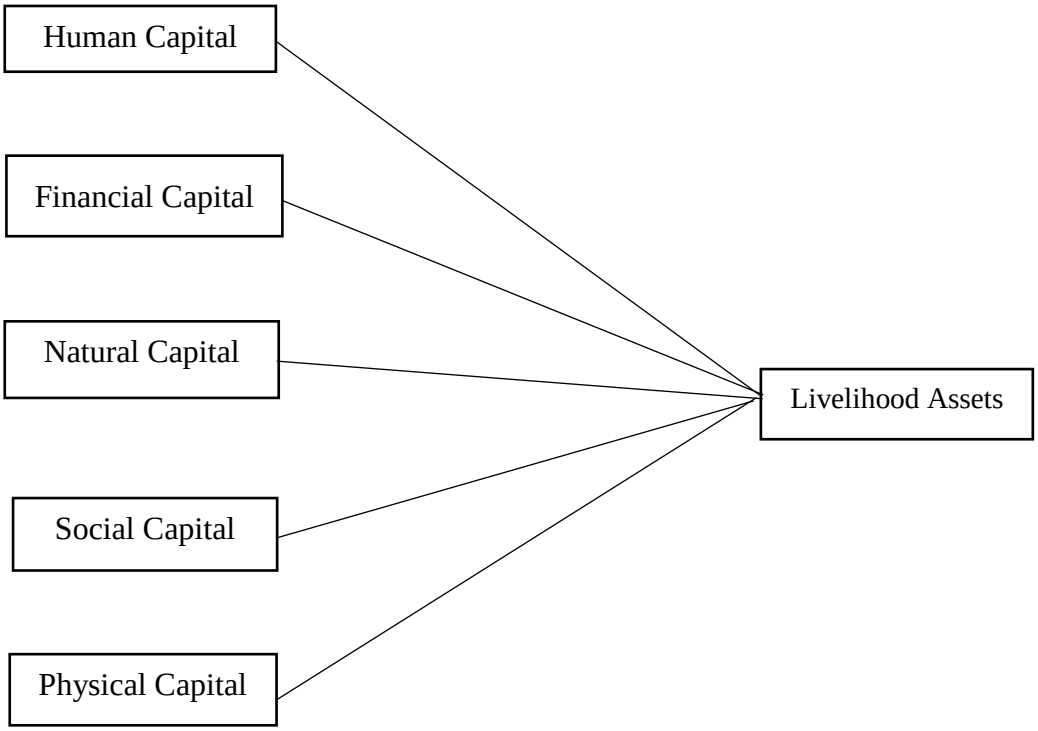
The option of renewable energy can change the livelihood of the people especially the children and women it can reduce their time on cooking and reduce the time for collection of firewood and use this time for other activities like education and improve their health so government must subside those renewable sources of energy which are viable for rural community and biogas plant is the best suitable for that purpose.

2.7. Type of Livelihood Asset

The livelihoods framework is a tool to improve our understanding of livelihoods, particularly the livelihoods of the poor. As the livelihoods approach is concerned primarily with people, it seeks to gain an accurate and realistic understanding of people's strengths (here called "assets" or "capitals"). It is crucial to analyze how people endeavor to convert these strengths into positive livelihood outcomes. The approach is founded on a belief that people require a range of assets to achieve positive livelihood outcomes. Therefore, five types

of assets or capitals are identified upon which livelihoods are built, namely human capital, social capital, natural capital, physical capital and financial capital.

Figure 1: Types of livelihood assets.



Source: DFID ,2000.

Human capital: Household member, active labor, education, knowledge, and skill.

Financial Capital: Saving, Income, Credit, and Insurance.

Natural Capital: Access to land, forest, water, cropping.

Social Capital: Group membership, social political influence.

Physical Capital: livestock, Equipment, vehicle, House, Irrigation pumps.

2.8.Benefits of Biogas Technology

Biogas plant includes different types of economic, social, and environmental benefits at a different level from national level global level. Economic benefits include job creation and increase investment in income generation activity. Social benefits include better education, health, and better sanitation system (SNV, 2010) and environmental benefits includes a reduction in deforestation and in GHG effect and reduce climate change effect (Bajgain & Shakya ,2005).

2.7.1 Economic Benefits.

Biogas had a tremendous effect it is estimated that approximately Rs3150 can save up to the plantation of one biogas plant which also the time, cost of wood fuel, LPG, and includes the reduction in the health bill. The introduction of biogas plant replaces more embryonic fuel due to which it reduces the fuel cost for household (Bajgain& Shakya, 2005; Takara, Jasinki & Khanal, 2013)

2.7.2 Health Benefits.

Energy fuel for cooking and heating and for lighting, increase indoor air pollution play a major role in increasing the respiratory infection in children chronic obstructive pulmonary disease and lung cancer (Bruce Parez-Padilla & Albalak, 2000; Pokhrel *et al*., 2010; Smith,Samet & Bruce 2000). Per world health organization more than 1.6 million death is due to indoor smoke and rank fourth among risk factor contributes to the burden of disease in developing country (Ezzati & Viegi, 2008). In this context, use of biogas plant has a positive impact on the health of its user. Biogas use as cooking fuel reduce the smoking in the kitchen and improve indoor air quality (Kutuwal & Bohara, 2009). Respiratory particles are low in biogas (0.25mg/m^3). Kutuwal and Bohara (2009) stated that asthma, eye infection, and lungs problem has decreased sharply after installing biogas plant.

2.7.3 Environmental Benefits.

The most important benefit of regarding environment is that it can reduce the deforestation which is calculated approx. $0.52m^3$ per annum, its reduced greenhouses effect and used for fertilizer which can increase the yield of the different crop while it can also increase the soil moisturizer, soil texture, and improve organic food. Dhingra *et al.,* (2001) stated that that household who had installed biogas plant emits 54% less global warming obligations as compared to those who had not installed the biogas plant, a rural household with biogas reduce 4.5 tonnes of CO_2 emission by reducing the use of firewood and kerosene oil (natural & Bohara, 2009).

2.8. Biogas Plant Design

There are three types or model of the plant which are mostly installed all around the word

I. Balloon plants

II. Fixed some plants

III. Floating-drum plants

2.8.1 Balloon Plants

A balloon plants in which upper parts at which gas is stored and it consists of rubber or plastic bag while the slurry inlay and outlet are directly attached to the upper part of the balloon skin. Because the balloon is not so much elastic and not have a huge size so when it is filled with gas it works like fixed doomed plant different feed material such as water hyacinths are used in balloon plants while on the other hand, the material for the balloon plant must be UV-resistance.

Advantages: easy construction, low cost, ease of transportation, easily maintained, uncomplicated cleaning

Disadvantages: Easily damage, short life (max 5 years), less scope for creating employment.

2.8.2 Fixed Dome Plants

Fixed dome biogas plant is mostly constructed in China, Nepal, Vietnam. These plants consist of the fixed digester and non-moveable holder which place on the top of the digester when gas production start the slurry move into compensation tank while the gas pressure increase while the increase in the volume of gas.

Advantages: low installation cost, long life of the plant (20 years), no rusting and moving parts involved, save space and inception construction types employment

Disadvantages: High technical skill is required for construction, gas linkages occur frequently, low gas production, gas extraction decreases with the interval of time due to scum development, finally it is stated that fixed dome plant are recommended where experience supervisor can supervise these plants

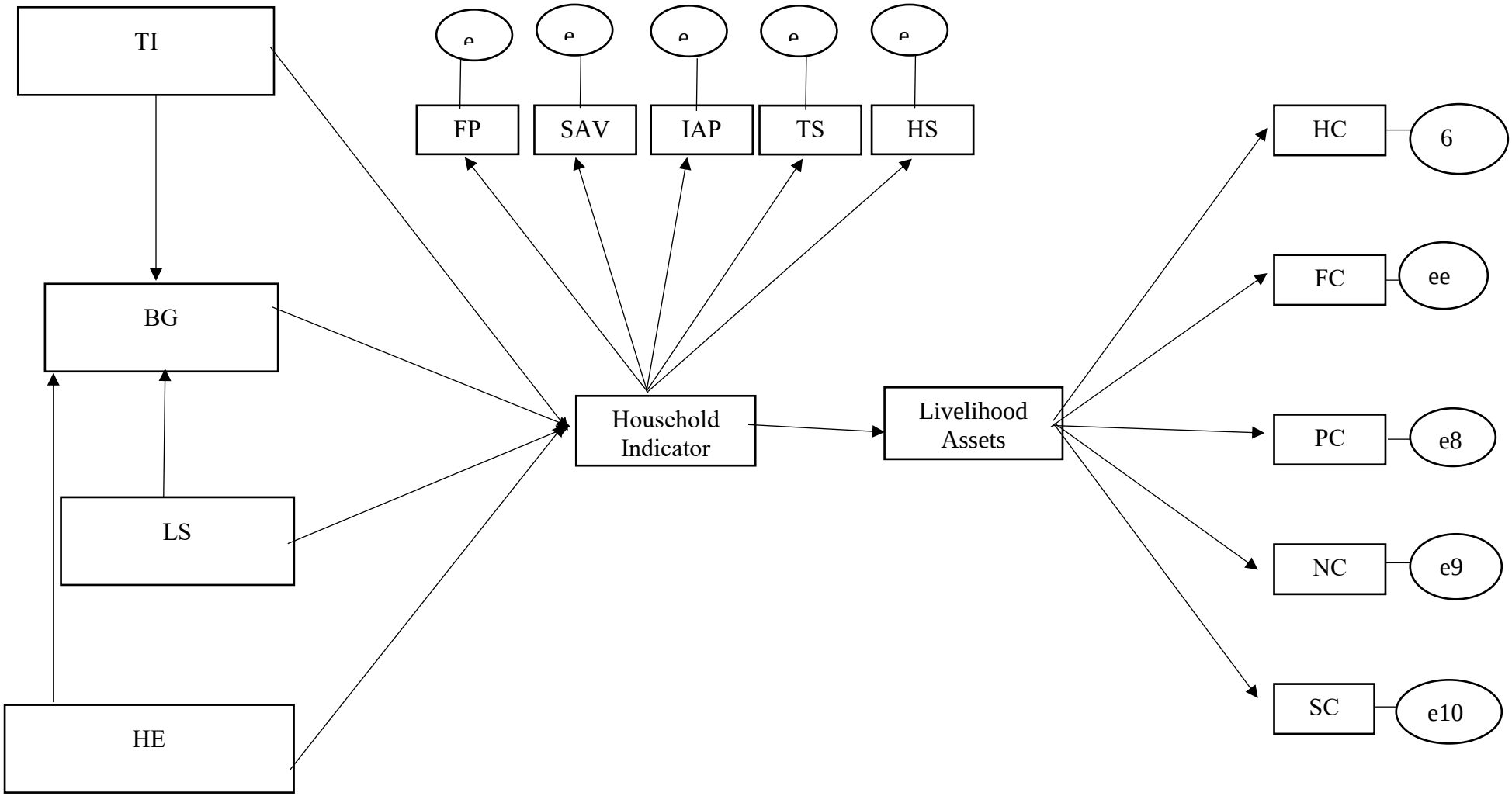
2.8.3 Floating Drum Plants

Floating-drum plant is mostly constructed in India and Pakistan. And had underground digester and moving gas holder. while the gas holder is floating on slurry or water jacket of its own. While the gas is stored in the gas drum which can be moved upward or downward per how much gas stored in the drum. While the gas drum is preventing from tilting through the guided frame. Because if drum float in water even if there is high solid content it cannot stick to it.

Advantages: easy to construct, constant gas pressure, storages gas easily visible, simple, and easy to understand

Disadvantages: Painting and rooming rust are to be maintained regularised drum are expansive, the life drum is short especially in the tropical coastal area is approximately 5 years.

Theoretical paths are shown in the diagram below: **Figure 2.**



Chapter 3

Definition of Technical Terms and Research Methodology

The focus of this research study is to check the socio-economic impact of biogas plant on the livelihood of people in two Tehsils of District Sargodha i.e. Sahiwal and Sillanwali. This chapter consists of topics related to technical information about the biogas plants. It explains the definitions of the key terms used under this model as input and output indicators. It explains the research methodology adopted for this research including sample size formulation and data analysis tools.

3.1. Model and Estimation Techniques

To establish the link of variables affecting livelihood, a number of input and output variables are selected. The purpose is to compute the significance of biogas plant on the livelihood of the people in select areas of District Sargodha. It is well established that social impact of biogas plant on the livelihood of people is a key focus of this study. To prove this connection of livelihoods and role of Biogas plant, structure equation model is used as an estimation technique in this study.

3.1.1. The justification for the Structural Paths

SEM is used to analyze the relationship among the variables, having complex and diverse orientation. For example, the use of biogas plant saves money and this saving causes an increase in educational expenses and improvement in health simultaneously. “Structural equation model (SEM) is a set of equations that can be applied to experimental and non-experimental data. This equation can be applied in all fields of psychology, marketing, and social sciences etc. It is a set of simultaneous equations which is useful for observed and unobserved variables” (Rex B. Kline 2011). Most of the researchers adopted this technique to

measure the impact of some program (like Arshad, 2014). “SEM technique is a widely used technique for estimation.

3.1.2. Specification of Variables

To assess the social impact of biogas plant on the livelihood of people, following variables are considered in this study.

3.1.3. Exogenous variable.

i. Biogas plant (BG)

This is dummy variable taking value “1” for a household who owns biogas plant and “0” for those who does not have biogas plant.

ii. Total Income(TI)

This income includes farm income and non-farm income in term of rupees.

iii. Livestock(LS)

This variable includes a total number of cattle, buffalo, and goats owned by the household. It includes those animals who gave milk and those who don’t and calculated in term of number as well as in terms of rupees.

iv. Highest Education in the family(HE)

This variable shows the higher education of the person in the household. In term of the year of schooling.

3.1.4. Household Indicator Variables

i. Saving(SAV)

SAV calculated through saving on fuel expenditure per month in term of rupees.

ii. Farm productivity(FP)

This variable is measured by income from farm yield per acre per year.

iii. Indoor Air Pollution (IAP)

This variable is measured by data about diseases that spread from air pollution. If the person visited hospital due to this disease, then value “1” and “0” otherwise.

iv. Time-Saving (TS)

This variable includes time saved in term of hours from collecting firewood, in kitchen and livestock caring.

v. Household Sanitation (HS)

This variable is measured by different indicators, relating to biogas as mosquito breeding, the increment in flies, smoke due biomass.

3.1.5. Endogenous Variables (livelihood Assets).

i. Human Capital (HC)

This is output variable. It calculated the number of children getting an education under the under the age 25.

ii. Financial Capital (FC)

This is also output variable. It is calculated by saving expenditure in term of rupees coming from the installation of biogas plant.

iii. Physical Capital (PC)

This is output variable. It includes the current value of assets in term of rupees that a household possesses.

iv. Natural capital (NC)

This is output variable. It is calculated on the basis of per capita area of cultivated land after using bio-slurry by a household.

v. Social capital (SC)

This is output variable. It is calculated by either they are part of an NGO or not if yes then the value "1" otherwise value ''0". It is used in medical estimations to deal with latent variables issues" (Emil Kupek, 2006).

3.2. Profile of District Sargodha

Sargodha has seven Tehsils. These tehsils are Sargodha, Sillanwali, Shahpur, Kotmomin, Bhalwal, Sahiwal and Bhera. Sargodha is located 172 kilometers northwest of Lahore. It is roughly 94 km from Faisalabad, due southeast. The city of Jhang lies in its east. The city of Mianwali and the Chashma Barrage are located in its west. Sargodha comprises fertile and flat plains. There are a few small hills on the Sargodha-Faisalabad Road. The River Jhelum flows on the western and northern sides, and the River Chenab lies on the eastern side of the city.

The city has a climate of extreme heat in the summers and moderate cold in the winters. The maximum temperature reaches 50 °C (122 °F) in the summer while the minimum temperature recorded is as low as freezing point in the winter. In Sargodha, the Beetal goat is a meat goat breed that is found in Sargodha district in Punjab Province, Pakistan. The Livestock Population from 9211 system are large animals 1182304, Small animals 943882 and Poultry 115751[1].

3.3. Sampling Framework

The top districts of the Punjab Province with respect to the availability of livestock are selected. Out of these five districts, Sargodha is selected using simple random sampling technique. To narrow down the geographic scope of the study, two tehsils i.e. Sahiwal and Sillanwali are selected out of the seven tehsils of District Sargodha. To survey more tehsils

[1] http://www.livestockpunjab.gov.pk/page/page_detail/district_profiles/59

have had more value but the availability of resources did not allow doing this. However, since all of the tehsils had agriculture areas, so the overall findings can be generalized in a wider context.

A representative sample of district Sargodha i.e. tehsil Sahiwal and Sillanwali, with confidence level 95% and confidence interval of 10 points [2] is calculated. The 70 household who had installed biogas plants were selected. The probability sampling was applied in this study for sample size and for sample design at household survey level to get the data with minimum error. It allows any household who had installed biogas plant be selected.

3.4. Household Survey

A household survey is conducted. A survey questioner is used to elicit a response from the respondent. In social research, the household survey has become a key method to collect data (O'Leary, 2013). It may be in the form of structure and semi-structured form to collect data. A survey can be defined as a collection of data by asking different people same question about, a way of living, character, and qualities (O'leary, 2013). Neuman (2002) stated that survey is useful when you are collecting data from a large number of individual and independent responses are required.

The aim of the survey in this study is to get to know the socio-economic impact of biogas plant on the livelihoods of people. A comparative analysis is conducted between those people who had installed biogas plant and who did not install biogas plant. It is examined how much biogas plant is effective in reduction in energy consumption and environmental emission. Considering the wide range of information collected from the survey, this study is helpful in policy reform in future.

[2] Sample size estimated from: www.surveysystem.com/sscalc.htm#one

3.5. Data Analysis

The data collected through HH survey in the form of structured and semi-structured questionnaires is treated as the quantitative data. The responses from the HHS survey were codified accordingly. A Structure Equation model (SEM) is used to test the proposed relationships to estimates the impacts of the Biogas plants on the livelihoods of the people in District Sargodha.

3.6. Limitation of the study

This study is conducted carefully keeping in mind the consideration and intended objectives of the research. Therefore, it has some limitations. The research comprised of quantitative approach and all the results are based on the response of HH representatives subject to designed structured and semi-structured questions. The qualitative aspects of the views of the respondents about the likely benefits and associated risk are not documented here. There were also time and resource constraints as well. The study is limited to only two Tehsils of Sargodha District out of its seven Tehsils.

Chapter 4

Results and Discussions

This chapter contains the results of estimations and their interpretations used to measure the socio-economic impacts of domestic biogas plants in the study area. The results are discussed in respective order of equations in the chapter. SEM adopted to estimate the impacts of the biogas plant on the socio-economic condition of the people in the select area. The results are discussed in two sections. First, the interpretation of estimated calculation of that household who installed biogas plant and the second section contains the comparison between that household who installed biogas plant and who have not installed.

4.1. Demographic Analysis

The demographic analysis required a set of methods that are usually used to measure the aspects and dynamics of the population. This study consisted of total 140 respondents. Convenient sampling was used for the collection of data. The size of the sample is better five times of the items Davis (2005) as per Davis saying the target sample size of the current research is significantly enough. 'Gender' pie chart shows that 111 out of 140 were male i.e. 79% of the respondents, rest were female i.e. 29 out of 140 i.e. 20% of the respondents. It shows that majority of respondents were male. Therefore, it can be concluded that the majority participants were male (figure 3).

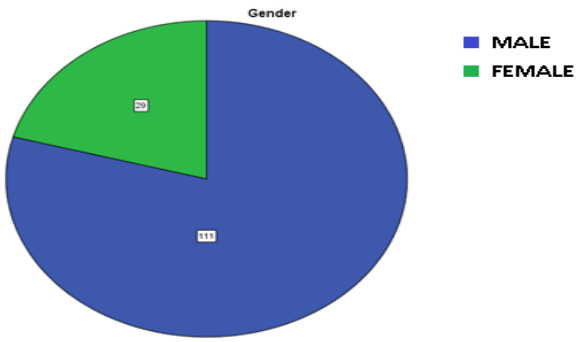


Figure 3: Gender Distribution Table.

The ‘Residence’ pie chart shows the where most of the household live the respondents 85 out of 140 i.e. 65% of the total respondents lives in villages, where 42 out of 140 i.e. 30% of the total respondents lives in farm or at Dera, 8 out of 140 i.e. 5% lives in both at villages as well as at Dera/farm (figure 4)

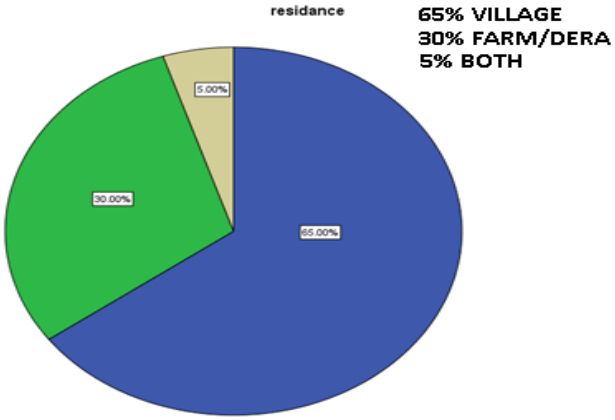


Figure 4: Residence of household

The household (figure 5) type pie chart shows what types of the house of the respondents. 75 out of 140 i.e. 53% household live in a pucca house where 62 out of 140 i.e. 44% lives in the houses which are both Kucha as well as pucca where 3 out of 140 i.e. 2% lives in Kucha houses (figure 5)

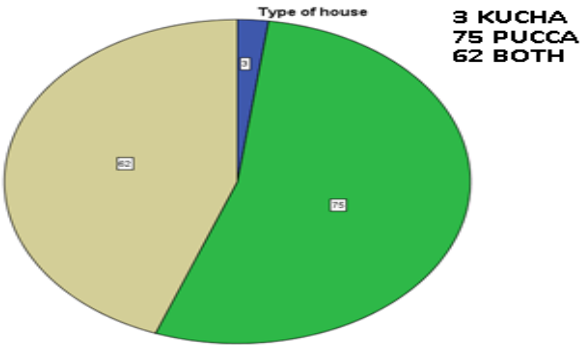


Figure 5: House Type

The Table 1 accounts that 11 out of 140 i.e. 7.9% respondents participated are ranging between 25 to 30 years, 18 out of 140 i.e.12.8% of the respondents fall between 31-35 years, 24 i.e. 17.4% of the participants from the age group between 35 to 40 years, 34 i.e. 24.2 from

the age group between 41 to 45 years and 23 out of 140 i.e. 16.4% were from the age group 46 to 50 years. The remaining are 30 are from 51 to above. So, it is absolved that most of the respondent are above 45 years of age.

The qualification of the respondents that 56 out of 140 i.e. 7.9% of the total respondents are illiterate, where 33 out of 140 i.e. 12.8% of the total respondents got primary education, 31 out of 140 i.e. 22.1% of the total respondents got secondary education, where 16 out of 140 i.e 11.4% got intermediate education and the remaining 4 out of 140 i.e. 2.8% respondents of the total respondents are got graduation or master degree. Majority of participants were having no education or primary education.

The income of the respondents is as follows 217 out of 679 i.e. 32.0% of the total respondents are earning below 20000, 158 out of 679 i.e. 23.3% of the total respondents are earning between 21000-30000, 118 out of 679 i.e. 17.4% of the total respondents are earning between 31000 to 40000, 71 out of 679 i.e. 10.5% of the total respondents are earning between 41000-50000 and the remaining 115 out of 679 i.e. 16.9% of the total respondents are earning either 51000 or above. The result showing that income of majority participants was below 20000.In this research, the researcher also gets the information about the occupation of the respondents. So, the above table also shows the ratio of the respondent's occupation. 88 out of 140 i.e. 62.9% of the total respondents were work on agriculture field, 44 out of 140 i.e. 31.4% of the total respondents were skilled labor whereas the remaining 8 out of 140 i.e. 5. % of the total respondents were businessmen or they got remittances. Most of the respondents of the study were work in their field (Table 1).

Table 1: Demographic Analysis of Respondents			
		Frequency	**Percentage**
Gender	**Male**	111	79
	Female	29	20
Age	25 to 30	11	7.9
	31 to 35	18	12.8
	36 to 40	24	17.1
	41 to 45	34	24.2
	46 to 50	23	16.4
	51 to 55	15	10.7
	56 to above	15	10.7
Qualification	Uneducated	56	40
	Primary	33	23.5
	Secondary	31	22.1
	Intermediate	16	11.4
	Graduation/Master	4	2.8
Income	Below 15000	25	17.9
	15001-20000	20	14.4
	20001-25000	35	25
	25001-30000	21	15
	30001-35000	20	14.3
	35001-above	19	13
Occupation	Agriculture	88	62.9
	Business	5	3.6
	Skilled	44	31.4
	Remittances	a 3	2.1

4.2. Correlation of Biogas with livelihood variables

Correlation is a representation of the linear relationship between two variables. It ranges from 0 to 1. The more the value of , the correlation for two variables is close to 1 the more their relationship is strong, positive, and significant and the more the value moves towards 0 the more the relationship of those variables is negative and weak.

Correlation Matrix (table 2) between biogas and Total income was (r=.527, p< 0.01) show a significantly positive association between biogas and total income. Likewise, the correlation between biogas and livestock (r=.518, p< 0.01) confirmed a significantly positive association between biogas and livestock. Similarly, the correlation between total income and livestock was (r=.718 p< 0.01) showing a positive association between total income and livestock. Likewise, the correlation between household sanitation and biogas is negative but significance (r=-.324, p< 0.01) was depicting strong relationship among both of them.

It is depicted that those who installed biogas plant has less household sanitation problem. The correlation between financial capital and biogas was (r=.07, p< 0.01) signaling the significant association between financial capital and biogas. Likewise, the correlation coefficient between natural capital and total income was (r=.721, p< 0.01) showing significant relation. Similarly, the correlation coefficient of total income and farm productivity was (r=.407, p< 0.01) depicts significant association between financial capital and biogas. In the same way correlation coefficient between indoor air pollution and biogas are significance (r=-.23, p< 0.01), but showing a negative association, which show that biogas plant reduces indoor air pollution. To test the issue of multicollinearity collinearity diagnostics test is used. In collinearity diagnostics, VIF is estimated. The value of VIF ranges between 2.068 to 1.000 which is less than the recommended value of 4 (O'brien, 2007). So, the collinearity diagnostics indicated that there is no issue of multicollinearity.

Table 2: Correlation matrix.

	TI	BG	LS	FP	IAP	NC	HS	HC	FC	SAV
TI	1									
BG	.527**	1								
LS	.718**	.518**	1							
FP	.407**	.0.13**	.437**	1						
IAP	.447**	-0.23**	-0.01	0.01	1					
NC	.721**	.580**	.520	.520**	.520**	1				
HS	-.360**	-.324**	-0.07**	0.05	-0.18	-.253*	1			
HC	.291*	.310**	0.01	0.15*	-0.06	0.05	-0.20	1		
FC	.470**	0.07**	.238*	.450**	0.20	.438**	-.408**	0.08	1	
SAV	.342**	0.08**	0.19	.476**	-0.03	.315**	-0.22	0.03*	.701**	1

**. Correlation is significant at the 0.01 level(2-tail).

*. Correlation is significant at the 0.05 level(2-tail).

4.3. Structure Equation Modelling (SEM)

The proposed relationship was checked by using structural equation modeling (SEM). The determinants of Livelihood assets have significant factor loads i.e. HC = .661*, FC = .562*, PC =.711**, NC =.621**, SC = .741*. Similarly, Household indicators also contain significant factor loads i.e. FP = .723**, SAV = .651**, IAP =.571**, TS =.691**, HS = .587**. In Table 3 the results of SEM are shown. According to the result, TI has a positive and significant influence on BG (β=.527, $p< .05$). Likewise, LS positively and significantly impact the BG (β=.029, $p< .05$), which provided support to the relationship. Furthermore, HE signifies positive influence on BG (β=.518, $p< .05$). Further, TI has positively and significantly exerted on household indicator (β=.217, $p< .05$). Additionally, BG has a positive and significant impact on household indicator (β=.363, $p< .05$). It depicts that the results are in the favor of this relationship.

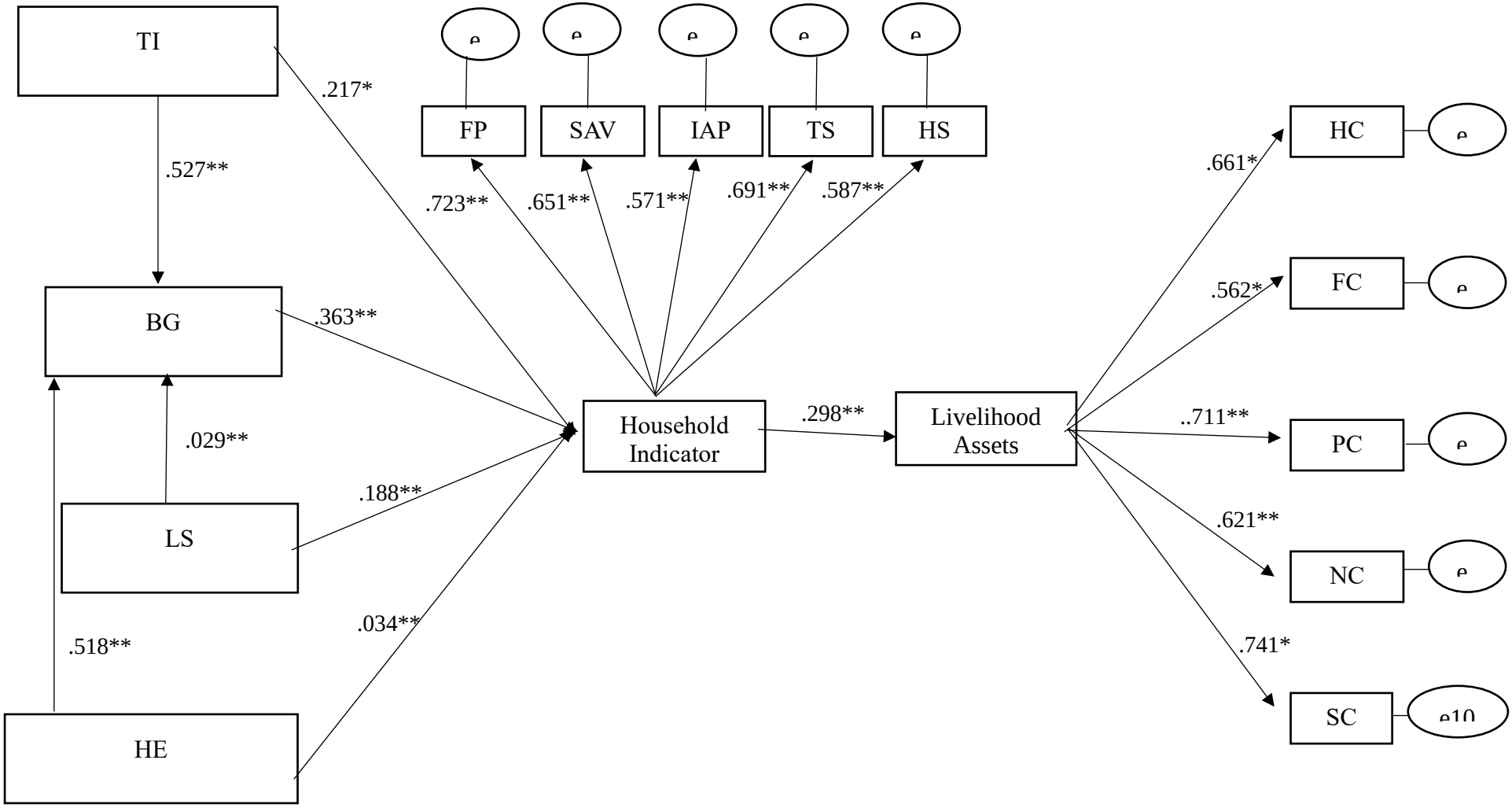
On the other hand, LS has a positive and significant impact on household indicator (β=.188, $p< .05$), results has supported the relationship. Besides, HE positively and significantly influences the household indicator (β=.034, $p< .05$). Additionally, the household indicator has positive and significant stimulation on Livelihood Asses (β=.298, $p< .05$).In accordance with the results, all the relationships are significantly supported.

Table 3.
Structural Path.

Path	Beta Coefficient	Sig Value
TI → BG	.527	**
LS → BG	.029	**
HE → BG	.518	**
TI →Household Indicator	.217	*
BG → Household Indicator	.363	**
LS → Household Indicator	.188	**
HE → Household Indicator	.034	**
Household Indicators → Livelihood Assets	.298	**

Note 1: *** $p < 0.01$, * $p < 0.05$*
Note2: TI=Total Income, BG= Bio Gas, LS=Livestock, HE=Higher Education

The theoretical path is shown in the diagram below: **Figure 6.**



4.4. Comparison of the mean value to illustrate the difference between two samples.

Keeping in view the objectives of the study, it meant values of study variables are depicted in Table 4. The results regarding TI showed that average income of the household with biogas plant is 25000 and without biogas, the plant is 20000, indicating that household with biogas plant has a higher level of income. The result regarding LS shows that average household with biogas plant possess six livestock animals and without biogas plant possess two livestock animals which indicate that household with biogas plant possesses more animals than who do not have biogas plant. Furthermore, results for education showed that those household who install biogas plant are more educated 'Intermediate level' and those who do not installed the plant have 'Matric level' education.

For the result regarding FP, those who installed biogas have average FP income of R.s 200000. The average farm production income without biogas plant is R.s 150000. It revealed that farm production of household with biogas plant is relatively higher than those who don't have biogas plant. The result regarding SAV showed that household who installed biogas plant save R.s 6000 and those who do not install biogas plant save R.s 800. It indicates that saving increases by R.s 5200 for those who install biogas plant. The result regarding IAP shows that those who install biogas plant visited the hospital once a year whereas those who do not install biogas plant visited hospital thrice a year. It indicates that those who installed biogas plant have less indoor air pollution compared to household having no biogas plant have more indoor air pollution.

Whereas results for TS shows that, that household who installed biogas plant spend 30 min on livestock care. Those who do not install plant spend 3 hours for collecting woods for burning. Therefore, a household with biogas plant is saving a significant amount of time as compared to the household without biogas plant. Furthermore, a result related to HS shows

that those who install biogas plants have good sanitation system while those who do not installed plant have bad sanitation system.

Result also revealed that for HC mean value is same for both so there is no significant difference between these two effects by those who installed biogas plant or not. While result show that average FC increase by R.s 6000 for those household who installed biogas plant while those who does not installed biogas plant spend extra R.s 1500 which indicate that saving increase by R.s 7500 for those who install biogas plant and The result regarding PC shows that average PC is R.s 150000 for those who installed biogas plant and R.s 100000 for those who are without biogas plant, showed that household with biogas plant have Rs50000more than who have not installed biogas plant. Furthermore, NC of both household is same, indicating that there is no difference between both households. Whereas for SC, a household with biogas plant is 1 and without biogas plant is 0, indicating that household one unit more SC than a household without biogas.

Table 4.
Comparison of study variables between Household with Biogas and Household without Biogas.

	With biogas	Without biogas
TI	R.s 25000	R.s 20000
LS	6	2
HE	Intermediate	matric
FP	200000 annually	150000 annually
SAV	R.s 6000	800
IAP	1	3
TS	30 min	3 hours
HS	2	4
HC	3 children	3 children
FC	R.s 6000	R.s -1500
PC	R.s 150000	R.s 100000
NC	12 acres	12 acres
SC	1	0

Note 1: TI, FP, FC, SAV, PC= Amount in rupees
Note 2:LS the =Number of a livestock animal
Note 3: HE=Matric, Intermediate, Graduation
Note 4: HC=Number of children going to school
Note 5:TS=Minutes/Hour
Note 6: HS, IAP= (1) Very Good, (2) Good, (3) Normal, (4) Bad
Note 7: NC=Cultivated land area in acres

4.5. Analysis and Discussions

This research examines the impact of Biogas on Household indicators and Livelihood assets and comparison among Household indicators and Livelihood assets of households with Biogas plant and without Biogas plant. The results revealed that people with higher income level are more inclined towards the installation of Biogas plant because they have higher buying capacity and can buy Biogas plant easily. Results regarding the relationship between Livestock and Biogas showed that households with a greater number of Livestock at home have higher tendencies to install Biogas plant. The reason behind this fact is that household with a greater number of Livestock has a higher amount of waste material for the production of biogas. Meanwhile, the relationship between Higher Education and Biogas showed that as Higher Education increases tendencies to install Biogas plant also increase because educated people have more information about farming, available opportunities, and modern techniques.

From the result, it can be comprehended that Total Income positively contributes towards Household indicators. These results indicated that as Total Income Increases Farm Production also increases. Farmers with higher Total Income level have more resources to purchase seeds and fertilizers which yields higher production level of the farm. For Total Income and Saving, the result showed that people with increased Total Income are Saving more, a significant amount left after spending to meet expenditures. Furthermore, the relationship between Total Income and Indoor Air Pollution indicated that as the income increases people move towards LPG or biogas plant which resulted in reduced dependency on traditional usage of burning fuel e.g. wood or dungs, so air pollution reduces. For the relationship between Total Income and Time Saving showed that as income increases people buy better technological equipment which results in saving their time which they spend with their family and friends. For Total Income and Household Sanitation, results showed that

household with a higher level of income level are more inclined to install proper drainage systems for sanitation problem and are dealing sanitation problems in a better way.

For Biogas and Farm Production, the result indicating that people with Biogas tend to get more farm production because of use of bio-slurry which is a by-product of biogas plants as a fertilizer. Furthermore, result related to biogas and Saving show that people with Biogas tend to have more saving because of using of Biogas plant 'gas' as compare to LPG or fire woods so their expenses related to fuel is reduced. Whereas Biogas and Indoor Air Pollution are indicating that Biogas and Indoor Air Pollution has a positive relation, the reason behind this fact is that installation of Biogas yield gas for cooking which resulted in reduced smoke in the kitchen which were previously generated by burning woods and dungs.

Meanwhile, for the relationship between Biogas and Time Saving the result show that as those people who install Biogas plant are saving time as now they do not have to collects or buy the wood which they previously used for burning. For Biogas and Household Sanitation show that those household who installed Biogas plant are using better drainage systems and are holding a higher level of the improved sanitation system. For the relationship between Livestock and Farm Production, the result showed that people with more Livestock are getting more Farm Production because they have more solid waste material which is using as fertilizer and increasing their farm production.

For the relationship between Livestock and Saving, the result showed that household having a greater number of Livestock are Saving more money. At one hand their Livestock provides them profits by selling milk and related products, on the other hand, they are using the solid waste material in Biogas plant gas as replacement of LPG and firewood which is also resulted in reduced expenses. Furthermore, the relationship between Livestock and Indoor Air Pollution are positive and results showed, that Indoor Air Pollution is reduced by

using livestock's waste material in a biogas plant. which are also resulted in a reduction in dependency of household on firewood and dry dungs which were causing indoor air pollution. Moreover, Livestock and Time Saving showed a positive association indicating that by using the solid waste material in a biogas plant, Household are saving time which previously they were spending on drying the dungs and then use it as cooking fuel. For Livestock and Household Sanitation the study shows the positive relationship as a solid waste material which is extracted from animals and used in Biogas plant, converted solid waste into bio-slurry which used fertilizer.

For Higher Education and Farm Production, the result inclined that the relationship is positive and showed that people with Higher Education tend to get more Farm Production because educated people have more information and a better understanding of harvesting. For Higher Education and Saving the result inclined to show that higher educated people have more saving because they can manage their household budget in an effective way and have a better understanding of how and where to invest. Furthermore, the relation of Higher Education and Indoor Air Pollution is positive, because educated people have better knowledge of health issues caused due to pollution. For Higher Education and Time Saving also show positive relation because educated people manage their time more effectively and efficiently. For Higher Education and Household Sanitation, the study show positive relationship as educated people has better knowledge of the effect of bad sanitation system due to which they take care of themselves more often.

Furthermore, results revealed that Household indicators have a positive effect on Livelihood Assets. The higher Farm Production, Saving, control over Indoor Air Pollution, Time Saving and Household Sanitation are the indications of better Household. The higher Farm Production yield in higher Livelihood Assets (i.e. HC, FC, PC, NC, SC). The increased farm production resulted in higher income level which escalated Human Capital because a

household with higher income level send more children to school for better education so, Farm Productivity increase Human Capital. Furthermore, higher Farm Production is also resulted in higher level of Financial Capital, as the Farm Production increase household have more money and their saving increases. Similarly, Higher Farm Production results in higher Physical Capital as Farm Production increase household buying power increase and they purchase more. Likewise, higher Farm Production resulted in higher Natural Capital as Farm Production increase, income level also increases and household buys more cultivated land to increase their assets. Furthermore, higher Farm Production and Social Capital have a positive relation to agricultural production enhance, social relationships are promoted in sustainable and conscious manner and reinforce relationship among people, and their communities.

On the other hand, Saving yield in better in higher Livelihood Assets (i.e. HC, FC, PC, NC, SC). Higher the Saving level higher the Human Capital because a household with higher Saving sends children to the better educational institution. Furthermore, Saving also resulted in higher level of Financial Capital, as the Saving minimize expenses. Similarly, Saving resulted in higher Physical Capital as Saving reduce expenditure and increase buying power. Likewise, higher Farm Production resulted in higher Natural Capital as Farm Production increase, income also increases and household buys more cultivated land to increase their assets furthermore, Saving and Social capital has positive relation and promoted sustainable manner relationship among people, and their communities.

The Indoor Air Pollution yield in higher HC, FC, PC, NC, SC because as Indoor Air Pollution decreases air quality increases and children are less exposed to smoke which related in eyes and throat diseases so Indoor Air pollution has positive effect with respect to Human Capital as if household is healthy they do not have to visit hospital frequently which resulted in save money and increase Financial Capital. Furthermore, decrease in Indoor Air pollution result in less disease separation and increase household saving which resulted in increased

purchasing power with respect to Physical and Natural Capital. On the other hand, Indoor Air Pollution resulted in better Social Capital because friends and family tend to sit together because of better Indoor air quality.

The Time-Saving yield in higher HC, FC, PC, NC, SC because due to Time Saving children who first collect firewood has now more time and they concentrate more on a study which increases Human Capital whereas household use this time for income generation which increases their Financial Capital. Furthermore, utilizing Time-Saving for income generation activities enhance purchasing power for Physical and Natural Capital. Social Capital and Time Saving are positively related as people have more time they interact more with the society and play an active role in the community.

The Household Sanitation yield higher HC, FC, PC, NC, SC because as good Sanitation system decreases diseases and has a positive effect with respect to Human Capital. Furthermore, if the household is healthy they do not have to visit hospital frequently which resulted in save money and increase Financial Capital. Moreover, better Household Sanitation results in less disease separation and increase household saving resulted in increased purchasing power with respect to Physical and Natural Capital. On the other hand, better Household Sanitation resulted in better Social Capital because friends and family tend to sit together in that household who have batter Sanitation and good environment.

Results regarding the comparison of two samples (with biogas and without biogas), it can be concluded that income level of household with Biogas is higher than the household without biogas plant.

The results regarding total income showed that average income of the household with Biogas plant is greater than whom who do not have biogas plant. The reason behind this fact is that that household who owns Biogas plant may earn more through an increase in their

Farm Production by using bio-slurry as compare to that household who do not own. Furthermore, they can save their fuel expenditures which may also uplift their income level. The result regarding Livestock shows that household with Biogas plant possess a higher level of Livestock animals as compared to without Biogas plant, indicating that household who have more Livestock get more solid waste material which they can use in biogas plant which shows that Livestock plays an important role with respect to Biogas installation. Furthermore, results also depicted that those household who install biogas plant are more educated this is because higher educated people tend to have better understanding and knowledge of technology.

For the result regarding Farm Production, those who own biogas plant can make use of bio-slurry as a fertilizing agent that resulted in increased farm productivity. The result regarding Indoor Air Pollution shows that those who install biogas plant visited hospital less whereas those who do not install biogas plant visited hospital more often because that household who does not process biogas plant face diseases related to eyes and throat. Furthermore, results Time Saving shows that that household who installed Biogas Plant While those who do not installed biogas plant, use firewood, and have to spend hours in cutting or buying woods. Furthermore, a result related to Household Sanitation shows that those who install biogas plants have better household sanitation because they have a better system of Sanitation to dump waste material as compare to those who do not installed plant.

It is revealed that for human capital, there is no difference between the two households, indicating both households have an equal level of human capital. However, those who installed biogas plant can send their children to private school because they save more money as compared to that household who do not have biogas plant. Whereas the result shows an increase in average financial capital of those who installed biogas plant because those who installed biogas plant save more with respect to expenditure on fuels.

The result regarding physical capital shows that those who installed biogas plant have more assets because of their savings. They tend to buy more physical capital. Furthermore, for natural capital, there is no difference between the two households, indicating both households have an equal level of natural capital. The reason behind this fact is that both types of household possess the same amount of cultivated land. Moreover, SC of household with biogas plant is higher because it is associated with some NGO. They assist to provide the technical sport while installing biogas plants. Whereas those whose does not installed biogas plant are not associated with any kind of NGO.

Chapter 5

Conclusion and Recommendations

5.1. Conclusion

This research examined the effect of socio-economic indicators on livelihood assets through the household indicators. From the findings of the study, it is obvious that social economic factor of household ultimately contributes to livelihood assets. The total income is the most important and the strong indicator for having installed a biogas plant at HH level. It is found that socioeconomic impacts of domestic biogas plants on rural households of district Sargodha are significant. The HH with functional biogas plants are saving income as well as low consumption of wood for cooking is making these houses more environmental friendly users of the renewable energy resources.

The selection of respondents from both BG plants holders and Non-BG plants holders in the study area enabled us to compare the associated benefits and problems or risk factors related to the installation of biogas plant. The research has found that BG input has significant impacts on FP, TS, IAP, HS, and SAV, which in turn are playing their role to improve the socioeconomic status of rural areas of district Sargodha.

Therefore, the installation of BG plants is successful to some extent. Out of all socio-economic indicators, total Income has a relatively greater impact on household indicators. Furthermore, from household indicator farm productivity and physical capital have more impact on livelihood assets as compared to SAV, TS, IAP, and HS. Additionally, it is also revealed that impact of socio-economic indicators on household ultimately turn into improving livelihood assets is higher in case of a household with biogas plant as compared to those who have not installed biogas plant.

The study also observed that inputs of BG plants play a significant role in improving the status of the rural household.

5.2. Policy Recommendation

- It is recommended that physical, capital and farm productivity should be elaborated to encourage household to installed biogas plant for improved livelihood assets, along this other variable like Saving, Household sanitation, and indoor air pollution should be considered for better livelihood assets.
- Results depicted that household with biogas plants have better household indicators and livelihood assets so installation of biogas plant should be encouraged, the government and some of the NGO's provided subsidies previously for the installation of the plants. It must be started again and the scope and budget of the subsidies should be increased.
- It is recommended that people should be educated on better and frequent utilization of domestic biogas plants. Whereas biogas plants technology may be provided on cheap to other rural households which are not presently using these domestic BG plants.
- In view of the prevailing situation, promotion of the biogas technology (B.T.) seems to be one of the best options, which could, not only partially offset the fossil fuel and fuelwood consumption but also could facilitate recycling of agro-animal residues as a bio-fertilizer. Moreover, being clean and renewable, it would also contribute towards environment protection, sustenance of ecosystem and conservation of biodiversity.
- There is, however, a tremendous need to promote public awareness, in particular, among youth and women, on the use of bio-energy (biogas) and bio-fertilizer and also to create awareness and know-how about eco-system management, conservation of biodiversity and sustainable use of natural resources.

- Due to mass social acceptance, Pakistan Council for Renewable Energy Technologies (PCRET) has to launch megaprojects on the biogas technology by installing biogas units all over the country to not only cater the needs of cooking but also for agriculture and commercial purpose in order to meet the shortage of gas and electricity in the country. These projects will pave the way for mass-scale dissemination of an environment –friendly technology; which apart from being greenhouse gas.

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SOCIO-ECONOMIC IMPACT OF BIO-GAS PLANT ON LIVELIHOOD OF DISTRICT SARGODHA; TEHSIL SAHIWAL & SILAHWALI

QUESTIONNAIRE

Name of the respondent | | | | | | | | | | |

Socio-Economic Profile of Respondent

1. Gender (a) Male (b) Female

2. Age: ……. Years

3. Year of Schooling: …….Years

4. Highest Education in HH: …….Years

5. Household Size: …….. No. Adult: …… No. Children: …… No. (18 years), Male: …… No.

6. Electricity (0) No (i) Yes

7. The total area of household (household land)
(in marlas,1 Marla = 272.25 sq feet) | | |

8. Residance (i) At village (ii) At farm/Daira (iii) Both

9.Type of house (i) Kacha (ii) Pucca (iii) Both

10. Main income source for the family:
i) Agriculture (ii) business (iii) Skilled (iv) Remittances (v) Other/specified

11. Monthly income in PKR? ……..Rs/Month

12. Landholding (0) No (i) Yes if No then >>Q16

13.Total land area | | acres

14. Cultivated land | | acres

15. Agriculture production

Agriculture Production in Last two seasons Rabi &Kharif	Area (Acres)	Total production (last year) (Mounds)	Selling Price per Mounds
Wheat			

Rice			
Sugarcane			
Cotton			
Citrus			
Maize			
Fodder (Rabi)			
Fodder (Kharif)			
Other (Specified)			

16. Do you own livestock? (0) No (i) Yes if no >>Q18

17. Livestock ownership

Livestock	Adult Nos.	Calf Ns.	Total dung in Kg (Per day)	The net worth of Livestock(PKR)
Cow/oxen				
Buffalo				
Goat				
Other/specify				

Mediators

18. Do you own a Bio Gas Plant? If no >> Q30
(i) Yes (ii) No

18. What are the reasons for installing the Plant?

Reason/Factor	Most important factor =1 least important factor =5				
Non-availability of other fuel sources	1	2	3	4	5
Economic benefits	1	2	3	4	5
Motivation from existing plant owners	1	2	3	4	5
The subsidy provided by the program	1	2	3	4	5
Female of the house urges you	1	2	3	4	5
Availability of the inputs (animal dung, etc)	1	2	3	4	5
Other /specified	1	2	3	4	5

19. Date of installation of the Plant …….. (DD/MM/YY)
20. Size of the Plant ……. m3
21. What type of biogas plant did you install? (i). Fixed dome (ii). Floating
(iii) Others/specify?
22. Who in your family took the decision to install a biogas plant?
(i). The male head of household (ii). The female head of household (iii). Your son/daughter (iv) Other/specify
23. Total amount spent on biogas plant during installation?
(i) PKR …… (ii) Do not know …….

24. Breakdown of materials used in the plant during installation involved in the construction of the plant (such as labour, plumbing, bricks, and cement)?

Cement	Bricks	Labor	Pipes
Number of bags	Number of bricks used	How many laborers were required?	The number of pipes used
Cost of one bag	Cost of one brick	Number of an hour of each labor	The cost of each pipe

25. How much PKR do you need per year for operation and maintenance of your plant?
(i) Rs_____ (ii) Do not know

26. For what purpose is biogas used?
(i) Cooking only (ii) Lighting only (iii) Both (iv) other /specify

27. What is the benefit of biogas plant?

Factor /Reason	1= Strongly agree and 5= for strongly disagree				
Enough gas for cooking	1	2	3	4	5
Enough gas for lighting	1	2	3	4	5
Bio slurry	1	2	3	4	5
Cleanliness in the Household	1	2	3	4	5
Workload reduction	1	2	3	4	5
Health improvement	1	2	3	4	5
Social prestigious	1	2	3	4	5

28. Does Biogas Plant save your drudgery time? Which were spent on the collection of firewood, animal dung, LPG Kerosene oil etc.? (0). No (1). Yes

29. If yes, where do you spend this saved time?

(i) Income generating activities (ii) Social work / societal relationships

(iii) Take rest / do nothing

30. Reason for not installing of biogas plant?

Reasons	1= Highly influenced 5= least influenced				
High cost of installation	1	2	3	4	5
Don't have animal dung	1	2	3	4	5
Don't have sufficient place	1	2	3	4	5
Hear from someone not beneficial	1	2	3	4	5
Waiting for subsidies	1	2	3	4	5
Have another substitute	1	2	3	4	5

31. What type of fuel are they using if biogas is not installed?

(i) Woods (ii) LPG (iii) Animal dung (iv) Animal dung & woods

32. Time spent in the collection of the fuel woods? ……Minutes

(i)0-30 (ii)31-60 (iii)61-90 (iv) 91-120

33. How much fuel is/was required for cooking (per month)?

	Before biogas installation				After biogas installation			
Types of fuel	Collect	purchase	price	Expenditure (RS)	Collect	Purchase	Price	Expenditure (RS)
Firewood (mounds)								
Kerosene (liter)								
LPG (Cylinder)								
Dung Cake (kg)								
Agriculture waste (Mounds)								
Other								

34. How much fuel is required for lightning?

	Before biogas installation				After biogas installation			
Types of fuel	Collect	purchase	price	Expenditure (RS)	Collect	Purchase	Price	Expenditure (RS)

Firewood (mounds)								
Kerosene (liter)								
LPG (Cylinder)								
Dung Cake (kg)								
Agriculture waste (Mounds)								
Other								

35. The frequency of hospital visits in 6 months?

(1) 0-1 (2) 1-2 (3) 2-3 (4) 3-4

36. Did any of the family member have the following disease?

	Before biogas plant	After biogas plant
Respiratory disease	Yes/No	Yes/No
a headache	Yes/No	Yes/No
Eye burning/ irritation	Yes/No	Yes/No
Diarrhea and dysentery	Yes/No	Yes/No
Burning case	Yes/No	Yes/No

Livelihood capitals

37. A number of children school going age, attending school?

	Those who installed biogas Plant	Those who do not installed biogas Plant
Male		
Female		

38. Total income before and after installing biogas plant?

	Those who installed biogas Plant	Those who do not installed biogas Plant
Expenditure related to fuels (PKR)		

Bio-slurry

39. Do you use biogas slurry as a fertilizer? (0). No (1). Yes If Yes. >>Q42

40. If no, what do you do with the slurry?

(i) Sale to others (ii) Give out to others
(iii) Drain (as in a nallah) (iv) Others/specify

41. Why don't you use slurry?
(i) Don't know if it can be used (ii) It is difficult to use
(iii) No land to use (iv) Others/specify

42. If yes, what do you do with the slurry? (Multiple options can be chosen)
(i) Fertilizer without composting (ii) Fertilizer after composting
(iii) Through irrigation canal directly (iv) Others/specify

43. Slurry used information?

Crops on which slurry used in last season	Area in Acres	Results / Output experience of slurry used (0). No, I have not noticed a difference in yield between the slurry and other fertilizer options (1). Yes, the yield INCREASED with the slurry (2). Yes, the yield DECREASED with the slurry
wheat		
Rice		
maize		
cotton		
Fruits		
vegetables		
Other/specified		

44. What are the main benefit of biogas plant related to household? (multiple answer)

A.	Reduction in burning case
B.	Liberation from smoke related disease
C.	Absent of black soot in kitchen/house
D.	Reduce expense related to health

45. Sanitation problems faced?
1-very frequently observed 2- frequently observed 3- no difference 4-rarely seen 5-very rarely seen

House flies ☐
Mosquitos ☐

Smoke
Bad Odor

46. Cleanness of the household?

(i) Very good (ii) Good (iii) Fair (iv) Poor
(v) Very poor

47.Existing nature of social capital?

1-highly gained 2- gained 3- neutral 4-declining capital5- highly declining capital

Relatives
Friends
Neighbor households
Land owner
NGO

48.Do you have any suggestion about biogas technology?