BIOGAS, AN ALTERNATIVE ENERGY AND ITS IMPACT ON WOMEN HEALTH AND RURAL DEVELOPMENT
(A Case Study from Itahara Village, Morang District, Nepal)

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Declaration

I, Milan Raj Gadtaula, declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for award of any type of academic degree.

Signature……..

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ABSTRACT

Nepal is one of the lowest energy consuming countries in the world. More than 80% of total energy consumed here comes from traditional biomass energy resources including agriculture residue, forests, by-products from crops etc. These types of energy consumptions not only make impact on environmental degradation and ecological imbalance but also have adverse effect on women health and economic status of people living in rural areas. Biogas is becoming popular in the villages as an alternative source of energy. In this context, the present study on the impact of biogas on women health and rural development addresses various factors of biogas use. The main objective of the study was to examine the health and environment impact of biogas on women as well as its impact on rural economy.

This study was conducted in Itahara VDC of Morang district. The study was based on a sample of 60 households (40 of biogas users and 20 non-users), selected through simple random sampling. Before starting the study, a brief review of existing literature was made. Analysis of the data was made by summary statistics. The data showed a relationship between biogas plants with workloads, timesavings, women health and economy of rural areas.

The sizes of 6 m^3 biogas plants were the most popular in the region followed by 8 m^3 plants. The households reported technicians of biogas companies and neighbors as the main source of information regarding biogas. Biogas was used only for cooking purpose. Biogas was only to a minor degree used for lightening. Installation of biogas reduced the number of health visits and reduced women health problem. Proper use of biogas slurry reduced farmers' extra expenses on chemical fertilizers and increased agriculture production. The time to collect firewood, cooking and cleaning utensils was also reduced. The saving has contributed to improving childcare and promoting social activities. The workloads of the women are reduced. Some of the respondents use their time in income generation activities.

Based on the study, that there is a need to promote biogas n this district. Apart from minimizing health issues, use of slurry and use of biogas for lighting should be promoted which could add additional benefits to the use of biogas.

Contents

List of Tables

List of Figures

Chapter 1: Introduction

1.1 Background

One of the sustainable global energy strategies has been to develop and utilize the renewable energy resources (Chang, 2009). 18% of global final energy consumptions was recorded to be produced from renewable (GSR, 2007). Renewable energy represents an enormous source of energy (Wrixon, 2000). There are two main distinctive features of biogas as compared to other renewable energy sources. First, it is a cleaner fuel with high methane components and second, it helps in collection of organic waste which can be utilized as fertilizers (Taleghani and Kia, 2005). The rural household biogas development strategy has been an important way to increase incomes of rural areas.

Approximately 590 million to 800 million tons of methane gas is considered released into the atmosphere from natural biodegradation of organic matter under anaerobic conditions (ISAT/GTZ, 1999a). Consequently, liberated biogas that potentially provides an energy sources are produced through the decomposition of various types of biomass. There are some distinctive features between anthropogenic anaerobic processes recovering and not recovering the required energy from biogas. The first categories include bioreactors which are specifically designed for substrates including sewage, industrial and municipal waste, and agriculture containing significantly bigger proportion of biomass that can be anaerobically-degraded (Bond and Templeton, 2011). In developing countries like Nepal, India, China, the foundation of biogas recovery systems is based upon comparatively small-scale reactors, which are particularly designed for digestions of cattle, poultry or any other excreta. In the second category, bio gas is produced and released into the atmosphere through municipal water treatment, landfill sites anaerobic processes (Bond and Templeton, 2011). Biogas contains 50 to 70 percent of methane and 30 to 50 percent of carbon dioxide as well as small volumes of other gases. These gasses have a direct or indirect impact on human health if not consumed and released directly into the atmosphere (Sasse, 1988). Methane has a calorific value of 21-24 MJ/m^3 (Dimpl, 2010). Because this biogas is used for multiple purpose including cooking, lighting, generation of electricity, heating etc. the broader plans can include larger plants, where bio gas can be connected into gas supply networks. These features of biogas show its direct or indirect impact on human health.

Nepal is an agricultural country situated in South Asia and located between 26º22' to 30º27' North latitude and 80º4' to 88º12' East longitudes where most of the rural population has the

tradition of raising cattle as an integral part of their farm. Total population according to the census of 2011 is 26,494,504 with the growth rate of 1.35% per annum. The total number of households in the country is 5,423,297. 4,377,722 households are in rural area of Nepal (CBS-NPHC, 2011). About ninety percent of the population live in rural area and are involved in agriculture. Per capita income is about $706.58 (World Bank data 2012). The traditional fuels are the main sources of energy in the rural areas in Nepal. Nearly 2/3 of the total households are found only using firewood as their normal source of fuel for cooking followed by LPG gas 21.03%, 10.38% as the cow dung, bio-gas 2.43%, kerosene 1.03%, electricity 0.08% (CBS-NPHC, 2011). Out of the total households presented above 3,647,746 households use electricity as a source of lighting from which nearly 73% are in rural areas. Similarly, 991,510 households in the country out of which nearly 96% households are in rural areas use kerosene. 15,264 households use biogas as their daily source of lighting out of which 76% are from rural areas. Households using solar and others are 403,504 and 330,170 in the country out of which 99.40% and 98.40% are from rural (CBS-NPHC, 2011).

The other part of this research is about women health. Out of total population 51.50% are female in the country. 83.74 percent of total female live in rural area. Out of total household heads, only 25.73% are female. Overall literacy rate for population aged from five years and above was 65.9% in 2011, an increased from 54.1% in 2001. Male literacy was 75.1% compared to 57.4% for female. The female ownership of either land or house in the country has been recorded to be 19.71% as whole households in the country (CBS-NPHC, 2011).

This is a high pressure on natural resources because of ever increasing population in rural areas. In order to solve the growing rural energy scarcity and minimize the negative impact of health; biogas plant is the only feasible and visible technology in rural areas of Nepal (BSP, 2012). A biogas program has been in use in Nepal since 1975. Nepal has a huge potential of biogas. Biogas technology has established itself as a viable and feasible technology in a wide range of socio-physical conditions of Nepal. The key socioeconomic variables are:

- Low level of per capita consumption:
- A large share of energy consumed in the domestic sector, in scattered dwelling, mainly for cooking and lighting:
- Low rate of literacy and skilled human resource:
- Low investment capacity, and
- Farming are practiced by the majority of the population:

In most of the rural parts, women are found using firewood as the main source of energy for cooking purposes. This does not affect only the health of users, but also makes the surrounding environment polluted and dirty. The lack of proper knowledge of managing waste also increases the risk of being affected physiologically and environmentally. Nepal is a land locked country without own petroleum resources. The majority of people in Nepal are farmers. The government started installation of biogas plants during 1974/75 under the name of biogas support program (BSP) to sustain alternative energy with positive impact on rural development. A total of 268,794 biogas plants for different household sizes were constructed across 75 districts of Nepal during July 1992- July 2012 (BSP, 2012).

The energy situation in Nepal is characterized by very low energy consumption per capita (WECS, 1994). The total domestic energy demand in Nepal was estimated to be 248 million GJ in 1990/1991 and this has increased by an average of 2.4 percent per annum (WECS, 1994). Almost 35 percent of export earning is needed for the import of petroleum products and coal, which meets about 8 percent of the total energy demand (RONAST, 1999). Total energy consumption per capita (Million British Thermal Unit per Person) for Nepal is 2.50, 2.499, 2.765 and 2.914 for the year of 2007, 2008, 2009 and 2010 respectively (IES, 2012). In 2009, the electric power consumption was 90.95 kWh (World Bank, 2010).

Therefore, the majority of the population relies on traditional fuel for cooking in the rural areas of Nepal. They depend on firewood for their energy and face much difficulty in collecting this material from their respective place because of the total dependence on forest for fuel-wood. As a result, the quality and quantity of forests deteriorates and problems like deforestation, flood, soil erosion and landslides are associate with degradation of forests. Various attempts have been made from individual to organizational levels. Some of the measures have already in practice including biogas, solar heaters, micro-hydro power etc. Among these, in order to solve the growing rural energy scarcity and minimize the negative impact on health, biogas plant is the only feasible and visible technology in rural areas of Nepal (BSP, 2008). Use of dung as fuel has deprived the soil of the necessary ingredients required for crop growth. All countries of the world were affected by the World Energy Crises of 1973, which was reflected by increase in price of kerosene and petrol. This energy crisis had serious implication on Nepal too. Because of rising prices of kerosene and petrol, there was a high demand for fuel-wood. This led people to cut trees indiscriminately. Moreover, pressure on forest increased also due to the increasing demand of land for farming and procuring fodder for livestock feeding (BSP, 2009).

In Nepal's context, women are active in kitchen, child bearing and also in farm and are affected by this problem. They go to the forest to collect firewood for cooking food, and sometimes children are also engaged in the same, depriving them of being able to read and write. Automatically, future generation of Nepal can potentially be of low quality and hence, could pose serious problem. In our country half of the total population is female. They work in households as well as in farm. If their health is poor, the production will be reduced. In rural areas, most women use firewood for cooking and lighting in their house. Due to this, kitchen as well as the surrounding environment becomes dirty and polluted and it affects their health. In our country this situation is a dilemma. We do not have sufficient petroleum and coal, so we are using biomass for energy. If we want to achieve sustainable development, we must preserve our ecosystem. For this we have to control our dependence on forest products. Unless controlled, the forest is going to decline and this will also affect the community in many ways. With this point of view, the government started to install biogas plants in the year 1974/75 under the name of biogas programme on the occasion of the "Agricultural Year". Currently, biogas plant installation number in the country is more than 90,000 which includes 64 districts (Silwal, 1999). Biogas and Agricultural Tools Company, a state owned enterprise began building biogas plants in Nepal from 1992. After the restoration of democracy in 1990, biogas was able to draw greater attention of the authorities (Silwal, 1999, research report).

1.2. Development of Bio Gas in Nepal

Humphery Davy in early stage of 18^{th} century pronounced the presence of combustible gas methane from farmyard manure, although it is said that Alessandro Volta in 1776 discovered biogas first. The active promotion of biogas was made only after the oil crisis of 1973. The most interesting step in this field came in the last 3 decades along with noticeable technical effort particularly in developing communities. Father B.R. Saubolle at St. Xavier's School at Godavary Lalitpur first introduced the development of biogas technology in Nepal nearly 6 decades ago by his own private and personal initiation. Government of Nepal promoted biogas much later. At the first phase biogas technology was installed in different parts of the country with direct supervision and monitoring of government. Since then, various other organizations and technology centers are contributing to development of biogas.

Because of the rugged terrain and other geographical difficulties, rural areas are very costly to reach. Wind and solar energy exploitation involve sophisticated technologies which are capital intensive. Installation of micro and mini hydro power plants too is not feasible in many areas due to unavailability of perennial water sources. Hence, in order to solve the energy

problem of Nepal's remote areas; a fast, easily implemented, cost efficient, small scale, completely decentralized renewable alternative which is technically feasible and economically viable has to be promoted. Biogas is well suited in the Nepalese context.

In 1968 Khadi and Village Industries Commission (KVIC) built a plant for an exhibition in Kathmandu. By 1974, Nepal had a total of four biogas plants, in the households of the elite in Kathmandu. Therefore, some groups built on their own initiatives a few biogas plants in the capital city of Kathmandu (CMS Nepal, 1996). To check the deforestation and to stop people from burning animal dung for cooking, His Majesty's Government of Nepal (HMG/N) for the first time lunched the biogas program in the year 1974/75. In that year, interest-free loan was availed to the farmers willing to install biogas plants. Under this program, loans were provided from Agricultural Development Bank (ADB/N) to the interested people willing to construct biogas plants. During 1975/76, 250 biogas plants were installed. In subsequent years, the government as an incentive gave loans with 6 percent interest (Karki, Gautam and Joshi, 1993). The Government of Nepal and Government of Netherlands came up with promotional activities for development of biogas in Nepal in 1992 called biogas support plan. The main objective was to promote a wide-scale use of biogas to substitute fuels resources such as wood, agricultural residues, cow dung, and kerosene usually used for cooking and lighting purposes (BSP, 2012).

In 1997, Gobar Gas and Agriculture Equipment Development Company Pvt. Ltd. was formed with joint investment of the United Mission to Nepal (UMN), ADB/N and Fuel Corporation (which later on merged into the Timber Corporation of Nepal). It was based on Development and Consulting Services (DCS) for bio-gas extension organization, with mandate to promote bio-gas technology in the country. Subsequently a need for offering incentive to biogas plant owner was realized. This led to the provision of a subsidy according to the ecological zone. There are many bio gas companies in Nepal at this time providing technical as well as supportive programs to each and every corner of the country. There are 107 qualified bio gas companies throughout the country. They make profit through sale of service and goods and promote the use of bio gas (BSP, 2012). There were 9 qualified biogas companies in Morang district alone until year 2010/2011.

1.3. Statement of the Problem

Nepal is a technically backward country as regard to fuel. Almost all Nepalese depend upon traditional energy sources; firewood. Besides this, fodder, agricultural residues, electricity and gas are also used. Using firewood causes destruction of the forest. It is known that

deforestation results in natural calamities such as landslides, floods, soil erosion etc. Nepal's per capita final energy consumption (14.7 GJ) is one of the lowest in the world. Only seven other countries in the world have a per capita consumption lower than Nepal (WECS 2012). Despite this low level of per capita energy consumption, the prevailing pattern of energy use and production indicate many elements of lower sustainability. The energy problem in Nepal arises not from excessive reliance on non-renewable energy resources, but rather from the fact that one form of energy (fuel wood) is being consumed at an unsustainable rate, while the vast potential of other forms of renewable energy remains virtually unused (BSP, 2012)

CBS-NPHC (2011) shows that nearly 80% population in Nepal are still dependent upon traditional fuels including fuel wood, dung cake, agricultural residues inside their homes as a main source of energy. Fuel wood as the fundamental source of energy in case of Nepal, biomass fuels and their demands far exceeds the sustainable supply (Rijal, 1998). There are many other socio-economic and health related adverse. Women are particularly exposed. Nepal is highly dependent upon imported fossil fuel making the economy more complicated. Furthermore, rise in price has been a burden due to fluctuating exchange rate of international currencies.

Evidence reveals association between economic development and per capita energy consumption. Despite such a lower level of per capita energy consumption, the prevailing pattern of energy use and production indicate many elements of unsustainability. The energy problem in Nepal arises not from excessive reliance on non-renewable energy resources, but rather from the fact that one form of energy (fuelwood) is being consumed at an unsustainable rate, while the vast potential of other forms of renewable energy remains virtually unused. Biomass has been the primary source of fuel since ancient times. About 90 percent of all energy consumed in Nepal at present is supplied by firewood. It is mainly consumed in the domestic sector in form of fuel wood for cooking and heating purposes. It is also used to a great extent by cottage, small scale and agro based industries.

The increasing demand of energy is caused by both lack of sufficient development of alternative energy resources and rising population. The fuel crises affect women in two ways. The first is the unwanted effect of carbon monoxide and the second is destruction of forest causing high transport cost.

Under these circumstances, it has become essential to reduce the consumption of fuel wood. In this regard substitution of fuel wood and conservation of the environment, wherever

possible, by indigenous sources of renewable energy is the only way out. Biogas provides useful energy for fuel and is one of the best energy in the country.

Uses of Biogas

- Cook meals
- Light rooms and other places
- Run internal combustion engines only on biogas or mixed fuel (biogas and Diesel/petrol)
- Produce mechanical power to run rural level agro-processing mills
- Generate electricity for rural electrification
- Operate kerosene-fueled refrigerators by replacing kerosene with the bio-gas burner.

One cubic meter of biogas as an energy content is equivalent to:

- 3.47 kg of wood
- 0.62 liters of kerosene oil
- 0.61 liters of diesel oil
- 1.5 kg of coal
- 0.45 kg of LPG
- 1.25 kw of electricity
- 13.0 kg of fuel dung

Now, in Nepal, 124,000 units of biogas plants have been installed with the operational rate of 97%. 120,280 biogas plants are in operation. These plants can reduce total 553,000 tones CO every year, and

Annual savings:

- Fuel wood 287469.2tonnes
- Agriculture waste 914128tonnes
- Dung cake 505176tonnes
- Kerosene 5.65million liters

Benefits of Using Biogas for Cooking

- Replaces firewood and kerosene
- Reduces smoke and provide clear environment
- Reduces drudgery of women

- Improves rural sanitation
- Helps in minimizing deforestation and improves ecological balance

Furthermore, biogas development brings about social benefits in many respects. For example, the quantity of animal protein supplied to the society may increase as a result of reduction of direct burning of stalks and development of animal husbandry. As the problem of fuel for the farmer's daily use is solved, trees are protected and forests are developed. The protection of trees and increase in vegetation areas can reduce soil erosion and improve ecological balance. The increase in organic manure can result in less use of chemical fertilizer, improving soil and increasing production. Environmental improvement in rural area reduces illness and build up people's health. Besides, in regions where biogas is used to generate electricity, cultural recreation and spare time study conditions can also be improved.

The study is expected to contribute in making the reader understand the importance of biogas as well as its impact on women health and the contributes to improvement of economic, social and health factors.

1.4 Objectives and research questions

Following are the principle objectives of this research.

1. To explore the impact of biogas in rural development especially in economical capability

   Research Questions:

   A) How does the use of biogas contribute in rural development?

   B) Why is biogas chosen as one of the measures for financial/economical improvement in rural places?

2. To examine the health and environmental impact of biogas on women

   Research Questions:

   A) How biogas plant can impact the health of women?

   B) What are the consequences of biogas plant to its surrounding environment?

3. To explore the time of women spent in other productive activities including household works.

   Research Questions:

   A) What are the other productive activities of women?

   B) How does a woman become able to manage time for indoor and outdoor activities simultaneously?

Chapter 2: Literature Review

2.1 Introduction

Introducing and identifying the most appropriate, up to date and relevant material regarding any issue is usually called literature search (Parahoo, 1977). The synthesis, evaluation, examination, analysis and conclusion is carried out within literature review in this work done along with some meaningful outcomes co-related with issue raised and specified objectives. Literature review is related with the review of different literature, it contains conceptual review from books and articles, review of various published and unpublished document of related organization and review of related studies from previous research. There are two parts in this section. The first part reflects the basic aspects of biogas and women health while second part of the literature review is used for presentation of research carried out throughout the world in similar contexts as empirical research.

2.2 Theoretical Perspectives

2.2.1 Use of Energy through Traditional Biomass Fuels

The principal energy is fuelwood which is exceeding in demand than sustainable supply due to lack of sufficient alternative resources (Rijal, 1998). Only 80.5% of energy supply is sustainable against the total demand. 88% of total sustainable energy is from fuelwood consumption in any form (MOF, 2007). Hence, use of biomass fuels are the best alternatives to replace fuelwood which come from decreased forestry area in Nepal.

2.2.2 Traditional Biomass fuels and adverse impact associated

A study conducted by Smith *et al* (2000) has indicated that 1kg Acacia wood burned inside mud stove can generate 318 gram of carbon. Particularly, in rural community in Nepal, one of the risk factors of Acute Respiratory Infections (ARI) among infants and children less than 2 years have the main cause of domestic smoke pollution due to their time spending near fireplace (Pandey, 1989). This applies not only to infants and children, but also to women who spent hours inside the house. Some of the health problems such as Conjunctivitis, Upper Respiratory Irritation, Acute poisoning from carbon monoxide, Cataracts, Lung Cancer, Chronic Bronchitis, ARI, Burns, Arthritis etc. are the main adverse effects on human health due to biomass combustion (WHO, 1991). The prevalence of Acute Respiratory Infection among children below five has significantly increased in the latest year (NHRC, 2010). Increase human mortality including women and children are caused by various factors, one of

those factors is the airborne particles which also cause eye ailments (Bajgain and Shakya, 2005). Cataracts in women have got high risk, caused mainly due to use of solid fuel in indoor stoves (Bates *et al*, 2005). These were the basic health impacts on women due to use of several conventional fuels.

2.2.3 Benefits of Biogas

There are several benefits of biogas. Some of the benefits are already explained in introduction part. The most important benefit of biogas is to replace fuelwood. The annual reduction of fuelwood can be two tones per household after installation of biogas (Winrock and Eco Securities, 2004). It also benefits on lighting (Bajgain and Shakya, 2005). Up to July 16, 2012 total number of 2,60,899 biogas plants were installed under BSP alone in over 2,800 VDCs and all 75 districts because of which, reduction of the workload of 260,889 households mainly women and girls by about 3 hours/day/household is calculated.

The saved time can be used for education and other income generation activities and leisure. One plant can generate sufficient energy for saving of fuelwood. E.g. fuelwood used for cooking at 2.5 tons/plant, agriculture waste at 0.35tone/plant, dung cake at 0.60tone/plant, kerosene at 6.4litres/plant etc (BSP, 2012). Similarly, annual reduction of GHG emission to 3tones/plant was achieved. Annual production of bio-slurry & bio-compost is found as 1.75tones/plant that improves agriculture yields. It also reduces the use of chemical fertilizers. Improvement of rural sanitations has been found by connecting 75% toilets in plants. Biogas also reduces indoor air pollution due to kitchen smoke in 260,899 households which can directly reduce the adverse effect on women and child/infants' health. Consequently, it reduces incidence of illness and expenses on health, generation of direct and indirect employment to some 13,000 persons (BSP, 2012).

The recorded toilet construction is higher in biogas households according to the review of IEIA (2012) which was study carried out by SNV/BSP. The study conducted particularly in Kaski and Tanahu districts showed the significant reduction in cough, eye infection and headache after biogas installation (RUDESA, 2002). Another research carried out in Bhaktapur District revealed that sixty seven percent of total households reported the reduction in smoke related disease after installing biogas plants (NGO Promotion Centre, 2003). East Consult (2004) concluded that the primary reason of improved health among people using biogas plants was due to reduction in indoor smoke and also has direct or indirect impact on

health-related expenses. Hazardous smoke particles can be avoided by using clean biogas stoves rather than burning fuelwood, straw and dung cakes (Li *et al,* 2005).

The benefit of bio-slurry is as important. The economic value of bio-slurry determines the return of total investment (Devkota, 2001). The annual savings of 39kg of nitrogen, 19 kg phosphorous and 39 kg potash per household can be made by using bio-slurry (East Consult, 2004). The problem of soil degradation can be solved through use of bio-slurry specifically in the area where dung was previously used as a burning fuel. This also reduces the quantity of buying artificial fertilizer saving total annual expenses in farming (Li *et al,* 2005). The trend of using bio-slurry in the form of fertilizer is increasing in the Nepalese context. Nevertheless, all the farmers are not aware of the importance of slurry and hence biogas may go without slurry utilization.

Greenhouse gases reduction is another important benefit of biogas. Biogas substitutes the traditional stoves and the kerosene stove which increases the cooking efficiency of combustion contributing by far the lowest GHGs emissions (Smith *et al,* 2000). 3, 4 and 5 tonnes of CO2 per plant can be mitigated by the biogas plants of size 4, 6 and 8 cubic meter respectively (Shrestha *et al,* 2003). By replacing fuelwood, dung, kerosene as well as agriculture residues, biogas helps to reduce 4.6 tonnes of CO2 per year per plant (Eco Securities, 2004). 6 cubic meters sized biogas plant can displace 3 tonnes of fuelwood or 38 litters of kerosene per annum and can reduce 4.9 tonnes of CO2 equivalent per annum (Devkota, 2007).

Biogas also helps on investments aspects and reduces payback period. Devkota (2001) found in his report that a plant costing NRs 27,204 will be paid back in 6.1 years. With a subsidy of NRs 9,000 only 4.1 years will be needed. The calculation was made on the basis of NRs 3240 saved from fuelwood, kerosene and from chemical fertilizer. Further maintenance cost, annual labour cost and miscellaneous cost were deducted in this calculation. The investment can be returned back in three or four years according to the economic value of the slurry. Li *et al* (2005) further mentions that the shorter payback period can help in making biogas plant affordable in common rural households and in poor areas.

2.2.4 National Policies and Action Plan for Development of Biogas

The promotion of biogas is part of the action plan on renewable energy. This plan is receiving increasing attention. Several plants have been established. In the plan the developmental target in relation with renewable energy technology was set. The eighth plan (1992-1997)

envisaged the real need of a coordinating body in order to promote alternative energy technologies in Nepal. As a result, the Alternative Energy Production Center (AEPC) was established as an authorized body. The long-term vision was only formulated after the implementation of ninth plan (1997-2002). Two main policies Renewable Energy Subsidy-2000 and the Renewable Energy Subsidy Delivery Mechanism-2000 were formulated and implemented. After the tenth plan smaller sized systems were given priority encouraging research for expansion of biogas system in the different hilly and mountainous reason.

Another plan called Perspective Plan as long-term vision (1991-2017) that has recommended the development as well as promotion of alternative energy resources and technologies, which included biogas as an integral part of rural developmental activities. Renewable Energy Perspective Plan of Nepal (2002-2020) is an approach which is prepared by CES/IOE. This plan was for on biogas installation program. The Government of Nepal has promoted the Rural Energy Policy in 2006 for the first time. The policy links renewable energy including biogas to economic activities. Another subsidy policy was implemented by Government of Nepal in 2006 as Subsidy for Renewable (Rural) Energy Subsidy, 2006 and its delivery mechanism, 2006 in order to ensure the proper flow of subsidy. Other supportive government policies were implemented.

2.3 A Critical Analysis on Empirical Research

In the study carried out by Charla Brilt in 1994, he argued that biogas clearly has a lot of promise in Nepal. It is a renewable relatively inexpensive decentralized energy source. It can help meet energy demand in rural areas, while lessening the deleterious consequences of fuel-wood use in an increasingly forest deficient world and alleviating problem in the supply of organic fertilizers. New ERA (1995) showed that the subsidy had attracted even more people towards the bio-gas. However, the poor sections of the society were still deprived of the privilege because many of them still could not afford it. Most of them did not have enough collateral to apply for the loan and they did not have sufficient cattle to run the smallest biogas plant.

Wim J Van Nes (1992) stated that the potential number of bio-gas plants in Nepal is estimated at 13 million, out of which 62% more than 8,00,000 plants are in the Terai, 37% or almost 5,00,000 plants in Hill and nearly 1% or 10,000 plants in the mountain. The most potential district for biogas plants are Rupendehi, Siraha, Dhanusa, Morang, Sarlahi, Syanjha, Gulmi, Kothang, Makwanpur and Dhading. He also mentioned the price of competing fuels as an

important factor to consider. Most often biogas replaces firewood. In these districts with high firewood price biogas will have a higher potential than districts where firewood is available without cost. He also stated that rich farmers can easily install a biogas plant or can get easily a loan through banks. So those districts with more rich farmers have a higher potential than those districts with mainly poor farmers.

Adhikari (1996) in his study on "Impacts of Bio-gas Plant on Family Health, Sanitation and Nutrition" suggested that most of the owners do not feed cow dung to the biogas plant everyday because of various reasons. They used to collect and deposit the cow dung in the plant inlet for 2-3 days. This practice might be favorable for disease causing organisms. It is suspected that deposition of dung in the inlet for longer period (2-3 days) could be one of the main reasons for increased prevalence of Mosquitoes. He has also mentioned that the smokeless biogas has greatly benefited the plant owners by contributing to a significant reduction in eye related troubles and problem of respiratory disease. Women felt better in terms of removal of eye irritation, eye pain, eye role, headache coughing etc.

Another benefit realized by the plant owners was a remarkable reduction in physical stress because of reduced time to collect firewood. The study mentions that the biogas owners do not seem to have experienced any noticeable change on their nutritional and income status due to biogas plant operation. Moreover, any minor changes what so ever in this respect is not directly attributed to the biogas plant operation despite several positive effects brought about by the biogas. Some adverse effects were also reported such as increased prevalence of mosquitoes, loss of warmth during winter causing diseases related to cold etc.

Vliet (1993) had carried out a study in Madanpokhara VDC in Palpa district to monitor the impact of biogas on the workload of women in 21 households who had installed biogas plants. According to her, all the plant owners had taken loans from the bank to install biogas plants. According to the users, installation of biogas plants had provided various positive impacts such as: time saving, relief from collecting firewood in jungles, easy to cook foods etc. A total of 1 to 2 hours of time was saved per day for each family which was used to some other income generating activities

According to the outcome of the study carried out by Gobar Gas Company (GGC) in Nuwakot district in 1994, biogas had very positive impact on the workload of women. They were liberated from difficult tasks of cooking in smoke filled kitchen, collecting of firewood

from dangerous jungles and cleaning of cooking vessels with black shoots. They now felt comfort in cooking and enjoy it.

GGC, the pioneer company in the field of bio-gas technology had also carried out various studies from time to time .One of the studies carried out by GGC (1994); "Impact of Biogas on Users" report that:

Due to the positive and liberal policy of the present democratic government in this sector, many biogas construction companies were emerging in the country in the nineties besides the Biogas and Agricultural Equipment Development Company. This is indeed a positive indication for the speedy extension of the technology. This would help in fulfilling the need of many farmers who were not covered under GGC due to its limited resources. This, of course, would enhance the service delivery mechanism of the companies. However, it was discouraging to note that GGC had not been able to consider these companies as good co-worker. These companies were not working to extend their services rather they were totally money oriented. The unhealthy competition between these companies, which were authorized to channel subsidy to the farmers and their behavior towards the farmers had been far below the expectation and this had resulted in an adverse situation for the promotion and extension of technology. Many farmers were complaining about their performances. Most of these companies did not manufacture biogas appliances on their own and hence they had jumped in this sector only to earn money. The personnel working for these companies totally lacked technical knowledge on biogas plant construction and operation and therefore most of the plants constructed by such companies were defective and they were not functioning well. In the present context of energy deficiency and need for exploitation of alternative sources of energies to the optimal level, the act of these private companies could be considered as obstacles in the way of promoting bio-gas technology. Therefore, the government had to enforce quality standard to build plants according to the design and drawing so that these company also worked as per the set standards. Otherwise, potential farmers would be distracted seeing the drawbacks and defects in the sector. The development of biogas technology, which was capable of fulfilling a major part of household energy sector demand, would be hindered. This would also affect the GGC adversely in delivering its services effectively. This of course was not a good sign for the promotion and development of biogas technology (GGC, 1994)

According to Final Report on Biogas Users Survey in 2000/2001, Conducted by AEPC, that a biogas household saves 990 Kg. of firewood and 40 liters of kerosene oil per year. The gas

production was reported to be insufficient in the winter by majority of respondents. One third of the households attached their latrines to the biogas plants.

The report deals with the digested slurry and its use. About half of the respondents used the slurry in the cultivated land and other used it in gardens. They perceived up to 23 percent increment in their agricultural production due to slurry application (AEPC, 2008). Decrease in occurrence of diseases was reported as positive benefit of biogas plant installation. However negative part of installation was increased prevalence of mosquito. Some (0.5%) even reported occurrence of typhoid. The gender issue had also been discussed. Most of the houses were owned by males. Male members kept contact with biogas companies. However double number of female members achieved training in biogas.

Final Report on Biogas Programme Phase III was conducted by BSP during March 1997 – June 2003. In this report it was mentioned that the target of Phase III was to construct 100,000 high quality, smaller, biogas plants during the project period. Despite the difficult security situation in the country, a total of 91,196 smaller biogas plants were installed in 65 districts during the project period. A strong quality control system was introduced, ensuring that the quality of biogas plant was high and the operation rate of plants was increased to 97 percent. Monitoring of biogas plants through Global Positioning Satellite (GPS) was introduced. Farmer's preference for larger plants changed during the period and farmers were motivated towards smaller plants. At the end of Phase III, the average size of plants was 5.8 m^3. Maintenance was also considerably improved.

Achievements in BSP III

- ► Adequate human resources were trained at the local level.
- ► Biogas companies were strengthened.
- ► Biogas penetration on rural areas had increased.
- ► More than 97 percent of installed plants were in operation.
- ► High quality standards on plant construction and maintenance were developed and applied.
- ► Various applied researches on biogas appliances and design were conducted to reduce costs and make plants more attractive to the farmers.
- ► A slurry programme was implemented to maximize the benefits to the farmers of using slurry.

- ► Prior to this programme, 90 percent of farmers were aware of proper utilization of slurry.
- ► Demand for increased even though subsidies decreased.

A study conducted by BSP in December 2004 "A Successful Model for Rural Households Energy Supply in Developing Countries" illustrated about the benefits of biogas technology in many aspects. It shows that, biogas systems provide multiple benefits at household, local, national and global levels with major impacts on gender, poverty, health, employment and environment.

Besides research conducted within the country, the author has tried to make a research carried out on international context but in the similar issue. He (2009) suggested that the main use of biogas was made for heating bath water in Assyria 10^{th} century B.C. and the anaerobic solid digestion might have been applied in ancient China. The decade of 1970s was the decade with the fastest growth of biogas use in most of the Asian, Latin American and African countries. Chinese Government promoted "use of biogas in every rural family" facilitated installation of more than seven million digesters (He, 2009). After the turn of twenty first century, the rapid speed of biogas development has been observed (He, 2009). Only in 2007, around 26.5 million biogas plants were installed with the volume of 6 to $10m^3$ (Chen *et al,* 2010). Three million family sized biogas plants were installed in India in 1999 and a subsidy was provided for another four million biogas plants after 2007 (Indian Government, 2007). The national project on NPBD provides financial support and various training and developmental courses and programmes.

Cookers/stoves, lamps, refrigerators and engines can be biogas fuelled appliances (ISAT/GTZ, 1999a). The best means of exploiting biogas into rural areas within developing countries are considered as biogas stove. Biogas burns with a blue and clean flame. 20% to 56% of biogas stoves' efficiency have been quoted providing better efficiencies (Itodo *et al,* 2007, ISAT/GTZ, 1999b). Switching from traditional to cleaner fuels helps to get several health benefits. More than 3 billion people worldwide use solid fuels which include wood, dung, agriculture residue, coal etc in order to fulfil energy supply needs (WHO, 2011). 2.7% of the total global burden of disease is caused by small particles and carbon monoxide (WHO, 2011).

Bond and Templeton (2011) also stated some of the benefits from biogas technology. It improves the health of users and is sustainable source of heating and lighting energy, can

benefit environment and various wastes can be treated. In order to move beyond a dependence on livestock manure small scale bioreactor is needed to digest available substrates in both Rural and Urban places. Kitchen waste, human excreta, weeds and crop residues are included in domestic level (Bond and Templeton, 2011).

Jiang *et al* (2011) carried out a research with the review of biogas in China. The authors mentioned that the biogas industry has the potential to improve the rural environment and can produce high amounts of sustainable energy in China as well as similar other developing countries like Nepal. The most important barriers are identified as the imperfect financial as well as environmental policies and lack of follow up services. The authors further suggested that the government should gradually introduce stricter environmental policies, timely and regular follow-up, to promote the use of standardized engineering equipment etc (Jiang *et al*, 2011).

Chen *et al* (2010) conducted a research to find the opportunities and constraints of using household biogas in rural China. Several opportunities are identified in the research in relation with household biogas development in areas. Chen *et al* (2010) suggested progress and prospects of rural biogas productions. Although the research was focused on Chinese rural environment, it is also relevant for Nepal. Most of the rural areas are extremely rich in waste resources, similar to China. The recycling, reuse and reduction of organic wastes has got a solution through biogas technology. China has been promoting and popularizing biogas technology in rural areas and achieved integration of technologies. The agriculture waste can be upgraded through this type of strategic initiatives.

Chapter 3: Methodology

3.1 Introduction

Methodology is the major aspect of any research. The main content of this chapter is a presentation of study site, research process, approach of research, research design, methods adopted, sampling, data analysis, validity, reliability ethics and limitation. Quantitative and qualitative methods are mentioned. Furthermore, primary and secondary data are also discussed in the chapter.

3.2 Selection of Study Site

3.2.1 Geographical Location

Itahara Village Development Committee (VDC) is located on 26.5471^0 North Latitude and 87.6208^0 East Longitude. In Nepal, the area lies in Morang District, Koshi Zone in the Eastern Development Reason in Eastern Terai with the area of 35.5 square kilometres. The overall area is with elevation range of 300 m to 397 meter from sea level. The VDC is generally dominated by Monsoon Climate as well as summer with higher temperature. The average temperature is recorded to be 28^0C.

3.2.2 Population of Study Site

The VDC consists of 3572 households with the total population of 15404, out of which 7011 are male and 8393 are female. The population density of VDC is 434 per square kilometre (NPHC, 2011). Various ethnic groups including Brahmins, Chhetries, Newar, Madhesis, Tamang, Ale, Pariyar and several other marginalized groups are inhabitants of the VDC. 79% of people living in Itahara are literate with primary, lower secondary, Secondary school and college education. Significant population group was found to be literate through several government initiated non-formal education programs. Most of the elder population above 60 years was found illiterate among marginalized ethnic groups.

3.2.3 Economic Activities

The main income source of the population is agriculture. However, the population is also dependent upon some other income sources such as foreign employment of members of family, retired pensions, government services, poultry farming, driving, shop keeping etc. The main crops in the VDC were found to be rice and maize in addition to flour, potato, vegetables, and several cash crops such as legumes, mustard. 87% of the households' heads

are male. Most of the of the total households use biogas as their main source of fuel for cooking purpose but fewer were observed using biogas as lighting source. However, alternative source of energy was observed to be biogas as lighting purpose along with solar energy utilization, particularly in load shading time. Most of the population living in the area are from middleclass families.

3.3 Research Process

Various ways and means of doing research are outlined in the research process. It includes selection of research philosophy, research methods and sampling (Blaxter *et al,* 2006). The outcomes of individual, social or organizational research on the same issue may give different result but the validity and reliability depends upon the presentation and analytical skills. Theory is the first step for any type of social or scientific research. The basic thinking and ideas related with actual problem and possible way of solution is given by theory and also plays the role of guiding principle while addressing any issue (Saunders *et al,* 2009).

The given issue is totally related on current social environment. The main issue of the research is the impact of biogas on women health and rural development. Here, the main theory is linked with the social needs and wants of people in current socio-economic environment. The question can be answered in number of philosophical options which may give different answers or solution for the research question. But in this research, realism philosophy is adopted because of its dynamic nature and is the combination of positivism and interpretivism philosophy. Some of the well known variables in this study were standardized which made author adopt positivist philosophy. Similarly, more complex and complicated social variables were aimed to solve following interpretivism which help to get more valid and comprehensive information. The main objective, following both the philosophies, was to find more valid and result with lesser errors.

3.4 Research Approach

There are two main different research approaches; inductive and deductive. In inductive approach we start with the observation and develop theories based on the observation. The information contained from the thorough research is considered to be bottom line which guides the entire outcome accordingly. In the deductive approach the research starts with the theories and hypothesis and try to falsify the hypothesis. In the other hand, theories are studied in the broader sense and are narrowed down in order to find out certain and more

specific problem. The deduction process is sequential and systematic. Goddard and Melville (2004) mentioned that these approaches are totally opposite to each other.

3.5 Research Design

The relations between phenomena and the occasions can be determined through appropriate research design. Mainly descriptive, explanatory and exploratory are three possible options to design a research work. If investigation on the same issue has been already well discussed in previous research, descriptive way of research design can be adopted. The researcher either manipulates the sources of information or the presents the variables in different ways on the basis of present information. Explanatory research design is much similar with descriptive research design but is mostly used for logical explanation of behaviour of only certain variables rather than minor comparison on the basis of available facts and figures (Bryman and Bell, 2007). Goddard and Melville (2004) stated that explanatory research design can be considered as the application of outcomes of some researches in a particular situation. If the variables under consideration are never researched before, exploratory designed is followed. The author has followed descriptive and exploratory research design in this research. Some of the international researchers have already conducted the researches on the use of biogas for rural development. However, in this research the author has intended to explore the impact on biogas on women health and their activity and daily needs.

3.5.1 Quantitative or Qualitative Method

Qualitative approach of research is used to collect information through direct social interaction. This method is used mostly in social studies. Qualitative method is relevant and suitable with social data gathering. Respondents are allowed to ask any question. This method is mostly used where there are more complicated and complex social variables. However, the method is more complicated and may go beyond the control if the researcher lacks perfection in the field (Silverman, 2004). Furthermore, it will be difficult to generalize the data collected since the method is not standardised. The nature of information gathered in this approach is narrative and hence cannot be verified through statistical analysis. The author used mainly quantitative method.

On the other hand quantitative method is used to convert complex and specific social information in numerical format. In this method, limited options of answers are provided to the respondents. In this research the author has followed quantitative method of research. There were various reasons for following this method. The study was conducted in a VDC in

Nepal and the timetable was limited. It was not possible for the author to afford high cost as well as spend long time in collecting information. The requirement of the course and content compelled the author not to follow more complicated and lengthy method, though it could be more valid and reliable. The author was able to test only the sample in the provided limited time period. Most of the data were processed and presented on numerical form.

Despite of having many benefits, quantitative method also has many loopholes. The information generated by quantitative method is in numbers and may not be sufficient (Allen *et al,* 2008).

3.5.2 Primary and Secondary Data

There are mainly two types of data in any research; secondary data and primary data. Secondary data is collected from secondary sources. Some other researchers had already collected those data. It is important to find out the validity of those data before using those data for any purpose in the research. It may be difficult for the author ascertain reliability of those data since the information collected may be for some other particular reason (Saunder *et al,* 2009). There are several sources of secondary data including various electronic and print media and online sources. Books, webs, journals, several statistical publications etc. are used as the main source of secondary data in this research. The journals and the other statistical publications are the main sources of secondary data obtained from online media during the research process. Secondary information was gathered from all those sources even before going to field to collect primary sources. Similarly, limited amount of information was collected from books available in the library and online. However, while gathering journals and books online and in conventional way, cost was the main challenge for the author. Some of the relevant article had to be left due to high amount of subscription charges to access journal sites. Limited number of books available on the issue raised was also a challenge to gather as much information as possible. However, author has tried to make the best use of available resources.

Primary data can be collected from direct observation, by sending questionnaires to the respondents or through direct physical interaction with the participants. The unique problem is solved by using unique data that can be obtained from primary source of information. In fact, the information collected from primary sources of data is the main intellectual property of any researcher. Primary information is collected with the main purpose of getting more customized information regarding the issue under consideration (Kumar, *et al,* 2005). The

most common tool to collect primary data is questionnaire. It is one of the important tools since respondents are fully aware of layout of the questionnaire. Questionnaire provides full privacy to respondents motivating them to express their views without any hesitation according to their best understanding. Lack of understanding capacity was another problem faced during data collection process. There were 5 different categories of questions in the questionnaire. The first part contained 9 questions intended to gather general information. Second category contained 11 questions directly related with biogas construction. Questions in the third category were used to get the information on biogas and health and included 7 questions. Fourth category, with 8 questions, was focused on activities and other engagement of respondent in the society. First category was used to get information from both biogas users and non-users, next three were asked only to those who were currently using biogas and the last category was used only for those who were not using biogas. The last category of the questionnaire contained 14 different types of questions. All categories contained multiple choices and some opened ended questions. Extra support was provided to make the respondent understand the questions. Means of interaction was in Nepali, but the data was translated to English since all the questions were developed in English language.

In conclusion, from questionnaire survey economic and social aspects as well as other aspects of the biogas plant were covered. The topics covered included (i) general demographic information (ii) live stock and related activities (iii) land holding (iv) occupation type (v) health and sanitation (vi) education status (vii) cooking and cleaning (viii) energy, especially fuel collection and use, and kerosene purchase and use and (ix) health of people

3.5.3 Sampling

Sampling design determines the process of selecting a sample from total population in selected study area. The researcher on best knowledge as well as on the basis of objective, application, reliability and validity chooses the sampling technique. The researcher decides the suitability of the appropriate sampling design techniques. A simple random sampling method was used. 4 villages from ward number 2, 3 and 4 with total of 210 households were taken first. Out them, 120 households were found to be users of biogas and remaining 90 were found to be non-biogas users. Out of the 120 biogas users, 50 users were finally chosen with the help of random sampling method using excel sheet. But only 40 were interested to answer. The remaining 10 showed time shortage or did not want to take part. Since they were given option and freedom to take part or not. Out of 25 households selected randomly from those

who were not using biogas only 20 household representatives were able to take part in the interview.

3.6 Data Analysis

In any research, data analysis is the most important part. Data analysis does not only give an overall idea about the research carried out but also contains the theme of the entire research (Donaldson *et al,* 2008). The data were systematized and summarized and organized in tables and graphs. Microsoft Excel has been used for the meaningful presentation of data obtained.

3.7 Validity

Sauders *et al* (2009) mentioned validity of data as the level of correct instrument of study. The aim of the author in this study was to use ways and tools of the study to get more current results which relate objectives. Data validity measurements were considered in three main ways. Content validity was the first which mentioned if instruments provide adequate coverage. The sample in the study was nearly 30% reducing the probability in sampling error. All the objectives are covered by the literature used in the second chapter, and the literature have been taken from valid academic sources. Similarly, criteria related validity is the second way of measuring validity that states the level of reflection of current study. And finally, construct validity compares the current study with already determined result or with some benchmark. In this study, theory has been considered as the benchmark. The gathered and processed data from practical situation have been compared and contrasted with the empirical research presented in literature review section.

3.8 Data Reliability

The quality of data if the same process of experiment is repeated frequently with the similar result is called data reliability (Saunders *et al,* 2009). Time, available resources, facilities, design of the result, cost and many other external factors impact validity of any research. It is important for a research to be reliable to take it into another situation. The author has applied measures to ensure reliability of the outcome. The first is the research design, which is more appropriate with the nature of issue. Respondents were encouraged to provide their views with best understanding and were also provided with enough space and time to answer the questions in the questionnaire in friendly environment. Individual interview was taken separately so as to minimize chances of influence of one another's responses. Regardless, the author has doubts that if other studies are to be conducted in a similar environment but different time intervals, the outcome could be different due to social environment and setting.

However, the author is confident that if another study is carried out in similar time interval and environment, the outcome would be same.

3.9 Ethical Consideration

Consideration of ethics as well as application is vital while collecting information from human being in social study (Donaldson *et al*, 2008). The study can be made more beneficial for society through the use of ethical application. There should not be harmed in any aspect. Various measures have been applied to make sure that the study is meeting all ethical requirements.

- The confidentialities of each member of respondent were kept secret
- Interviewees were free to refuse or could say no or skip while answering any question.
- Friendly environment was created during time of interview
- The purpose of the study was fully explained to all the respondents and other concerned people
- All concerned, including respondents were thanked after the completion of interviews
- Interviewees were encouraged to feel free to ask the question in simpler ways
- They were assured that they were not obliged to answer the questions but were asked with due respect from the author
- The sources of secondary data are fully credited along with the required citation
- Direct or indirect impacts of research component on any individual organization has been taken into account and have been avoided

3.10 Limitation of the study

- The study analyses and represents only a small percent of the total plant holding in Itahara VDC
- Due to the time and financial constraint, this study has been carried out within a narrow framework. Hence, generalization at the national level is not advised and may not be valid
- Data, used and derived are as recent as could be collected but since not much has been done on this aspect, within the country, these may not be up-to-date
- In terms of deeper analysis, this study will be limited, as only a few variables have been chosen to be analyzed, out of the innumerable variables concerning the impact of these plants

- The analysis of data is mainly based on averages and percentages. As more complex and sophisticated tools have not been adopted; finding of this study may be considered tentative
- The analysis on health impact on women, gas use and slurry production have been completely based on the approximations made by the respondents as per their memory, since exact record was not kept and exact measurement was not possible
- Youth mobilization, GO/NGO/INGO working in the field of health, women empowerment (excluding women health awareness) and different ways of poverty alleviation through biogas has not been considered in the study.

Chapter 4: Result

4.1 Demographic Analysis of Respondents

Out of 60 respondents interviewed during this study, 40 were from Biogas Households and 20 from Non-Biogas Households. 10 percent of the respondents from the biogas households were male and 90 percent were from female in this study. Similarly, 25 percent were male and 75 percent female from non-biogas households. The detailed results are presented on table 4.1. However, marginalized Dalit people represented only 5% on non-biogas users.

The major age group of the respondent was between 26 to 55 years with total of 77.5 percent in biogas users. Only 20 percent of the respondents from biogas households were above 55 years but there were none above 55 and below 25 in non-biogas users. 97.5 percent and 100 percent respondents were married in biogas households and non-biogas households respectively. The total population of 60 sample households (40 having biogas, 20 without biogas) is 280; of which 64.28 % belong to the households having biogas. The female population in these households is 51 %. The average family size of plant owner households is 4.5, which is not so much larger than the national average size. Similarly, the family size of without biogas households is 4.75 which is comparable to the national average. The number of members in the family ranges from 3 to 8. It is found that among the total population 43 persons are residing outside of the country. Table 4.1 shows the population pattern of the sampled households.

Educational status can affect the biogas installation. The majority of the households' heads are literate in both biogas users and nun-users households. . Educational status of 90 percent of biogas users was literate and 10 percent was illiterate whereas 85 percent non-biogas households were literate and 15 percent were illiterate as table 4.1 shows.

Table 4. 1 : Demographic Analysis of the respondents

Particulars		Biogas Households		Non-Biogas Households	
		No. of Respondents	%	No. of Respondents	%
Sex	Male	4	10	5	25
	Female	36	90	15	75
Literacy	Literate	32	80	17	85
	Illiterate	8	20	3	15
Ethnical Groups	Brahmin and Chhetris	30	75	10	50
	Newar	6	15	5	25
	Rai, Limbu, Gurung etc.	3	7.5	4	20
	Madhesis	1	2.5	-	-
	Others (Dalit)	-		1	5
Age Group	15-25 years	1	2.5	-	-
	26 to 35 years	10	25	4	20
	36 to 45 years	8	20	13	65
	46 to 55 years	13	32.5	3	15
	55+	8	20	-	-
Marital Status	Married	39	97.5	20	100
	Single	1	2.5	-	-
Family Size	1-5	30	75	8	40
	6-7	7	17.5	10	50
	8-9	3	7.5	2	10
	>9	0	0	0	0
	Average		4.5		5

Source: Survey 2013

Figure 4. 1: Diversity of respondents on the basis of ethnicity

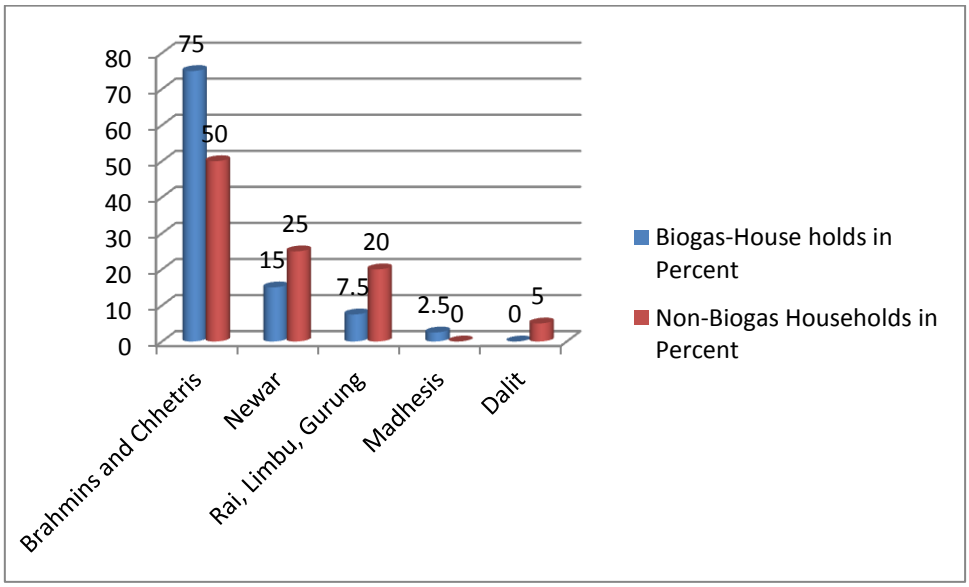


Figure 4. 2: Age diversification of respondents

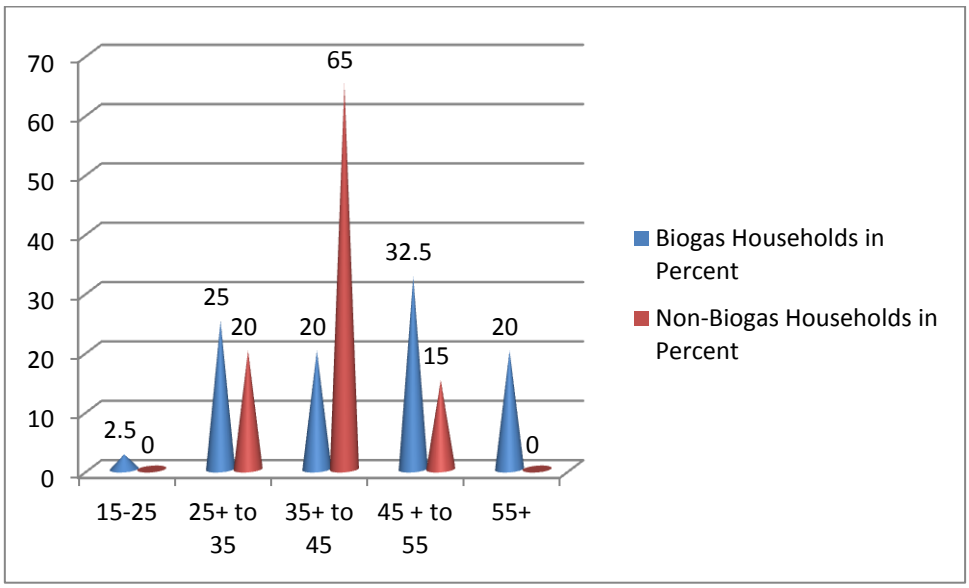
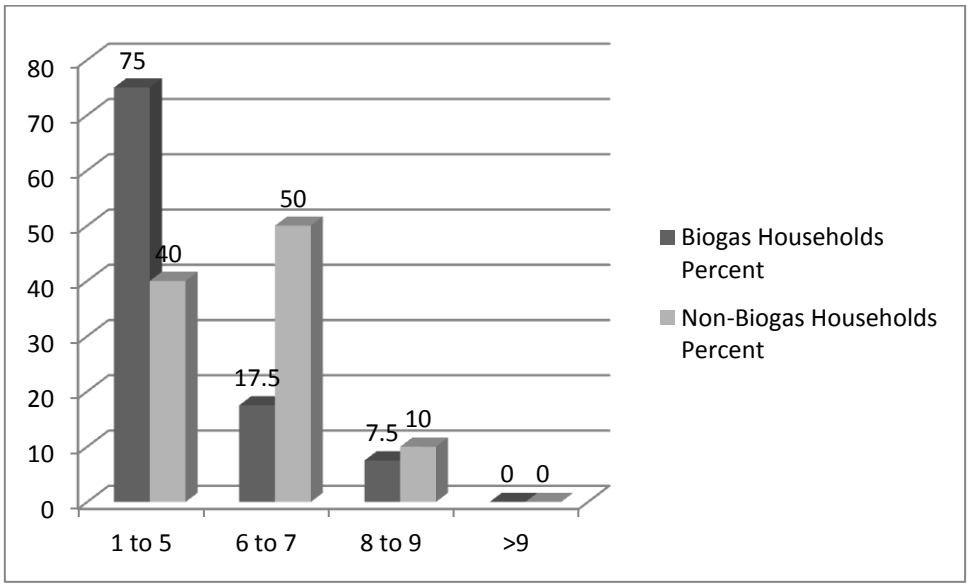


Figure 4. 3:Distributions of family members in sampled households

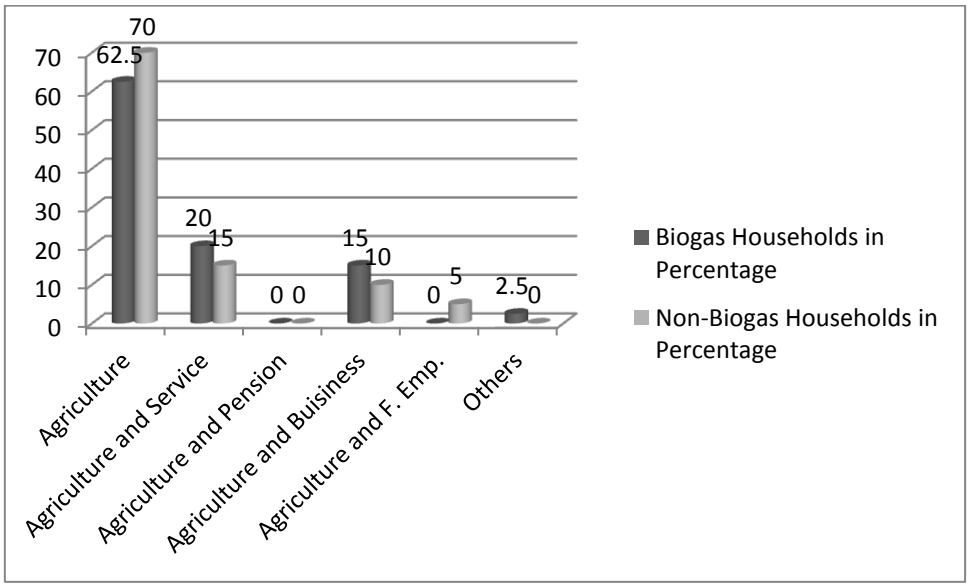


4.2 Analysis Economic Status

4.2.1 Occupation

Agriculture and animal husbandry is directly related to the installation of biogas plants, since biogas plant needs dung to feed the bio-digester, while bio-slurry produced as a by-product can be used as fertilizer in the farm. Survey of the occupation shows agriculture as the main occupation of the area in both types of households, biogas users and non-users (62.5% for biogas users and 70% for non-users). 100 percent in total respondents derived their livelihood from farming and farm labour either partial or full source of income. Agriculture is not only the main occupation of the majority of the household but also the major source of livelihood for their family. Besides agriculture, the stated main occupations of the biogas households' are agriculture and service (20 %), and only 15 percent are involved in agriculture as well as business. Similarly, 15% biogas non-users are engaged in agriculture as well as service and only ten percent of biogas non-users households' are engaged in agriculture and business.

Figure 4. 4: Distribution of respondents according to their occupation



4.2.2 Land holdings Pattern

Land is the main resource of the rural people. The possession of land and animal indicates the wealth of the rural people. It was also seen from many studies that those who have large land holding keep more cattle and they have therefore enough material to feed the biogas plant. In this study, only operational land holdings were taken into account. The land use and cultivation patterns are observed to be very similar to that of the traditional Nepalese practice. It is found in most of the cases that the owners themselves cultivate the land. There are very few instances of land being rented. The average land holding size per family is 1.3 bigha (1 Bigha or 20 Kattha = .677263 hectare = 1.6735 acre). The figures on land holdings are shown in Table 3. The maximum land holding in having biogas HH is 3 bigha and the minimum is 0.4 bigha (8 Kattha).

Table 4. 2 : Land Holdings

Land Holdings	Biogas Households		Non-biogas Households		Total	
	No. of	Percentage	No. of	Percentage	HHs	Percentage
Up to 10 Kattha	4	10	9	45	13	21.67
10 to 20 kattha	12	30	8	40	20	33.33
>20 Kaththa	24	60	3	15	27	45

Source: Filed Survey 2013

4.2.3 Comparison of live stock

The main source of raw material to produce biogas is the number of live stocks held by the users. It seems that all of the respondents keep live stock in. Major households have cow as their main type of live stock with 60% and 80% in HH with biogas and HH without biogas respectively.

Table 4. 3 : Live Stock

Live Stock	Biogas Households		Non-biogas Households		Total	
	Number	Percentage	Number	Percentage	Number	Percentage
None	-	-	-	-	-	-
Buffalo	2	5	2	10	4	6.67
Cow	24	60	16	80	40	66.67
Both	12	35	2	10	14	23.33
Others	-	-	-	-	-	-
Total	40	100	20	100	60	100

Source: Filed Survey 2013

4.2.4 Comparison of household type

One of the determinators of economic status of any family is household type. Usually in rural areas people construct their houses in three major ways; concrete, mud and brick and hut which is the combination of mud and thatch. It is found that major types of household were made from mud and brick with the total of 45% followed by hut (28.33%) and concrete (26.67%). The detailed information of households' comparison is presented in Table 5 and fig 4.7. More non-biogas users are found with mud and brick houses than biogas users.

Table 4. 4: House Type

House Type	Biogas Households		Non-biogas Households		Total	
	Number	Percentage	Number	Percentage	Number	Percentage
Concrete	12	30	4	20	16	26.67
Mud & Brick	16	40	11	55	27	45
Hut	12	30	5	25	17	28.33
Total	40	100	20	100	60	100

Source: Filed Survey 2013

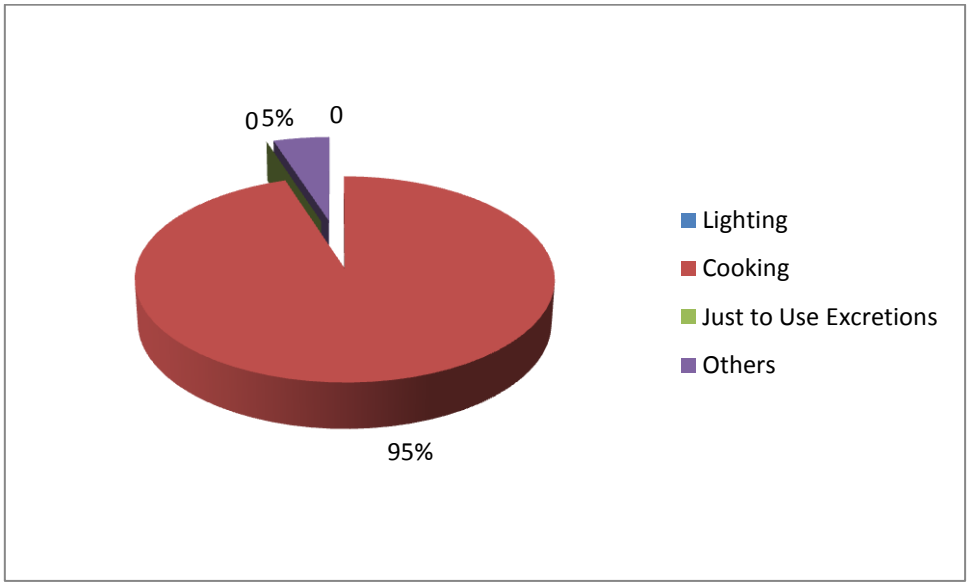
4.3 Biogas Use and Installation

This section, the variables were collected only from those using biogas as their source of energy. Several multiple choice questions were asked in relation with purpose of using biogas, reason of using biogas, size of biogas etc.

4.3.1 Purpose and reasons of biogas installation

95% of the respondents answered that the purpose of using biogas was just for cooking. Only 5% of the respondents were found using biogas for both lighting and cooking. Similarly, the main reason to make respondent use biogas was found to be rumours (70%) and 27.5% were inspired by others such as technician, neighbour, health consciousness and lack of firewood (Table 6).

Figure 4. 5: Purpose of using biogas

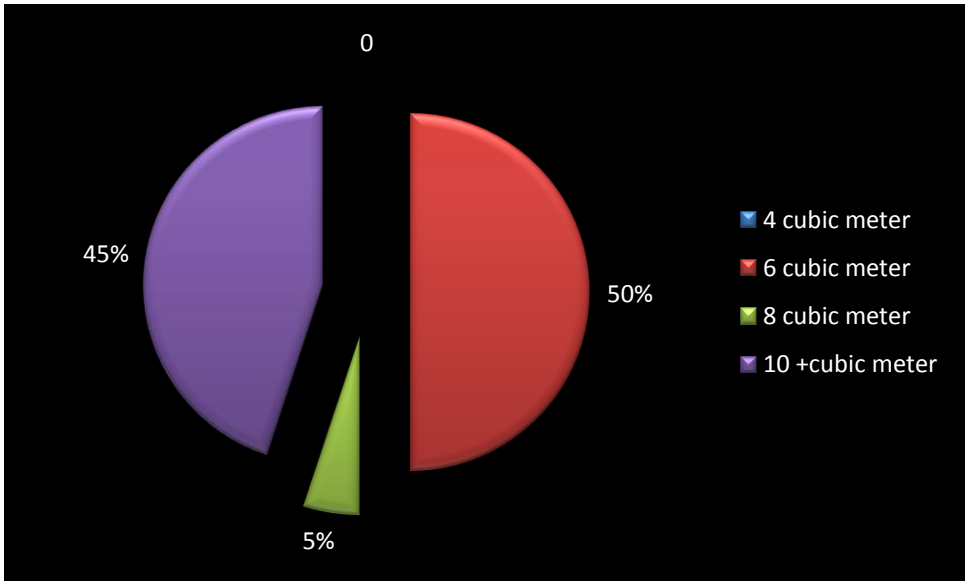


4.3.2 Size of Biogas

All the 40 sampled plants are of a fixed concrete dome design adopted from a Chinese biogas plant. In this type of design, the plant remains constant but the gas pressure varies. This type of plant can be constructed at the site with the locally available materials excluding cement. This design is popular in this VDC as well as all over the country. The schematic diagram of dome-design plant is given in Annex 2. Among the 30 sample households, four sizes of biogas plants, $4m^3$, $6m^3$, $8m^3$, and $10m^3$ are reported. The majority of the biogas plants are of

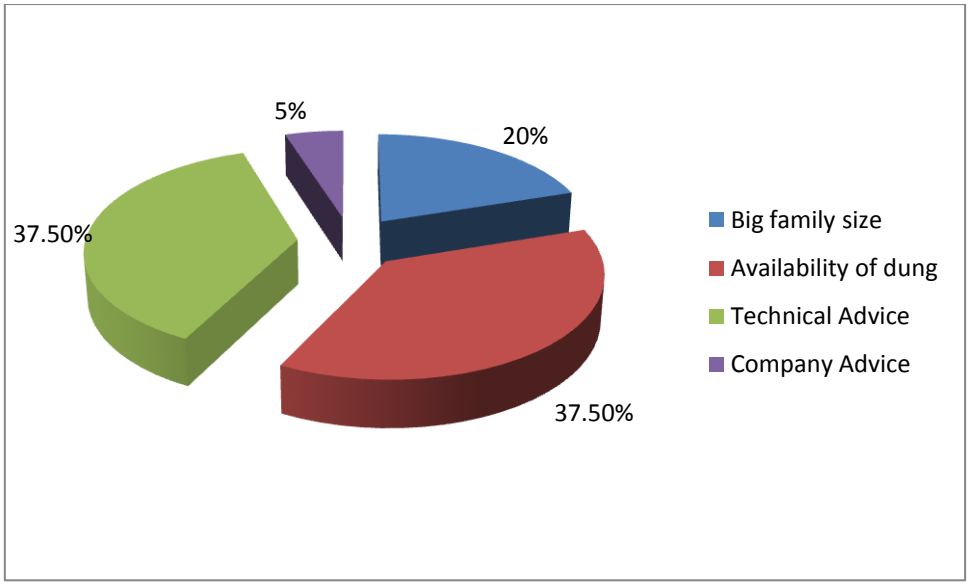
6m³ (50%) and 10m^3 (45%) capacity. Only 2 households have 8m^3 (Table 7). None of the respondents were found using less than 6m^3 size of biogas plant.

Figure 4. 6: Size of biogas plant



The main determinant of biogas plant size was found to be availability of dung (37.5%) and technical advice (37.5%). There was not any role of ample space, bank's advice, required number of stoves and lamps or any financial reason to determine the size of plant installed.

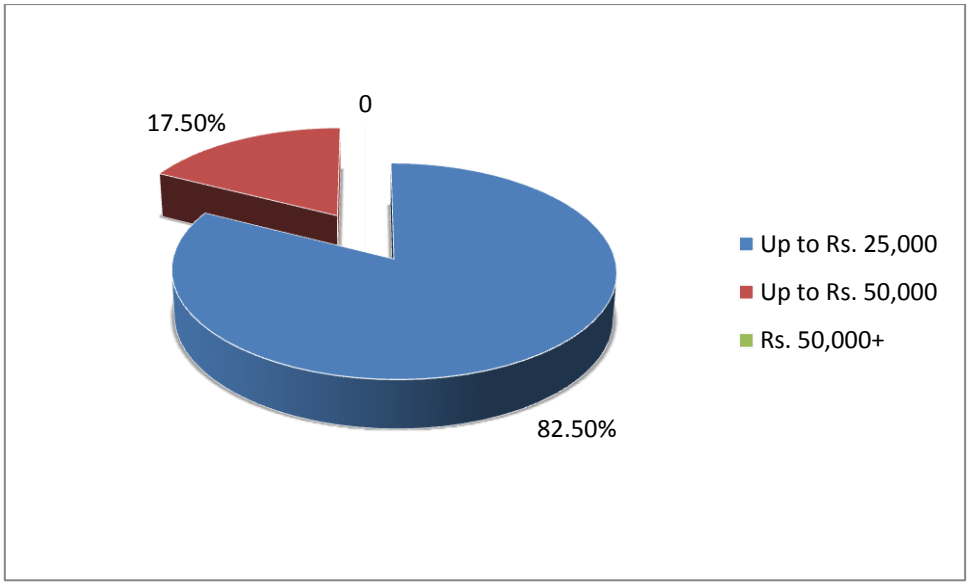
Figure 4. 7: Plant size determinant components



Another component on biogas installation is the cost incurred. 33 (82.5%) of the respondents were found spending up to Rs. 25,000 where none of them was found spending more than Rs.

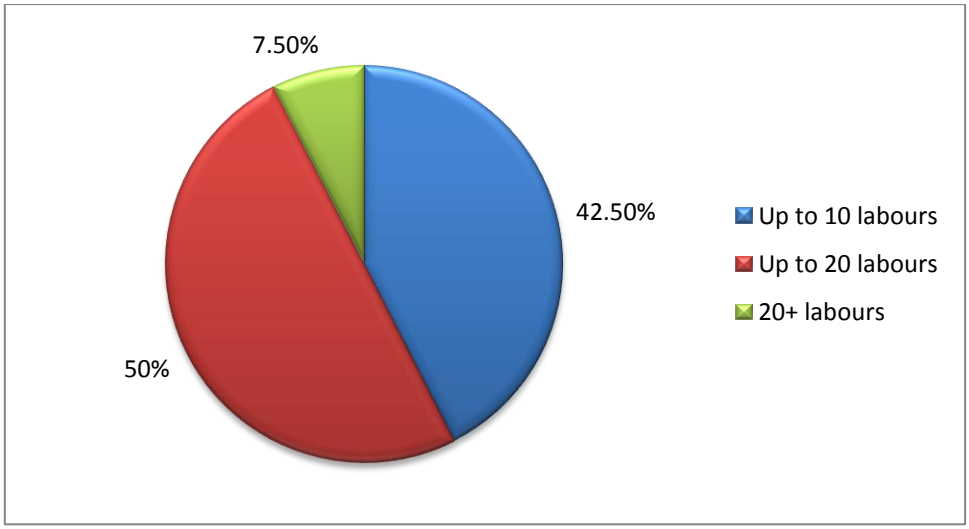
50,000 on installing a biogas plant. Only 7 (17.5%) respondents replied that they spent between Rs 25,000 to Rs 50,000 on biogas installation.

Figure 4. 8: Total cost of Plant



The number of labours for construction of biogas plant was calculated for entire process of installation requirement. 42.5 percent of respondents were found hiring up to 10 labours while 50 percent of the respondents were found hiring more than 10 but less than 20 labours. The number of labours was calculated in total. For example, if 3 labours worked for 4 days then the number of mandays was 12.

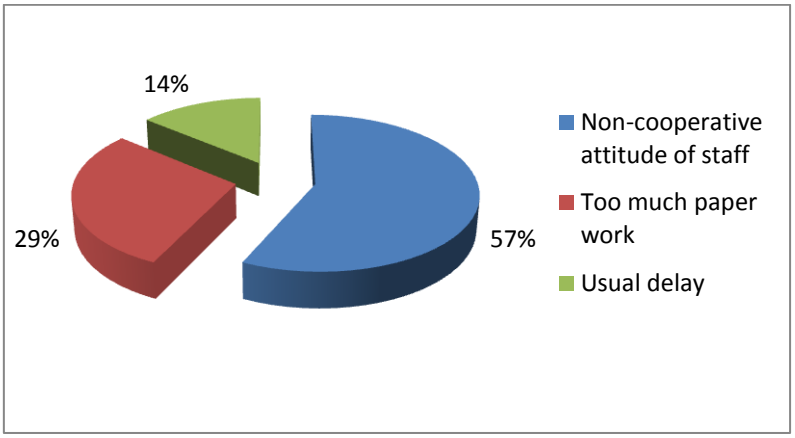
Figure 4. 9: Number of mandays for construction of biogas plant



4.3.3 Loan Funding

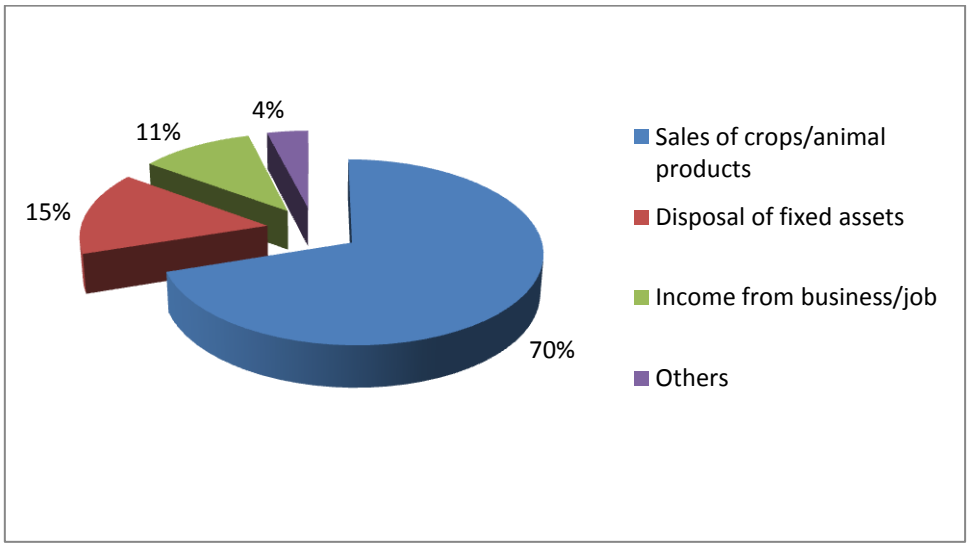
Out of 40 respondents, 67.5 respondents were dependent upon loan funding for biogas installation. However, 26% of the respondents complained about the loan funding. Major problem of loan funding was found to be non-cooperative attitude of staff (57%) and the next was followed by too much paper work (29%). Quick loan was provided particularly from local banks, finances and co-operatives with high interest rate (up to 18%). A loan from government was another option with low interest rate but it was a lengthy process to obtain such a loan. Secured and unsecured loan was provided to the users. Paper work included the recommendations from Village Development Committee, approval for the low interest rate from local authority, assessment from biogas companies for installation. The process would have to be repeated if not accepted by the authorised government officials.

Figure 4. 10: Factors of Loan Problem



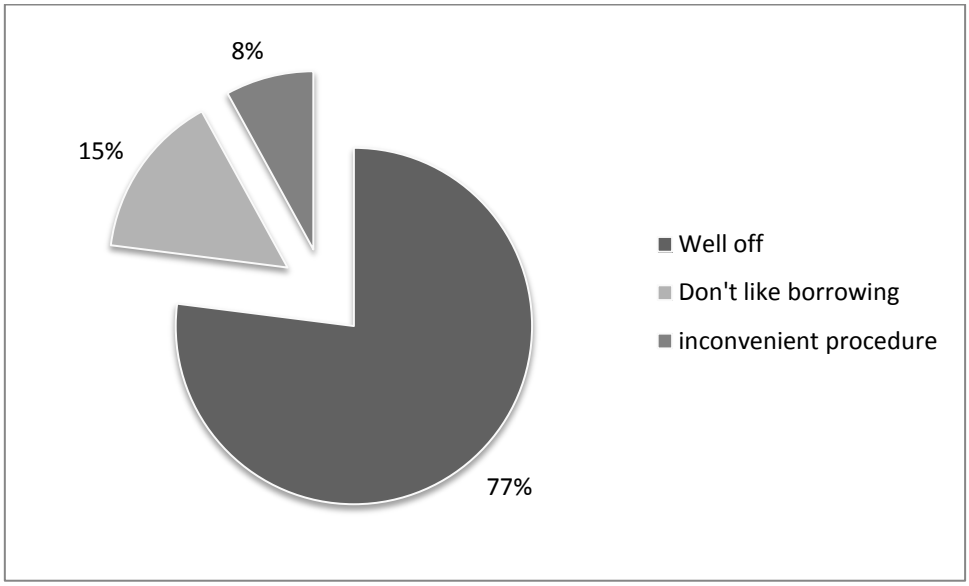
The major source income for repayment was found to be sales of crops and animals (70%) followed by disposal of fixed assets (15%), income from business (11%) and other sources (4%).

Figure 4. 11:Source of loan repayment



77% of the respondents who did not take loan were found to be well off while 15% did not like borrowing and 8% did not like to borrow due to inconvenient loan procedure. There was no other source of borrowing apart from loan.

Figure 4. 12: Reason for not taking loan



4.3.4 Other aspects of biogas installation

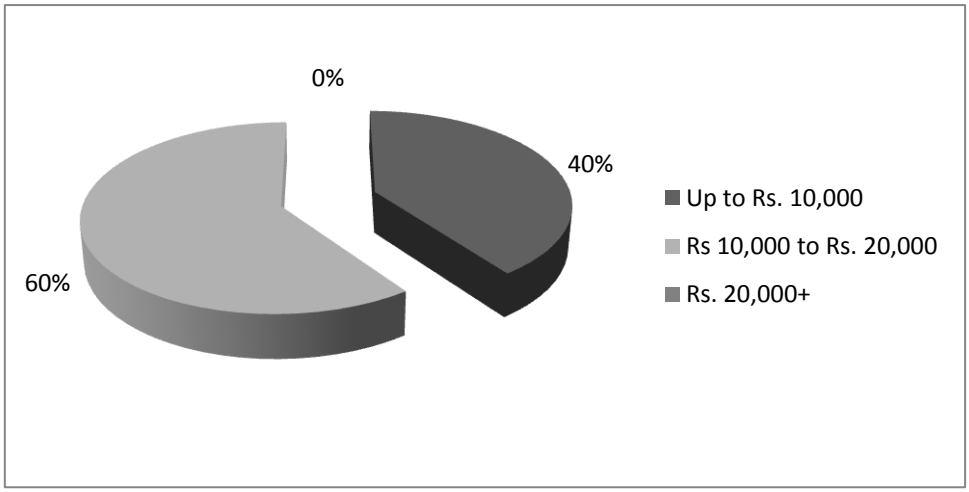
a. Source of water

The main source of water was found to be underground pump (95%) while remaining was public water supply. There was no other source of water to use in biogas plant.

b. Expenditure on chemical fertilizer

Cow dung or other similar organic fertilizers are used in the farm. Cow dung can be to produce gas and the slurry can be used as the fertilizer in the field. The maximum numbers of respondents (60%) were found spending an amount between ten thousands to twenty thousand rupees on mineral fertilizer. No one answered of spending more than Rs. 30,000.

Figure 4. 13: Expenditure on Chemical Fertilizer



c. Training provider

None of the government organizations were found providing training to the respondents. Family, friend and neighbour (37.5%) were found as the main source of training provision to run biogas plant. The detailed outcome is presented in Table 9.

Table 4. 5: Training Provider

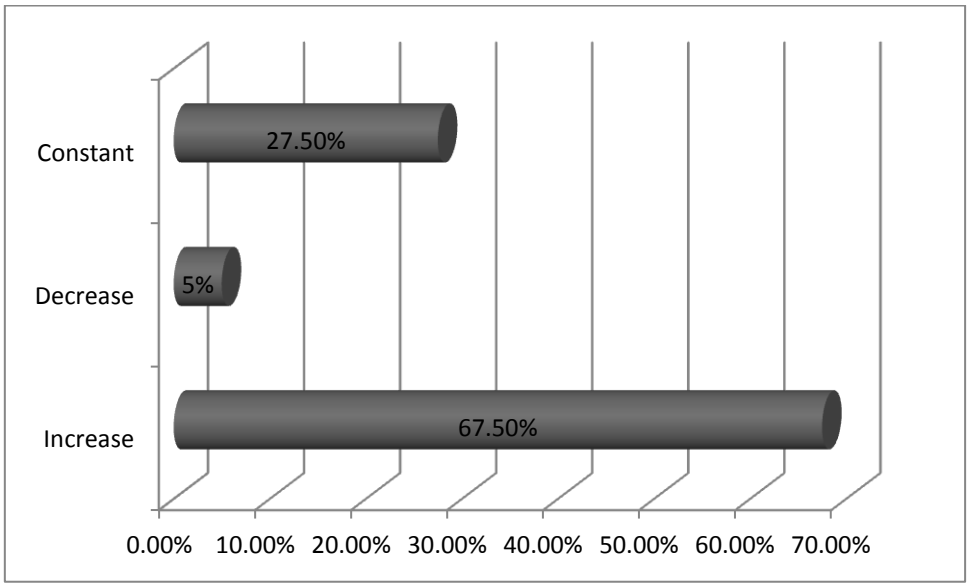
Particulars		Number of Households	Percentage (%)
Training Provider ***Others: Technician= 9** **Self= 1** **No Training= 6** **Did not participate= 2** **Total= 18**	Government	-	-
	NGO/INGO	7	17.5
	Family/Friend/Neighbour	15	37.5
	Others	18	45

Source: Filed Survey 2013

d. Change in Income after using biogas

The saving due to reduction on expensive energy cost and fertilizers is important. However, due to raw material requirement and time allocation for biogas plant, there the chance of reduction on income; means increment on expenses. 67.5% of respondents reported an increase in income after installation of biogas plant while only 5% complained about reduction on income after installation. 27.5% were found with constant income even after the installation of biogas.

Figure 4. 14: Increase/Decrease on income after using biogas



4.4 Health and Hygiene

4.4.1 Main reason to use biogas

Shortage of firewood is the reason for 65% of the total biogas users for using biogas. 17.5% were found to be aware of the hygienic advantage of using biogas and hence replied cleanliness and to stay hygienic as the main reasons of using biogas. In the same time 15% were found using biogas to save time.

Table 4. 6: Reason of using biogas

Particular		No. Of House holds	Percentage
Main Reason to Use biogas	Time saving	6	15
	Clean and hygienic	7	17.5
	Shortage of fire wood	26	65

	Others ***(Got information from pvt. Co.)**	1	2.5

Source: Filed Survey 2013

4.4.2 Health and Hygiene

All the respondents were asked about their health and hygienic conditions and other health related problems. Average number of washing of an individual respondent was found to be 2.5 times a day while average bathing was found to be 0.5 times a day which means once in two days. After installing biogas 98% respondents perceived that respiration has been easier while only 2% replied that it has been difficult. The reason is that they avoid the smoke from burning firewood. The level of cold and coughing was found decreased by 95% after the installation of biogas plant for household purpose. All of the respondents answered that they sometimes suffer from fever but were not sure about the frequency (Table 4.7)

Table 4. 7: Health and Hygiene

Particular			No. Of House holds	Percentage
Health and Hygiene	Hygienic condition	Average Washing: 2.5 times a day	×	×
		Average Bathing: 0.5 times a day		
	Respiration	Easy	39	98
		Difficult	1	2
	Cold cough	Increase	2	5
		Decrease	38	95
	Fever	Usually	0	0
		Sometimes	40	100

Source: Filed Survey 2013

4.4.3 Number of Health visits in a year

Out of total respondents using biogas plant, 82.5% were found visiting health clinics for health check up. 35% of the total respondents were found visiting for health check up at the range of one to five in a year. The detailed information is presented in Table 13.

Table 4. 8: Number of health visits in a year

Particular		No. Of House holds	Percentage
Health visit?	Yes	33	82.5
	No	7	17.5
Number of Health visit in a year	0	7	17.5
	1-5	14	35
	6-10	10	25
	10+	9	22.5

Source: Filed Survey 2013

4.4.4 Other health problems

Respondents were asked about the health visits. The major health problems were gastritis/ gastro- enteritis, asthma, leg pain, joint pain, back pain, normal health check up, headache, eye problem, fever, knee pain, women's internal problem, pain in bone and respiration. However, it was found that 90% of the respondents said that the number of health visit due to asthma and respiration has been reduced after the installation of biogas. Similarly, 80% mentioned reduction of eye problem after installation of biogas. Apart from those, other types of health problem in family members were knee pain, allergy, blood pressure high/low, diabetes, uterus problem, weakness etc.

4.5 Household Activities

4.5.1 Cooking and cleaning

It is important to know about the household activities and the impact of biogas installation on household activities. 100% respondents answered that the female member is involved in cooking. Average hours on spent on cooking before biogas was found to be 4.3 hours per day, while only 2.5 hours per day was spent in the kitchen after installation of biogas. Similarly time spent on cleaning utensils was found to 2.5 hours per day before biogas installation and 1.2 hours per day after biogas installation.

Table 4. 9: Cooking and cleaning

Particular		No. of Households	Percentage
Who Cooks in Family?	Female	40	100
	Male	0	0
Time Spent for cooking	Average Hours Before biogas: 4.3 hours per day Average Hours After biogas: 2.5 hours per day	×	×
Utensils cleaning time	Average Hours Before biogas: 2.5 Average Hours After biogas: 1.2	×	×

Source: Filed Survey 2013

4.5.2 Time spent after biogas saving

Table 14 shows the time saved after use of biogas. 63% of the respondents were found spending time saved due to biogas installation on farm work while 22% spent their saved time on child care. 10% replied that the time saved by biogas was spent on business and only 5% mentioned about social activities. 93% of the respondents mentioned increase in child care time while remaining was found without child at home.

Table 4. 10: Time spent after biogas saving

Particular		No. of Households	Percentage
Time spent after biogas saving	In farm work	25	63
	Child care	9	22
	Service	-	-
	Business	4	10
	Social Activities	2	5
	Development works	-	-
	Others	-	-
Child care time after and before **No child = 3 HH**	Increase	37	93
	Decrease		

Source: Filed Survey 2013

4.5.3 Daily biogas maintence

Daily maintence on the biogas plant was studied. 68% of biogas users were found spending less than an hour on daily maintence while 32% spent more than an hour but less than 2 hours every day. None of the respondents were found spending more than an hour to set up biogas.

Table 4. 11: Time spent to run and daily maintenance of biogas

Particular		No. of Households	Percentage
Everyday	< 1 hour	27	68
	> 1 hour	13	32

	>2 hours	-	-
	>3 hours	-	-

Source: Filed Survey 2013

4.5.4 Other activities

63% of respondents were found spending their time on assisting on household works while 20% replied that they spend their remaining time for social/community service. The detailed information is presented in Table 4.12. The comparison is analysed critically in next chapter.

Table 4. 12: General activities

Particular		No. of Households	Percentage
Time spent in other activities	Support to family	4	10
	Social/ Community service	8	20
	Education	1	2
	Assisting on household works	25	63
	Others	2	5

Source: Filed Survey 2013

4.5.5 Comparison on different activities time

100% respondents were found spending their more time in social work after biogas installation. Similarly, same number of respondents also replied that their business work time has been increased after biogas installation. None of the respondents were found taking part on service work.

Table 4. 13: Comparison of activity time

Particular		No. of Households	Percentage
Social work after biogas	Increase	8	100
	Decrease	0	0
Business work after biogas	Increase	6	100
	Decrease	0	0
Service work after biogas	Increase	-	-
	Decrease	-	-

Source: Filed Survey 2013

4.6 Biogas Non-Users

In this section the data shows the outcomes obtained from biogas non-users. The information was collected to find out the reason of not using biogas, their health and hygiene conditions, fertilizers they use in farm, whether there was anything aspect to inspire them to use biogas, their health and hygiene awareness etc.

4.6.1 Reason of not using biogas

40% of the respondents informed that the costs to install biogas plant were too high, 20% did not have any interest, 20% replied due to lack of dung and remaining answered some other reasons.

Table 4. 14: Reason of not using biogas

Particulars		No. Of households	Percentage
Reason of not using biogas	Cost	8	40
	No interest	4	20
	Lack of dung	4	20
	Others	4	20

Source: Filed Survey 2013

4.6.2 Any inspiration to install biogas?

35% of the respondents replied that they were not inspired by anyone to install biogas. 20% were inspired due to rumours in the society but still did not install the plant. The main sources of inspiration were neighbours and technicians. There was no evidence of government programs or advice from NGO/INGO involvement

Table 4. 15: Inspiration source

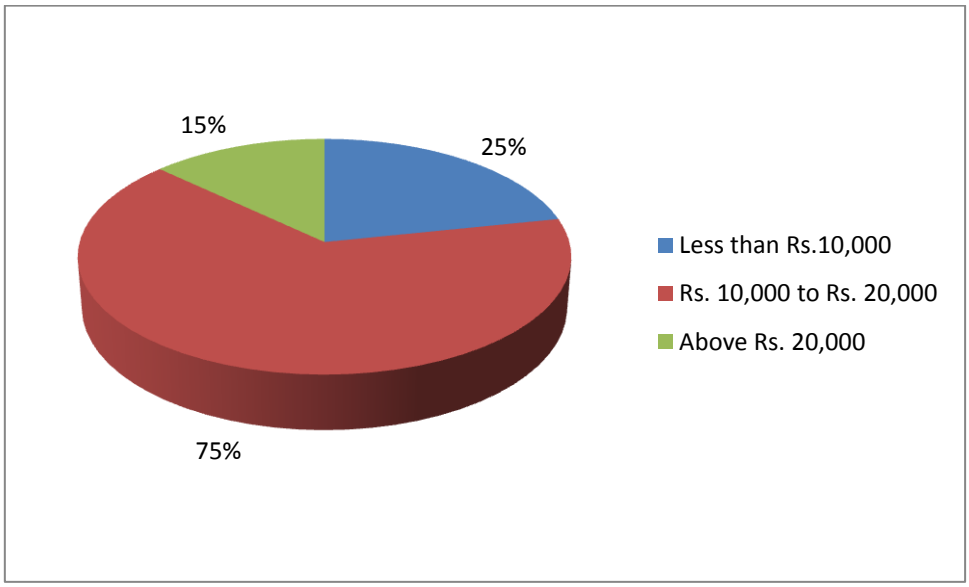
Particulars		No. Of households	Percentage
Who inspired you to install biogas ****Others refers to Technician, neighbours etc.**	Government Programs	-	-
	Rumours	4	20
	Advice from NGO/INGO	-	-
	Others	9	45
	None	7	35

Source: Filed Survey 2013

4.6.3 Expenses on chemical fertilizers

The biogas non-users were also asked about their expenses in relation with chemical fertilizers. 25% of the respondents were found spending up to Rs. 10,000 on their chemical fertilizers and 75% were found spending up between Rs 10,000 and Rs. 20,000. Similarly, 15% of the respondents were found spending up between Rs. 20,000 and Rs. 30,000. None of the respondents were found spending more than Rs. 30,000.

Figure 4. 15: Expenses on Fertilizers



4.6.4 Hygiene and Health

Biogas non-users were also asked about their general health and hygienic conditions. Average washing was recorded only 3 times per day while average bathing was found to be 0.45 time a day. In the case of opinion on own health, 65% percent of the respondents were without respiration problem while 35% of the respondents reported respiration difficulties. 70% of the respondents were found with cold and coughing problems. 40% of the respondents complained about their usual suffering from fever while 45% were found with fever sometimes. 15 percent of the respondent did not have any health problem in last 12 months.

Table 4. 16: Hygiene and Health

Particulars			No. Of households	Percentage
Hygienic condition cleanness		Average Washing: 3 times per day	×	×
		Average Bathing: 0.45 times per day		
Health Feeling	Respiration	Easy	13	65
		Difficult	7	35
	Cold/Cough	Yes	14	70
		No	6	30
	Fever	Usually	8	40
		Sometimes	9	45
	Others	**No problem**	**3**	15

Source: Filed Survey 2013

95% of the respondents were found visiting health posts while 5% were found not visiting health post for a single time. 80% of respondents replied that they visit health clinics at the

range of one to five times in a year. 15% were found visiting up to ten times in a year. None of the respondents were found visiting more than ten times in a year.

Table 4. 17: Health Visits

Particulars		No. Of households	Percentage
Do you visit health post?	Yes	19	95
	No	1	5
No. Of Health Visit in a year	0	1	5
	1-5	16	80
	6-10	3	15
	10+	0	0

Source: Filed Survey 2013

The respondents were asked to express other reasons for visiting health clinics. Urinary problem, fever, stomach pain, cold, leg pain, eye problem, chest pain were the main problem making them visit health clinics. Out of them chest pain and fever caused the highest number of health visit (80%). The respondents' family members suffered from other health problems such as gastritis, sweating from body, back pain, pain in bone, pressure, children problem, knee pain etc.

4.6.5 Cooking and Cleaning

One of the major tasks of women in rural areas is cooking. 100% of the respondent answered that the female member of their family are directly involved in cooking. Average hours on cooking were calculated to be 4.4 hours a day. This cooking time included collecting firewood fuel before starting cooking. 20% of respondents were found spending an hour in cooking, while 15% were found spending more than an hour and less than 2 hours in cooking. 65% of the respondent replied that the female member of their family spend more than 2 hours in cooking. Similarly, average time of cleaning utensils was calculated to be 3 hours per day.

Table 4. 18: Cooking and cleaning

Particulars		No. Of households	Percentage
Who cooks in family?	Female	20	100
	Male	0	0
Time spent to cook in a day Average hours on cooking: 4.4 hours a day	1 hour	4	20
	1 hour to 2 hours	3	15
	2 hours +	13	65
Average utensils cleaning time: 3 hours a	×	×	×

day			

Source: Filed Survey 2013

4.6.6 Installation of biogas

Respondents were asked about their intentions of installing biogas in the future. 60% of respondents replied that they are planning to install biogas in the future while 40% replied they have not thought about installing biogas. Various components were identified as the attracting features of biogas installation. 50% of the respondents were found that they were installing biogas just to show off in the society. Time saving, hygiene awareness and lack of firewood were the other main three reasons of installing biogas with 16.67% respondents on each.

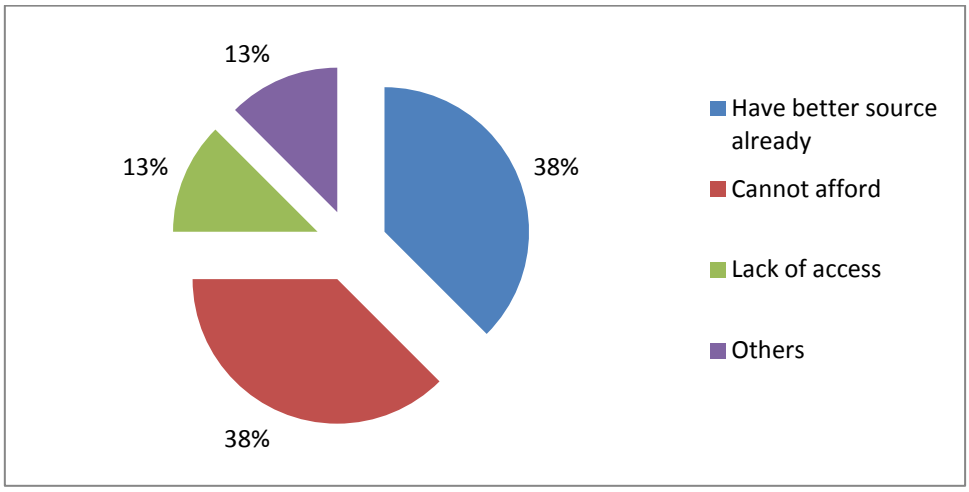
Table 4. 19: Installation of biogas in the future

Particulars		No. Of households	Percentage
Are you going to use biogas in the future?	Yes	12	60
	No	8	40
Reasons for installing biogas	To show off	6	50
	For time saving	2	16.67
	Hygiene awareness	2	16.67
	Promotional programs	-	-
	Others **(Lack of firewood)**	2	16.67
The reason not to install biogas in the future	Have better source already	3	37.5
	Cannot afford	3	37.5
	Lack of access	1	12.5
	Others **(No idea about Bio gas)**	1	12.5

Source: Filed Survey 2013

The respondents were furthermore asked about the reasons for not installing biogas in the future. 37.5% of respondents were found to have a better source of energy making them not interested in biogas. Electricity and LPG gas were the better source for them. Lack of funds was found among 37.5% of the respondents not planning to install biogas in the future. The detailed information is provided in Table 4.19.

Figure 4. 16: The reason of not installing biogas



Chapter 5: Discussion

5.1 Introduction

This chapter discusses the results and the information collected to help us achieve the goal of the research and accomplish the objectives. Three main objectives of the research were to:

- Explore the impact of biogas in rural development
- Examine health and environmental impact of biogas on women and
- Explore the time of women spent in productive activities.

5.2 Demographic Analysis

The outcome of the research presented in chapter 4 reveals that 90% of the respondents of biogas users and 75% of the respondent of non-users are female. This shows active participation of females in the survey. The female participants were found to be actively involved in collecting information. This also shows the importance of biogas for females However, chance of lesser reliability could be due to significantly low participation of male participants. It could possibly include in some biases. More than 80% of respondents were literate with varying educational qualifications. This indicates their capability to deal with new technology. The research also had participation from a diversified ethnic group.

Most of the respondents were in the age group 26 – 55 years. Almost all of the respondents were found to be married, and had broader knowledge of the family's economic status. The average number of members in a family was found to be 4.75

5.3 Contribution in Economic Status

67.5% of the households have increased their annual income after installation of biogas plant. 27.5% experienced constant income even after installation. This shows that biogas installation can improve the households' economic situation.

5.3.1 Relation of Occupation and Biogas

The major source of income for 62.5% of the biogas users and 39% of non-biogas users' was found to be agriculture. Nearly, 100% of the respondents had agriculture as the major source of income, followed by business or external employment.

The biogas users can use the biogas waste as organic fertilizer (it may not be an aim to reduce mineral fertilizer as mineral fertilizer and organic fertilizer may work well together). The slurry from biogas may also result in improved soil condition. Usage of organic fertilizer

increases level of production in farming and makes a positive impact on the user's economic status.

5.3.2. Land Holdings and Biogas and Live Stock

The average land holding of each household was found 1.3 bigha (1 Bigha = .677263 hectare = 1.6735 acre), which is higher than an average family in Nepal. All families had livestock. In section 4.2.1 it has been stated that most of the population is dependent upon agriculture. Use of biogas reduces the expenses on fuel. Furthermore, organic fertilizer of high quality is made available.

5.3.3 Household Type

In the Nepalese context, families with higher income build concrete houses. In the study, only 26.67 percentages of the sampled households were found to have concrete house; whereas, 45 percent of the sampled households had traditional mud and brick houses. This indicates the average level of income in the village. Installation of biogas also depends upon the family's economic status. In the study, it was found that irrespective of households type, biogas plan were installed by the family members. There was not any significant correlation of household type and biogas plant.

5.3.4 Installation of biogas

95% of the users' installed biogas for cooking. There was negligible involvement of NGO/INGOs and no active participation from the government to encourage installation of biogas among people. This indicates that people are genuinely interested in installing biogas. Biogas installation can reduce the consumption of firewood and other resources. Reduced usage of firewood can reduce deforestation. The protection of trees and increased vegetation in turn reduces soil erosion and improves ecological balance. Environmental improvement also ensures reduction in illness.

Most of the households installed a biogas plant of 6 m^3 size (50%) or 10 m^3 (45%). Dung availability and technical advice were the main determinants of biogas plant size. 82.5% of the respondent spent up to Rs. 25,000 and remaining spent more than Rs 25,000 but lesser than Rs. 30,000 to install biogas. 42.5% hired 10 labours and 50% hired up to 20 labours for biogas plan construction and installation. The average size of biogas, average capacity to spent money and hire labours indicates the requirement of biogas particularly on middleclass family. It is evident that technicians are believed to be the best source of information for installation. The average capacity of lower middle class family could be seen on the basis of

their expenses and labour hiring capacity. Hence, biogas has direct impact on income source of household of any economic status.

5.3.5 Source of investment

Out of total biogas users, 67.5% were dependent upon loan. However, it is seen that 26% of the respondents were not happy with the loan procedure. According to them, a non-cooperative attitude of staff (57%), followed by excessive paperwork were the most common factors. Sale of crops/animal products (70%) is the main source for repayment of the loan. However, some of the respondents were not interested in loans as they could finance biogas installation themselves. 8% of the respondents were not interested in loan funding due to inconvenient loan procedure. Low interest or loan funding could be provided from the government along with subsidy to promote biogas adoption.

5.3.6 Other aspects

95% of the biogas users were found using underground pump which is a low cost source of water. It helps in reducing cost of running the biogas plant after installation. Reduction in cost of biogas leads to increased economic capability of the users. Non biogas users were spending more money in chemical fertilizers than biogas users. Hence, biogas doesn't only maintain the fertility of the land but also minimizes the cost of agricultural production. This also helps in strengthening the economic ability of the users.

5.4 Comparison of Hygiene and Health

It is well accepted that biogas installation substantially helps in improving general health condition of the recipient family members. It helps in eliminating indoor air pollution caused by smoke, which contains carbon monoxide, formaldehyde and other respirable suspended particles. However, such benefits are rather difficult to quantify. The benefits of biogas can be better understood with reference to a 1994 WHO publication. It states that the amount and toxicity of smoke inhaled by a person cooking on traditional system of using firewood, crop residues, dung-cake etc. was found to be equivalent to smoking 40 cigarettes per day if the person continuously remains in the place of cooking. It should be noted that biogas may not eliminate all smoke from kitchen as they still continue to use traditional fuels for cooking cattle-food, milk-boiling, roasting pop-corns (response by 90%) etc..

The installation of biogas plant has shown to influence households' indoor environment. Improved hygiene conditions automatically lead to better health and sanitation among the users. Biogas usage leads to substantial improvement in kitchen environment and also to

female members who are usually responsible for kitchen-based activities. Because of this, the impact of biogas applies mainly to females who reap the benefit of smokeless and less-laborious cooking after biogas plant installation. The study findings also support these arguments.

The present study also reveals that all the sample plant owners admire the health benefits. They inform that there are visible implications on personal health and general sanitary condition after biogas plant installation. Women interviewed frequently mention that they coughed much less, have fewer incidences of headache and dizziness, suffer from fewer eye infections and feel greater ease in respiration.

82.5% of biogas users visited health clinic due to different problems whereas 95% of the non-users visited the health clinic. 35% of the respondents using biogas visited health clinic up to five times in a year but 80% of biogas non-users visited up to five times.

Both groups' respondents were asked to express reasons behind their health visits. They mentioned that headache, eye problems, fever, knee pain, joint pain, back pain, normal health check up, women's internal problem, pain in bone and respiration were the main health issues in their families.

5.5 Biogas and Household Activities

100% of the respondents answered that women were involved in household activities including cooking, cleaning utensils, baby seating etc. As responded by users, the gas is being used mostly for cooking.

5.5.1 Cooking and Cleanings

The focus on cooking is primary because biogas is primarily used for cooking. The average hours spent every day on cooking before use of biogas was found to be 4.3 hours while only 2.5 hours was spent in the kitchen after installation of biogas. On the other hand, the average hours spent on cooking among biogas non-users was calculated to be 4 hours a day. This shows a saving of 1.8 hours per day. Next important household activity to be performed by women in the sampled population of Itahara VDC was cleaning utensils. An average of 2.5 hours was spent on cleaning utensils prior to installing biogas whereas 1.2 hours was spent on cleaning utensils after installation. This shows a saving of 1.3 hours per day from cleaning utensils. Similarly, 3 hours per day was spent by biogas non-users only for cleaning utensils. This shows that biogas installation can also lead to higher efficiency in household-work.

Carbon monoxide produced from firewood fuel and kerosene makes cleaning utensils more complicated and dirty without biogas. Efficient stoves used for biogas help in keeping utensils clean and reducing time spent on cleaning them.

5.5.2 Use of saved time

This is another benefit of the biogas plants. The time saved differs between households and is not always easy to determine exactly. The gas produced from the plants is used for cooking and hence burning hours of fuelwood is saved. It is quicker to cook on gas compared to on firewood. The time taken in collecting fuel-wood and kerosene for cooking is saved. Hence, a lot of time is saved, allowing for more engagement in other activities.

After installation of biogas, there is considerable reduction in workloads of the family members especially among the women members. Reduction in workload is measured in terms of saved working time. Less time is required for cooking as well as collecting fuel. Time saved in cooking and cleaning cooking vessels directly results in time saving. Besides this, less time is needed to wash clothes, as they get less dirty as biogas is close to being smokeless. Time reduction in cleaning the household (without black soot) and reduction of time to clean the surroundings (especially for those who attach toilets in their plants) are some benefits that help in saving time.

It shows a daily saving of 3.1 hours per day due to saving time on cooking and cleaning utensils. Since, it has been mentioned that only females were found to be involved in cooking and cleaning utensils; the time saved for women could be used for participation in other activities. 63% of the respondents were found spending their saved time on farm activities while 22% were found spending saved time in child care. More time was also spent on business and social activities. 93% of the respondents mentioned that their child care time has been increased. 7% were without children. From these results we can see three major benefits of using biogas from a household perspective. First, it gives biogas users more time to spend on other productive activities including business and farming. This in turn contributes to increased income and can boost the economic status of people in rural areas. Secondly, more time can be spent with children. Thirdly, it increases the involvement of women in social activities.

5.5.3 Other activities including social impact of biogas

Time spent to run biogas everyday was lesser than an hour for 68% of the respondents and more than an hour for 32%. Apart from that, there were several other activities in which women involved. 63% of the respondents were found spending time to support household works, 20% for social/community service, 2% on education and 5% on others. This shows that the saved time can also be utilized on those particular activities which help for personality, skill and knowledge development. Social impacts of biogas are sometimes intangible and these need to be assessing from users' perception, which is not very easy to assess.

The outcome of the study shows that the positive impacts of biogas, directly influencing social aspects of beneficiary households include:

- Biogas plant raises social status of the family; it is a symbol of prestige
- Gives more time to visit relatives and neighbors
- More engagement in social or political activities,
- Faster serving of tea or food to incoming guests is a matter of social prestige
- Increase of time for social work and business work after installation of biogas

5.6 Environmental Impact of Biogas

Effect of biogas installation on women health is an important part of this thesis. The project implementation document of BSP states that the overall objective of the programme is to develop and disseminate biogas as an indigenous, sustainable energy source in rural areas of Nepal. Further, it aims to reduce the rate of deforestation and environmental deterioration by providing biogas as a substitute for firewood and dung cakes to meet the energy demand of the rural population. The objective also includes improving health and hygiene among rural population, especially women, by eliminating firewood smoke, reducing hardships faced in collecting firewood and management of digested dung as organic fertilizer.

Hence, it is evident that there are benefits connected to the use of biogas. The major beneficiaries include: recipient families in rural areas who have adopted the technology, the actors involved in disseminating the technology and their ability to carry out their tasks and the environment.

The environmental impact of biogas on deforestation is very difficult to assess. This should be seen in a broader context. Burning of firewood, dung-cakes or agricultural waste is not

sustainable when the use of fuel-wood exceeds production, resulting in deforestation. Also, organic matters and nutrients are lost in the process. Biogas is a sustainable and renewable source of energy because it is part of a closed cycle (Wim van Nes and Jan Lam, 1999). The organic materials that are fed into the plants are used without being destroyed. The nutrient and organic matter (apart from some carbon and hydrogen) will still be available in the slurry and can be returned to the soil.

The environmental impacts of biogas plant can be summarized as follows:

- Biogas, when used for cooking, saves fuel-wood, dung-cakes and agricultural waste. The organic matters and nutrients of agricultural waste and dung-cakes, which are otherwise burnt, are available to sustain the fertility of soil
- It helps in reduction of CO2 emission
- When used for lighting, biogas replaces kerosene, which ultimately helps in reduction of CO2 emission
- By the installation of biogas plants, the management with regard to dung on the farm improves. Biogas slurry has a higher nutrient value than ordinary FYM
- Biogas slurry is always favorable compared to the ashes of agricultural and animal waste used for cooking purposes. Besides possible savings on nutrients, biogas slurry contributes to arrest the declining amount of organic matter in Nepalese soils. The study, "Evaluation of Subsidy Scheme for Biogas Plants", carried out by CODEX (1995) for BSP valued the nutrients saved due to non-burning of dung as well as non-leaching of nutrients due to installation of biogas plant yielded rates varying from 9.69% to 44.98%.

Hence, the impacts of biogas use on the environment must be viewed from a number of perspectives, most of which relate to the conservation of biomass. The introduction of biogas as a substitute to traditional sources allows the forests to remain intact. Also, the dung is used for two purposes: as gas for cooking and lighting purpose, and as slurry, a replacement or a supplement to inorganic fertilizer in agricultural production.

When biogas is introduced as a substitute to traditional fuels such as residues from agricultural and fodder crops or the dead wood from jungle, it usually has no significant impact on forest conservation. But, if it replaces the living trees as the fuel source, there will be significant positive impact. Hence, as a method of conserving the forest the direct benefits

of biogas is not easy to calculate. From this argument it can be concluded that installation of biogas plants help in conservation of forest.

5.7 Biogas Non-Users

To identify the problems in the rural areas that make people not to use biogas, few questions were asked to non-users of biogas plant.

5.7.1 Reason of not using biogas

40% of the biogas non-users replied the reason for not using biogas was the cost of installing biogas plant. The other main reasons were no interest and lack of dung. The outcomes show that the majority of the people in rural place want to install biogas plant but face some problems. Only 20% were found with no interest in installing biogas plant but they could not state the exact reason for not being interested. It may be argued that if they got information on the benefits of biogas usage, they could be positive towards biogas adoption. Cost associated has been the main problem of lower middle class families in the VDC.

5.7.2 Inspiration to use biogas

35% of the biogas non-users replied that they were not inspired by anyone to install biogas. 45% replied that technicians, neighbors encouraged them to install biogas but they could not do it. 20% were inspired from rumors. No involvement from any of the government organizations and NGOs/INGOs was found within the village. This indicates the absence of initiatives from government as well as other organizations in rural areas. No direct promotional and awareness programs have been held in the VDCs.

5.7.3 Installation of biogas in the future

60% of the respondents not using biogas were found planning for biogas installation in future. 50% of those who were keen to install the plant were planning it for prestige purposes. 16.67% were going to install the plant due to hygiene reasons, 16.67% were found to use biogas plant to save time and 16.67% were going to install the plant caused by lack of firewood. It shows that, people are aware of prestige in the society and aware of the time saving from biogas usage. Lack of firewood indicates increase in deforestation which has a direct impact on economic as well as environmental aspects.

37.5 % of the respondents who were not going to install biogas in the future answered having a better source already. The better source was use of LPG gas and electricity. 37.5% replied

that they are not planning for installation in the future because they cannot afford it. 12.5% were found having no idea about biogas. The only distributor of LPG gas is Nepal Oil Corporation which is under huge loss and has been going through several crises. There are chances of disruption on easy supply of LPG gas in the future. Hence, biogas may be the best alternative energy. On the other hand, Nepal face load shedding up to 18 hours in a day. This significantly reduces reliability of electricity provided from government on a continuous basis.

Thus, there are several advantages of using biogas especially for rural development, health and hygiene, social activities, environmental issues etc. However, implementation of several programs is important to Nepal, as it promotes rural development as well as for women health. Despite these positive impacts, reduction in gas production during winter season and delay in rendering post installation operation and maintenance by companies were some of the problems that have to be addressed in order to speed up uptake of biogas.

Chapter 6: Conclusion and Recommendations

6.1 Conclusions

Biogas has been very useful for the female members of the family. Workload among women has been greatly reduced. As biogas plant reduces the need of firewood collection, and thereby saves time that would have otherwise been spent on firewood collection. Food is also cooked in lesser time. Since no smoke is produced, the cooking job is easy and can be done in relatively short time, as the utensils are not black with smoke. So, half of the time was saved in washing the utensils. Hence, much time was saved. Therefore, time was saved after biogas installation. However, most of the women have to be involved in other households' activities and agriculture. Only a few have used the gained time in income generating activities. The chances of occurrence of health problems such as burning of eyes, headache, diarrhea and fever have been reduced.

However, the adverse outcomes of the use of biogas includes prevalence of increased number of houseflies and mosquitoes as the biogas plant serves as sites for mosquito breeding, despite biogas promoting good sanitation. People have not connected their latrines to the biogas plants, primarily from a tradition and cultural aspect. Biogas also results in saving of considerable amount of firewood and in turn, money as well. Most people use the saved time for farm activities and care of children.

In the past, local forest was the primary source of firewood for the villagers. With saving in use of firewood, the pressure on the nearby forest will be greatly reduced. The digested slurry contains more easily available nutrients than the traditional compost or farm yard manure. The use of digested slurry showed increased yields. A subsidy can be used for promoting biogas installation. After the installation of biogas plant, the livelihood standard of villagers can be expected to become high which helps reduce poverty and ultimately enhance rural development.

In most of the cases, there was lack of active participation of government and non-government programs to promote biogas installation in the rural areas. Cost of installation was a major problem for biogas users and non-users. However, some of the users were found to be taking a loan for the installation. Time spent on social and other productive activities

was found to have increased along with an increased average income after installation of biogas plants.

6.2 Recommendations

It was observed that biogas plant installation has resulted in considerable time saving. In order to maximize the social benefits of the plants, one needs to emphasize on the importance of social awareness programmes. The time of the users saved through the installation of biogas plant could be utilized to promote such programmes. The initiative should come from the users themselves. Long term loans for installation of biogas is furthermore important. This helps to spread the loan payback over a longer period of time, thereby reducing the size of each payment. A great deal of time and money has been saved after installation of biogas. Therefore women can have more time for income generation activities. Concerned authorities should pay attention to this.

The cause of leakage of slurry from the plant should be studied and prevented. Precaution should be made in new constructions to avoid the problem. The operation of biogas plant depends upon the quality of construction. It is directly related to the skill of masons. If one mason has construction responsibility of more than one plant simultaneously, the quality of plant is found to be inferior. Government should conduct women's education programmes, awareness and publicity campaigns and other useful programmes to motivate farmers to adopt biogas. The company should organize extensive training to different people such as local leaders (social and political), schoolteachers or local government officials. For these purposes, BSP, ADB/N, RBB/N and other biogas company should be involved.

Supervision by field staff should be carried out more frequently. Due to lack of supervision when biogas plant does not work smoothly, the plant owners revert to the traditional *chulo* (a traditional oven made from mud in which firewood is used as the fuel). Therefore, for proper functioning of the biogas plant, service of the trained staff of the construction companies should be made available on time. To enhance qualitative plant construction, the masons should be well trained. Likewise, to enable the low-income farmers to benefit from the biogas program, interest free loans could be provided.

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Appendix 1: Acronyms

ADB/N	:	Agricultural Development Bank Nepal
AEPC	:	Alternative Energy Promotion Center
CBS	:	Central Bureau of Statistics
BSP	:	Bio-gas Support Program
CMS	:	Consolidated Management Service
CO	:	Carbon Mono Oxide
GDP	:	Gross Domestic Product
GJ	:	Gija Joule
GNP	:	Gross National Product
GSR	:	Global Status Report
GTZ	:	Gesellschaft für Technische Zusammenarbeit
HMG/N	:	His Majesty's Government of Nepal
HH	:	Households
ISAT	:	Information and Advisory Service on Appropriate Technology
IEA	:	International Energy Agency
IES	:	International Energy Statistics
LPG	:	Liquid Petroleum Gas
MOF	:	Ministry of Finance
MW	:	Mega Watt
NHRC	:	Nepal Health Research Council
NLSS	:	Nepal Living Standard Survey
NPC	:	National Planning Commission
NPCS	:	National Planning Commission Secretariat
NPHC	:	National Population and Housing Census
NRB	:	Nepal Rastra Bank
RBB	:	Rastriya Banijya Bank
RS	:	Rupees

SNV/N	:	Netherlands Development Organization Nepal
UNICEF	:	United Nation Children Fund
VDC	:	Village Development Committee
WECS	:	Water and Energy Commission Secretariat

Appendix 2: Questionnaire

Please, fill as per the instruction of the interviewer

Part A

1. Caste/Ethnic
2. Village name:-
3. V.D.C.:-
4. Ward No:-
5. House type
   (a) concrete
   (b) mud and brick
   (c) hut (thatch and mud)
6. Family information

S. N.	Name of Respondent	Family Member	Sex	Educational Status	Marital Status	Married Age	Occupation
				Lit/Illi			Main/secondary

7. Farm size
   Bigha……..Kattha ……Dhur…...
8. Livestock Yes…….No……..
   If yes, number
   a) Buffalo… b) Cow…..c) Others (specify)
9. Do you use biogas?
   a) Yes (Please Complete Section B, C and D)
   b) No (Please Jump to Section E)

Part B

10. The main purpose of using biogas….
    a) Lighting
    b) Cooking
    c) Just to use the excretions
    d) Others

11. How were you inspired to install biogas?
    a) Government Programs
    b) Rumors
    c) Advice from NGO/INGO
    d) Others (Please Mention)……..

12. Biogas plant size
    a) 4 m^3
    b) 6 m^3
    c) 8 m^3
    d) 10 m^3+

13. Which one of the following has made you to determine the plat size?

Big family size	Availability of dung
Technician's advice	Company's advice
Ample space	Bank's advice
Required number of stoves and lamps	financial reason

14. Investment in biogas plant
    (a) What was the total cost of the plant? Rs…Number of Labours….
    (b) Have you got loan for the plant? Yes….. No….
    (c) Have you faced any problems in getting the loan? Yes (continue), No (go to Q.12)
    (d) If yes, what type of problems have you got?
        Non co-operative attitude of the bank staff
        Several visits
        Graft money asked by the officials
        Too much paper work
        Usually delay
        Others (specify)

15. What is the source of income for repayment?

a) Sale of crops / animal products
b) Disposal of fixed assets
c) Income from business
d) Borrowing from other sources
e) Others (specify)

16. Why didn't you borrow loan? (Complete only if relevant)

Well off	Don't like borrowing
High interest rate	Loss of social prestige
Inconvenient loan procedure	Inconvenient bank location
Unofficial money grant	Others (specify)

17. What is the source of water?
a) Underground Pump
b) Public water supply
c) Others

18. How much do you spend on chemical fertilizer if you do farming per year (Nrs)?
a) 0-10,000
b) 10001-20,000
c) 20,001-30,000
d) 30,000+

19. Who provided you training and skills to run the biogas plant?
a) Government
b) NGO/INGO
c) Family/Friend/Neighbour
b) Others…….

20. Impact of biogas on household income (Interviewer may help to calculate in percentage)

Increase (in %)	Decrease (in%)	Constant

Group C

21. Why do you use biogas?
    a) Time saving
    b) Clean and hygienic
    c) Shortage of fire wood
    d) Others (specify)
22. Hygienic condition; cleanness in
    a) Washing (frequency)
    b) Bathing (frequency)
23. Since having biogas, how do you feel about your health?

a) Respiration	Easy	Difficult
b) Cold / Cough	Increase	Decrease
c) Fever	Usually	Sometime
d) Others (specify)		

24. Do you visit health post or hospital or clinic? Yes No
25. How often you and your family members do visit in a year?
    a) 0-5
    b) 6-10
    c) 10+
26. For what health problems do you visit?

    ……
    ……
    ……
27. What types of health problems have occurred in your family?

    ……
    ……
    ……

Group D

28. Who usually cooks in your family?
    Female Male
29. How much time would you spend for cooking a day before and now?
    Before (hours)……. After (hours)……..

30. How long do you need to clean utensils before and after the use of biogas?

Before (hours)……. After (hours)……

31. Have you felt time saving after using biogas? If yes, what do you do with your time saving?

a) In farm work
b) Child care
c) Service
d) Business
e) Social activities
f) Development works
g) Others

32. Child care time after and before

(a) Increase (b) Decrease

33. How long do you take to set up the biogas every day?

a) <1 hour
b) >1 hours
c) >2 hours
d) >3 hours

34. What do you consider your other activities spent for?

a) Independent support to family with job, business etc.
b) Social/Community service
c) Education
d) Assisting on household works
e) Others……..

35. After the use of biogas plant, time increase or decrease on activities such as:

a) Social work Increase Decrease
b) Business Increase Decrease
c) Service Increase Decrease

Part E (Only for those who do not use biogas)

1. Why do you not use biogas?

a. Cost
b. No interest
c. Lack of dung
d. Others…….

2. Were you inspired to install biogas by any of the followings?
   e) Government Programs
   f) Rumors
   g) Advice from NGO/INGO
   h) Others (Please Mention)……..
   i) None
3. How much do you spend on chemical fertilizer if you do farming per year (Nrs)?
   e) 0-10,000
   f) 10001-20,000
   g) 20,001-30,000
   h) 30,000+
4. Hygienic condition; cleanness in
   c) Washing (frequency)
   d) Bathing (frequency)
5. How do you feel about your health?

e) Respiration	Easy	Difficult
f) Cold / Cough	Increase	Decrease
g) Fever	Usually	Sometime
h) Others (specify)		

6. Do you visit health post or hospital or clinic? Yes No
7. How often you and your family members do visit in a year?
   a) 0-5
   b) 6-10
   c) 10+
8. For what health problems do you visit?

……
……
……

9. What types of health problems have occurred in your family?

.....

.....

10. Who usually cooks in your family?

Female Male

11. How much time would you spend for cooking a day (In Hours)?

……

12. Are you going to use biogas in the future soon?

Yes (Please Answer Question 13) No (Please Answer Question 14)

13. What has attracted you to install biogas?

a) To show that you are capable
b) For time shaving
c) Hygiene awareness
d) Various promotional programs held
e) Others (It may include any two or more of above)……..

14. Why are you not going to install biogas in the future?

a) I have already better energy source (Please, Mention)…….
b) I cannot afford for it in soon future
c) Due to lack of facility access.
d) Others (Please, Specify)……