CHAPTER 1

INTRODUCTION

1.1BACKGRUOND

Nepal is primarily an agricultural country with about 26.6 million human populations out of which 83 percent population resides in rural area and 74 percent people are highly dependent on agriculture (CBS 2011). Fuelwood has been and still is the major source of fuel daily used by rural mass in Nepal. This total dependence on fuelwood as the source of energy for cooking has resulted in deterioration of the quality and quantity of forests and has posed a serious threat in maintaining ecological balance, thereby manifesting various problems like deforestation, flood, Global warming, soil erosion, landslides, climate change and so forth. The pressure on forest resource for energy fulfillment is considerably increasing due to high population growth in rural areas causing scarcity of fuelwood for cooking. As a consequence, many people in the rural areas are burning livestock dung and other agricultural residues. This has been one of the factors in deterioration of environment and soil fertility in the country (AEPC, 2006).

Biogas is an important alternative source of energy and also a source of income for a developing and agricultural country like Nepal (BSP, 2010). According to article 12 of the Kyoto Protocol, under Clean Development Mechanism (CDM), for minimizing the externality effects after the establishment of biogas plant and micro hydropower project in Nepal, the purchase-sale agreement has been signed with the World Bank Carbon Fund for Community Development (CDCF). As per the agreement, 7 dollars per Certified Emission Reduction (CER) in bio energy and 10.25 dollars per CER for micro-hydropower will be received. Currently, Nepal will receive the grant of about US $ 680,000 annually, given the number of 19511 gas plants registered in the year 2009/10 and 6774 additional plants were registered in the first 8 month of 2011(MOF, 2011).

Nepal is an agricultural country and cattle farming are an important component of Nepalese agricultural system. The number of the households with cattle or buffaloes in Nepal was estimated to be 2.7 million in 2001 (BSP, 2004). Based on this, the technical potentiality of biogas plants installation is assumed to be around 1.9 million. By the end of the year 2009, a total number of 204,490 plants were installed under BSP (BSP year book 2010).

The use of firewood is also an important factor in the declination of forests in the world and thereby an important factor to climate changes. Other negative effects from excessive biomass usage are erosion, degrading soils and water resources. Converting from today's use of biomass into cleaner ”greener” technologies in rural developing areas would increase the standard of living, health and local environment and at the same time help to reduce climate change. Furthermore, it would give an improved chance of economical development. (Bajgain*et al* 2005)

The use of biogas as an energy source has proven itself to be an important strategy in solving the problems of energy usage in rural areas of developing countries. By using existing substrates like dung and other waste products to produce biogas, single households and communities can become more or less self sufficient in terms of energy. The biogas can be used as a clean cooking fuel without the effects of hazardous particles typically associated with firewood and can also be used to generate electricity or for heating. (Bajgain*et al* 2005)

Energy is a basic necessity for survival. It is an important factor for economic development and attaining the reasonable standard of living. Energy crises leads to supply shock, thereby adversely affecting the economic condition of nation. In Nepal, majority of people depend on the traditional sources of energy. The use of fuel wood constitutes 78.6 percent of total energy consumption that comes from forest, shrub-lands and crop-lands.Commercial and the other alternative sources of energy contribute only around 10 percent of total national consumption (Lekhak, 2003).

Energy used in Nepal can be broadly classified into three categories: traditional, commercial and alternative energy. Traditional energy includes firewood, agriculture and animal residuals. Commercial energy consists of electricity, petroleum product and coal. Energy sources other than commercial fuels and biomass based fuels in traditional form are included under the alternative energy source. In FY 2009/10, the ratio of traditional, commercial and renewable energy consumption was 84.4 percent, 14.9 percent and 0.7 percent, respectively. In the first eight months of FY 2010/11, this ratio was recorded as

86.5 percent, 12.8 percent and 0.7 percent, respectively. The data reveals that Nepalese economy's high dependence on traditional energy has not changed. (MOF, 2011)

Although about 84.4 percent of the total energy consumption in fiscal year 2009/10 in Nepal is occupied by traditional biomass based fuel (MOF, 2011), the importance of alternative source of energy has been gradually increasing in the last few years. In Nepal, the main sources of alternative energy are micro- hydropower, solar energy, wind energy and biogas. As other energy types involve higher costs, bio-gas remains to be the best alternative that stands technically and economically feasible.

Biogas technology, which is a clear and convenient fuel for cooking and lighting in the household, has gained high popularity as the most appropriate option to meet the growing energy needs in rural areas of Nepal. Biogas technology in Nepal was first introduced at St. Xavier's School, Godhawari, Lalitpur by the late father B.R.Soubolle in 1955. Thereafter, Nepalese government officially started biogas program in FY 1974/75. Agricultural Development Bank, Nepal (ADB/N), Non Government Organizations (NGOs) and Community Based Organizations (CBOs) have also now started getting involved in this technology. The Biogas Program came under the Alternative Energy Promotion Center (AEPC) of Ministry of Science and Technology (MoST) in 1996. In FY 1997/98, the total number of biogas plants was 37,345. The number of biogas plants installed rose to 204,497 under BSP/N by the end of October 2009 (AEPC, 2010).

Per-capita energy consumption in Nepal is 336 kg of oil equivalent (BSP, 2004). Energy consumption pattern is divided into three parts by their sources, namely traditional, commercial and renewable. Large proportion of energy consumption is met by traditional energy resources with increasing pressure on forest resources leading to environmental imbalances. Nation's demand for fuel is increasing at an alarming rate. About 75.3 percent of total energy consumption is met by firewood, about 5.6 percent by animal dung and about 3.6 percent by agriculture residue (MoF, 2011).

Although, Nepal has a huge commercial potential of hydro electricity (43000 MW), energy crisis has been a constant feature due to low level of utilization of the water resource, owing to the lack of infrastructure and poor capital base and a host of other factors. Nepal also does not have natural reserves of oil and coal. Energy supply, in this context is largely based on agriculture and forest. In Nepal, the per capita consumption of fire wood is 332 kg per year (WECS, 2003). This obviously has been one of the major causes of widespread deforestation.

Nepal stands second to Brazil in terms of potential of water resources. However, due to financial and technological constraints on one hand and lack of political vision and commitment on the other, favorable environment to harness the hydropower potential has never been created. Fuel demand has been rapidly increasing day by day. Despite the total potential of 83,000 MW of hydropower, Nepal has been able to tap only 661 MW by the end of the fiscal year 2009/10 (MoF, 2010). The glaring consequences of this meager utilization is the load shedding that went as high as 16 hours per day in recent years, playing havoc with the country's industrial sector.

Lack of proper utilization of water resource for electricity coupled with ever increasing demand for energy consumption has led us to the search for alternative sources of energy to meet the growing demand. Biogas is a combustible gas produced by anaerobic fermentation of organic materials by the action of methanogenic bacteria. Biogas is mainly composed of two gases: methane (CH_4) and carbon dioxide (CO_2). In biogas, about 50% to 70% is methane and 30% to 40% is carbon dioxide and there are some other elements in small proportions such as hydrogen, nitrogen and water vapor. Methane gas is combustible gas produced by anaerobic fermentation of organic materials by the action of methanogenic bacteria (BSP, 2007). It is colorless and smoke free when burnt. Biogas can be used for cooking, lighting, running fuel engines and so forth.

In Nepal biogas is mainly used for cooking and lighting. But, benefits of biogas do not end there. It has other indirect advantages too. After using the cattle's dung in the biogas plant, the digested slurry can be used as compost fertilizer. This helps to increase the productivity of land which helps to minimize the food shortage. Moreover, as the cattle (i.e. cows, buffalos) have to be kept in sheds for the use of their dung in the gas plant, the problem of overgrazing is minimized. After using the biogas for cooking, the kitchens remains smoke free and hence the chance of reduce in smoke borne diseases, which help to reduce the medical expenses. Biogas also saves time and money, which can be used for different income generating activities. Use of biogas helps to reduce deforestation, which is another positive impact of biogas plant installation. Biogas plant installation also helps in creating job opportunities for skilled human resource.

Kerosene and other oil based sources of fuel are scarce and costly to be easily available for small marginal and medium farmers residing in rural areas. Furthermore, frequent alarming hike in prices of imported oil and chemical fertilizer have serious economic threat to the rural poor. In this context, to reach the self-sufficiency in energy and fertilizer and to minimize the pressure on traditional biomass fuel, biogas technology can be one of the best alternative energy solutions, which could be achieved through the active mobilization and economic utilization of local indigenous resources available in the country.

This study concentrates on the use of biogas plant as an alternative source of energy and at the same time tries to explore the various benefits of adopting biogas such as economic, environmental, social and health inDhaijan VDC of Jhapa District, Nepal.

1.2 STATEMENT OF THE PROBLEM

For the development process of our contemporary society, energy is essential. Nepal is facing energy related problems such as rising prices of fuels, deforestation and so forth. In the context of Nepal, the possibility of fuller utilization of solar, wind and water for energy seems unlikely due to the lack of capital, poor manpower, time lag and political instability. In this context, biogas is the most viable alternative energy source. Biogas energy is comparatively more advantageous in terms of cost, time and technology than other renewable energy sources like solar, wind, water and so forth.

According to MOF (2011), 84.4 percent of the Nepalese populations still burn traditional fuels (fuelwood, agricultural residues and dung cake) inside their homes. Fuelwood being the principal energy source among these biomass fuels, its demand far exceeds the sustainable supply (Rijal 1998). In addition, there are other socio-economic and health

related adverse impacts, many of which are disproportionately suffered by the women and the poorest of the poor. On the other hand, Nepal is dependent on the fossil fuel; the rising price of fossil fuel in the international market is a burden on its foreign exchange.

The main challenge of present world is to harness the energy source which is environment friendly and ecologically balanced. This need has forced to search for other alternate source of energy. But unfortunately the new alternative energy sources like the solar, hydro, wind and so forth. require huge economical value and technical power to operate, which seem to be very difficult for the developing countries like Nepal. In the present moment biogas energy can be one and only reliable, easily available and economically feasible source of alternative and renewable source which can be managed by locally available sources and simple technology for these rural villages.

Biogas may be instrumental in alleviating these problems by reducing the pressure of high energy demand to a significant extent. In Nepal, especially in rural areas, people use the cattle dung for cooking which results in the wastage of compost fertilizer. However, dung obtained from cattle can be better utilized if converted into biogas. Biogas also helps to minimize pollution, thereby contributing to clean environment.

Due to these manifold adverse impacts associated with traditional biomass fuels, there have been efforts from all sides to substitute these traditional energy sources with alternative energy sources, which are cleaner and greener.

1.3 OBJECTIVES OF THE STUDY

The purpose of the study is to analyze the different impacts of biogas plants in case study area. However, the specific objectives of the study are mentioned as follows:

- To analyze the extent to which biogas has substituted the use of firewood and petroleum products in household use.
- To analyze the contribution of biogas to time saving through the qualitative information.
- To find out the health, economic and environmental benefits of biogas plants
- To calculate the payback period for the biogas installation

1.4 SIGNIFICANCE OF THE STUDY

This study helps to broaden our knowledge about the various benefits of biogas in terms of its capacity to substitute other sources of fuel in household use and its contribution to time saving.In the present context of ongoing power crisis in Nepal, which faces as much as 16 hours of load shedding, any alternative source of energy is of enormous importance. Biogas as an alternative source of energy certainly comes handy as a substitute for electricity, especially in relation to cooking and heating. Biogas has the following points of significance:

- By using biogas, we can minimize ongoing power crisis.
- Biogas helps to reduce deforestation.
- It helps to minimize the environmental pollution.
- Installation of biogas plant is economically, technically and socially viable.
- It helps to improve the agricultural productivity.

- By installing the biogas plant, infection causes from firewood smock will reduce.
- It plays certain role in saving time and money of the users.

1.5 LIMITATIONS OF THE STUDY

Because of the various constraints, it is not a comprehensive study and it is mainly focused on the analysis of a few specific aspects as economic, social and environmental impact of biogas plant. It is expected to have the following limitations:

- The organizations working in the field of health, environment, public awareness, poverty alleviation, women empowerment, and youth mobilization has not been considered and the study entirely focused on the benefits of biogas plant installation.
- It is based on the limited sample size of 26 households, and, hence, conclusions or generalization of this study may or may not be applicable in other parts of the nation.
- It has mainly analyzed the impact ofbiogas on firewood saving and in-depth analysis of other impacts has not been considered.

1.6 RESEARCH QUESTIONS

The potentiality of biogas energy is considered to be very high in Nepal. However, the progress achieved in this sector is not that much encouraging. The reasons for this may be numerous. There is lack of adequate information on the socio-economic impact of biogas, which necessitates further studies and research in this area. Increasing population with increasing demand for fuel lead us to explore the viability of biogas as an alternative source of energy.This research tries to enhance the installation of biogas by increasing attention and awareness of people towards the use of biogas as an alternative source of energy.

The research questions for this study will be:

- Is there any relationship between the biogas plant installation and their social status?
- Is the consumption pattern and saving pattern of firewood differing for different ethnic group?
- Is the biogas is an effective substitute of firewood as a fuel?
- Is there a significant rate of saving of firewood after installation of biogas plant?

- What is the main motivating factor for biogas installation?
- Which size of the biogas plant is mostly used by the farmers and why?
- Whattype of relationship exists between the biogas installation and the health related problems among the households?
- What is the main reason for installing the biogas plants?
- what are the different problems facing by the households after installation of biogas plant
- What are the factors that help to reduce the payback period?
- What are the visible environmental benefits obtained from the installation of biogas plant in the society?

1.7 OPERATIONAL DEFINITIONS AND ASSUMPTIONS

1.7.1 BIOGAS TECHNOLOGY

Biogas technology is a modern, ecology-oriented form of appropriate technology based on the decomposition of organic materials by putrefactive bacteria at suitable, stable temperatures. Methane, commonly referred to as biogas, develops under air exclusion (leaving behind digested slurry) in the digester - the heart of - any biogas plant.

To ensure continuous gas production, the biogas plant must be fed daily with an ample supply of substrate, preferably in liquid and chopped or crushed form. The slurry is fed into the digester through the mixing pit. If possible, the mixing pit should be directly connected to the livestock housing by a manure gutter. Suitable substrates include:

- Dung from cattle, pigs, chickens.
- Green plants and plant waste,
- Agro industrial waste and wastewater.

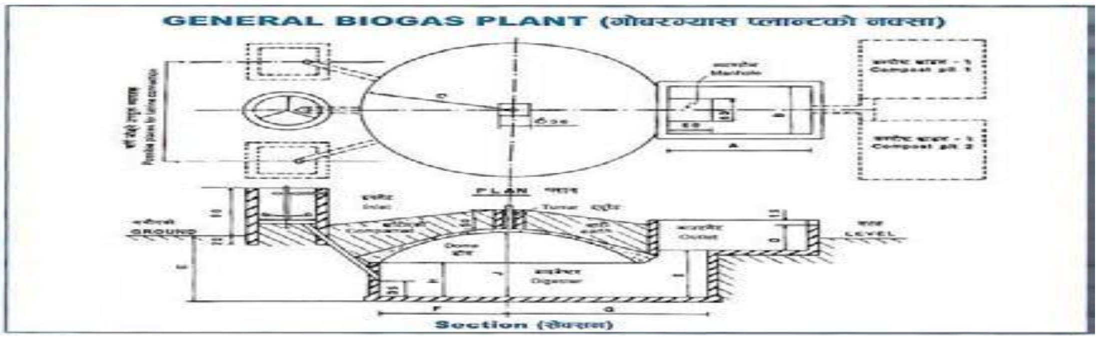
1.7.2 BIOGAS PROJECT

The biogas project has a number of benefits to rural households along with reducing greenhouse gas emissions. Beside carbon revenue, other tangible benefits associated with this technology are availability of clean energy, availability of organic fertilizer, time saving on daily household works, improvement in sanitation and health, cleanliness in and around the house and environmental protection. The feasibility of producing electricity from biogas as well as the use of slurry is being examined. Thus, given a government favorable policy, the combined efforts of private sector, the Biogas

Company, the Agricultural Development Bank of Nepal, and the United Mission to Nepal could contribute significantly to the development of biogas in Nepal.

1.7.3 DESCRIPTION OF GGC 2O47 MODEL:

The Chinese fixed dome model biogas system (also called drumless digester) was built in China as early as 1936 (CMS 1996). This fixed dome model was introduced in Nepal in 1980 by DCS, Butwal. After several modifications, the fixed dome design (GGC model Fig 2) was approved in 1992. BSP-Nepal has recently made further modifications in this design and is in the process of recommending the "Modified GGC 2047" design in the near future .The GGC 2047 systems are available in the following sizes: 4, 6, 8, 10, 15, 20, 35 and 50M^3 volume. However, fixed dome biogas plants of 5, 7, 9 and 12 and larger sized fixed dome biogas plants of 75M^3 and 100M^3 especially for running engines had also been designed (Devkota 2001).



1.7.4 POTENTIALITY OF BIOGAS IN NEPAL

For Nepal, being an agricultural country, livestock plays an important role in the Nepalese farming system .The total households with cattle and buffalo in Nepal was estimated to be 2.7 million in 2001. Based upon the study of technical biogas potential of Nepal, it is estimated that a total of 1.9 million can be installed in Nepal out of which 57 percent in plains, 37 percent in hills and rest 6 percent in remote hills or in mountain region. According to BSP Year Book (2009), a total of 204,490 plants have been constructed under BSP and 4,111 biogas plants under GSP. It is reported that at the end of 2009, more than 200,000 biogas plants had already been installed in about 71 districts of Nepal (BSP 2009).

1.7.5 SUMMARY OF SOME OPERATIONAL ASSUMPTIONS USED

- Per Capita Fuelwood Consumption = (Average fuelwood consumption per family per day × total number of families in the ecosystem)/ Total number of people in the ecosystem (Maharjan 2008).
- Annual income saving from reduction in fuelwood was calculated at the local rate of NRs. 400 per "*Bhari"*.
- The Carbon Abatement Revenue was calculated at the negotiated rate was US$ 7 per ton of carbon for Certified Emission Reduction (World Bank).
- All the Biogas plants surveyed were constructed under subsidy and the payback period per plant was calculated from the Average Total Investment including Subsidy.
- Payback period without subsidy = Total investment cost / (annual revenue-annual expenses) (Devkota 2007).
- The subsidy rate of NRs. 9,700 per plant forterai region was used (BSP 2012).

CHAPTER 2

LITERATURE REVIEW

This chapter presents the summary of the outcomes of various research studies carried out to evaluate the welfare gain achieved from the installation of biogas plants by the users. The literature is reviewed from various sources such as those presented by former students, reports and papers presented at seminars, articles published in various bulletins, journals and newspapers, and information published by concerned agencies. Both theoretical and empirical literature is reviewed

2.1 THEORETICAL REVIEW

Biogas is one of the most important alternative sources of energy which has several direct and indirect benefits. The use of biogas is justified not only from economic ground that it is a substitute for expensive petroleum fuel, but it also protects environment, improves health and saves time. Although the use of biogas gained popularity only after 1970, various studies on different aspects of biogas have been performed since then. In the context of Nepal, the technology is appreciated and used mainly as the alternative source of energy for household for cooking, lighting and the digested slurry as better organic manure for agricultural crops and vegetables.

Bista(1981) concluded that biogas is considered as the most reliable alternative energy resource replacing fuel wood, of which, the greatest part is used for cooking especially in rural areas of Nepal. It means that there is an urgent need for substituting rural energy through non-conventional energy sources.

Bachman and Saubolle(1983) write about the use and importance of biogas for people in remote areas of South East Asia or other tropical or subtropical countries where electricity is not sufficiently available and fuel is hard to get. Biogas has enabled these people to have a very cheap, abundant and efficient fuel produced from ordinary cow dung. The cooking is clean and hygienic, the pots do not get black, there is no smoke or smell and the gas is non-toxic; the farmer can use the slurry in the field asfertilizers.

New ERA (1985) has revealed that one of the main attractions of the biogas plant is the easy availability of gas for cooking. Almost all the users used gas for cooking, and more than half of the owners used it for lighting as well. The main reasons for not using biogas for lighting purpose by all the users were the availability of electricity, frequent breakage of the gas lamp and mantle and insufficient gas generation, particularly in the winter. However, most of the users reported that they were satisfied with the use of gas for cooking. The reasons behind this satisfaction were mainly due to less requirement of time for cooking, no black soot on the cooking pots and smoke-free kitchen.

Gopalkrishnan, et.al (1990) revealed the significance of biogas from both individual and national perspectives. From individual perspectives, the primary impact of biogas plants is to some extent contributed on poverty alleviation by reducing expenses on fuel for cooking and to some extent lighting. At the national level, it helps in reducing imports bill of the country used for chemical fertilizer and petroleum products. In addition to this, installation of biogas plants also helps in creating job opportunities for skilled and semi-skilled manpower for the construction work that requires considerable number of such manpower andthere by contributes to rural poverty alleviation.

BSP(1992) has mentioned the following as the objectives of installation of biogas plants: a) to reduce the rate of deforestation and environmental deterioration by providing biogas as a substitute for fuel wood and dung cakes to meet the energy demand of the rural population; b) to improve health and sanitation of the rural people, especially women, by eliminating smoke produced during cooking on firewood, and by reducing the hardship concerning the collection of firewood; and c) to increase the agricultural production by promoting an optimal use of digested dung as organic fertilizer.

Devpart-Nep (1998) aimed at evaluating the effects of biogas on the users. It concluded that smoke-free cooking and easy working environment were found to be the main reasons for plant installation. It also revealed that all the owners of the sampled plants admired health benefits and time saving capacity of the plants.

Silwal (1999) has made some important findings. His study has revealed that the tangible impacts of biogas are realized in terms of savings in firewood, kerosene, and time, while intangible benefits such as reduction in the instances of respiratory diseases plus other benefits are also perceived to be quite significant by the users.

AEPC (2001) conducted a study to explore the various benefits of biogas. The study found that biogas provides fuel for cooking and also lighting. Consumption of other fuels namely firewood, kerosene, and LPG can be reduced significantly by using biogas. Time and money can be saved as cooking from biogas is faster than it is from firewood or kerosene. Due to the clean and healthy environment the living standard of the people may improve. Biogas also provides highly nutritive organic manure for soil which raises the productivity and saves money required to purchase chemical fertilizers. From the macro perspective it protects the natural resources such as forest and prevents deforestation.

Dhakal (2002) presented his M.Sc. thesis entitled "Microbial Digestion of Vegetable and Kitchen Waste for Biogas Production." In this research, he studied microbiological method of producing biogas from vegetable and kitchen waste with or without cow dung. He found that biogas production through anaerobic digestion of the biodegradable portion of waste is continuous and self-sustained process, which once established has array of advantages. It becomes cost-effective in the long run because it is continuously a clean burning fuel and high quality fertilizer from low-value waste. The study concluded that the equal volume mixture of cow dung, vegetable and kitchen waste is an effective feed material compared to kitchen waste only for increased yield of biogas, which is beneficial especially for marginal farmers. If the ambient temperature is suitable, biogas can be produced easily even at outdoor environment. Alternatively, vegetable and kitchen waste can replace the use of animal and human excreta for biogas production. The use of such feed materials can initiate the management of biodegradable solid waste in urban areas. At the same time, along with alternative energy production, high quality fertilizer also comes to be available.

Shrestha (2003) reveals that biogas is used instead of traditional sources of energy. The use of biogas minimizes the consumption of firewood and kerosene. This saves foreign exchange. The changed method of cooking in the house saves time. After the installation of biogas plant, forest is preserved and people get cleaner environment

2.2 EMPIRICAL REVIEW

ADB/N (1986) reported that a biogas plant owner had saved 55 and 41 quintals of firewood (65 percent of the requirement) in the Terai and the Hills, respectively. Likewise, 102 liters and 83 liters of kerosene were saved in each of the regions respectively contributing to the reduction in deforestation and import of petroleum products that is kerosene and LPG. As far as saving in time is concerned, the use of biogas had saved 1.8 hrs and 0.6 hrs per day per household in the Terai and the Hills, respectively. The gained time could be utilized in productive activities.

Vliet (1993) carried out a study to monitor the impact of biogas on the workload of women in 21 households in MadanPokhari VDC of Palpa district. The study found that the installation of biogas plants had provided various benefits such as timesaving, relief from the collection of firewood from jungles and convenience in cooking food. A total of 1 to 2 hours of time was saved per day per household, and the saved time was then used in some other income generating activities.

Poudyal (1993) reveals the economic significance of the bio-gas system. The role of biogas technology was to increase the biological efficiency of farming system also reflects its economic significance. In case of a $10M^3$ biogas plant, we can produce $2.7M^3$ of gas per day with feeding of 60 kg dung and this can run a stove for 7 hours which can easily meet the energy required for cooking purpose of the normal farm family size (5-8 members). Thus biogas helps the farming system to be economically sound. He also discussed the substitution effect of biogas. The given table shows the substitution effect of biogas produced from different size plants.

TABLE NO. 2.1SUBSTITUTION EFFECT OF BIOGAS PRODUCED FROM VARIOUS PLANT SIZES

Size of the plant (in M^3)	Per day gas generation (in M^3)	Substitution for		
		Fuel wood (kg per day)	Kerosene (in liter per day)	Cow dung cake (in kg per day)s
4	1.62	5.62	1.00	21.06
8	2.16	7.50	1.34	28.08
10	2.70	9.37	1.67	35.10

Source: Poudyal (1993)

Britt (1994) has shown concise overview of studies specifically designed to measure the effects of biogas on women's workloads in different geographical settings of Nepal and the studies were done in Rolpa, Rupandehi, Nuwakot, and Chitwan districts. The result from the study states that given the overwhelming workloads for women in most parts of Nepal, the saving in time in the majority of instances was quite significant. But it remarks that the introduction of biogas did not appear to fundamentally alter the position of women. The so-called traditional or unequal patterns in the division of labour were sustained, with women working for long hours simply substituting one labour activity for another. It was found from the study that estimated time saving for women in Rupendehi was 4 hours and 30 minutes (on average) and 2 hours and 3 minutes (on average) in Nuwakot. However, in a village based research, the estimated time saving was found to be 1 hour and 55 minutes in Madanpokhari, 3 hours and 14 minutes in Pithuwa and 15 minutes in Hathilet village.

BSP (1995) finds that a total of 41867 metric ton firewood has been saved from the subsidy provided by BSP to install biogas plants. Similarly, a total of 670 kilolitres of kerosene has been saved, resulting in a saving of approximately Rs. 6832000 annually. Likewise, 1280 hectares of forest (6 percent of the total depletion) has been saved from the decrease in fuel wood consumption.

WECS (1995) has conducted a research in Rupandehi district on biogas. The research was focused on the socio-economic impact of the biogas on women. After biogas installation, the time for fuel wood collection was reduced by 0.5 hours to almost 1 hour per day on an average. Furthermore, the average cooking time was reduced by 50% from 4.3 to 2.1 hours a day. The time thus saved can ultimately be utilized in other income generating activities, which can be seen as another indirect contribution of biogas. Likewise, the increased agricultural productivity through increased soil fertility form the slurry is also considered as a positive impact of the biogas plant on the economy. Moreover, time and money saved through improved health and hygiene, e.g. reduced cases of eye and respiratory illnesses and the number of burning cases can be considered as another indirect positive impact on the economy. The major benefits for women and children are seen in the changes in the cooking environment: biogas cooking produces no smoke which means that eye and lung diseases can be reduced; cooking utensils get less dirty than in case of firewood cooking; and cooking on bio-gas becomes easier and faster. Similarly, it is less time consuming than collecting firewood and making dung cake preparation, and as a result, girls get more time for other activities, e.g. going to school.

BSP (1996) found that the benefits of biogas installation were saving in time, visible implications for personal health and general sanitary condition, saving in firewood and kerosene. One hundred biogas plants were estimated to save 2.8 hectares of forest.

Adhikari (1996) has shown the impact of biogas plant on several fronts. This study has considered the negative and positive impacts of biogas. This report is based upon the survey of 25 samples households of Ishaneshowor village of Lamjung district. The most important positive impacts on health were reduction in eye disease; headache, coughing and throat ache whereas the negative impacts were increased prevalence of mosquito and loss of warmth in house in winter. Sanitation condition and practices were improved and the study reported 62% reduction in firewood consumption after biogas plant installation.

BSP (1997) reported that installation of biogas during the first and second phases of BSP achieved the following results: a) time saving of 3 hours per day per family; b) saving of 60000 tons of firewood annually; c) saving of 800000 liters of kerosene annually; and d) job opportunities for 7000 skilled and semi skilled manpower.

Consolidated Management Services Nepal (1998) conducted an economic analysis of the community gobar gas plants which showed that the diesel saved from the dual- fuel engine was not as high as expected. It was previously thought that the saving in diesel from the dual-fuel engine would make the mill more profitable since less amount of diesel would be used. But the mills had to be operated mostly on diesel alone because the plants were unable to generate enough gas during winter season when customers' demand for the processing grain was very high. The prevailing high consumption of the diesel may be attributed to the inefficiency of engine resulting from faulty installation of the huller and engine. As a result, many community plant owners found themselves in much higher debt than they should have been. They seemed to have developed the feelings that if the mill was operated on diesel fuel only, their income would have been much higher.

Ghimire (1999) revealed that the main benefits of biogas plants to the users was the cooking and lighting facilities that saved a considerable amount of time and money. The total time saving amounted to 1.22 hrs per day per family.

BSP (2002) found that 97 percent of installed biogas plants were in operation in Terai. There had been a decrease of 3.39 kg of fuel wood per household per day in summer and 7.55 kg of fuel wood per household per day in winter. The corresponding figures for the hills were 5.54 kg and 6.47 kg in summer and winter respectively. After the introduction of biogas plant, the consumption of kerosene had been reduced by 0.3 liters and 0.33 liters per day per household in Terai in summer and winter respectively. Similarly, biogas households in the hills had experienced a decrease in kerosene consumption by 0.36 and 0.42 liters per day per household in summer and winter respectively. An 85 percent of biogas households perceived a remarkable decrease in smoke after they had had the biogas plants. The result of the survey indicated that introduction of biogas had impact on the control of cough, symptomatic eye infections, incidence of dysentery and tapeworm infestation. Presence of these diseases was found to be 4 to 5 percent lower in biogas households. After the installation of biogas plant, daily consumption of fuel wood was found to be reduced by more than 50 percent. Crop production was found to have increased by about 10 percent after the use of bio- slurry which resulted in the upliftment of economic condition of the farmers. It was also found that due the use of bio- slurry, the use of chemical fertilizer was reduced by 9 percent.

Bajgain (2003) found that biogas provides a direct benefit, especially to rural women, as a result of the reduction of the workload while shifting from cooking on firewood to using biogas. The study recorded average time saving of approximately three hours a day per family mainly due to reduction in time used for collecting firewood, cooking and cleaning utensils. Reduction in workload provides more time to the housewives for doing remunerative and productive work. It is also found that one biogas plant saves about 2.3 tons of fuel wood per year. It roughly saves 0.03 hectares of forest land per year. Thus, with 1, 00,000 biogas plants installed in Nepal, it would save approximately 3000 hectares of forest every year.

Sharma (2004) describes biogas and its commercial use. According to him, as a cooking fuel, it is cheap and extremely convenient. Based on the effective heat produced, a 2m cubed biogas plant could replace, in a month, fuel equivalent to 26 kg of LPG (nearly two standard cylinders), or 37 litres of kerosene, or 88 kg of charcoal, or 210 kg of fuel wood, or 740 kg of animal dung.

Upreti (2004) has carried out the study on "Economic Impact of Biogas in Khaireni VDC, Chitwan". This study was undertaken to analyze the economic impact of biogas plants. Descriptive method was used for the study. Information was collected from field survey whereas 30 samples of biogas households were taken from whole population. Questionnaire, interview and observation were used as main tools for the study. The main findings of the research are as follows: a)There is a considerable reduction in the workload of the family members especially women; b) A significant amount of time has been saved and the saved time (63.3%) has been used mostly in agricultural activities; c) Most of the households have latrine facility (90%) but the number of latrines connected to plant is very negligible (20%); d) In-house pollution due to smell of kerosene and smoke as well as medical expenses has been reduced; e) Consumption of kerosene has been reduced by 0.25 and 0.19 litre per day per household in summer and winter respectively; f) The consumption of LPG has decreased by 43.7 % in summer and 19.8 % in winter; g)

Only 10 out of 30 households have completely stopped the use of traditional stoves; and h) Most of the users use slurry in composted form (60%). Application of bio-slurry to the crop has resulted in increased agricultural productivity, which has resulted into monetary gains for them.

Aryal (2010) writes that biogas is a reliable alternative source of energy. Nepal has the potential of installing 1.3 million biogas plants. However, the actual number of plants installed is only about 150000, which has reduced the consumption of firewood by 250000 ton and that of kerosene by 4 million liters. In general, a household with two cattle can install a biogas plant. Although the plant installation cost is high, the government has provisioned a subsidy program for the ultra poor to ease the problem. Biogas can be very handy while cooking, lighting, as well as providing agro-fertilizer through bio-slurry. In Nepal, if biogas potential is fully realized, it can support 10 percent of total energy consumption of the country.

2.3 TRADITIONAL BIOMASS FUELS IN ENERGY USE

Fuelwood is the principal energy source among the biomass fuels; its demand far exceeds the sustainable supply (Rijal 1998). In Nepal, out of the total amount of traditional energy used (85.50 percent of total national energy demand), the share of fuelwood consumption was 88.68 percent (MOF 2007).

2.4 ADVERSE IMPACT RELATED WITH TRADITIONAL BIOMASS FUEL

A study indicates that a kilogram of *Acacia* wood burned in a traditional mud stove generates 318 gram Carbon (g-C) equivalent of Carbon emission (Smith et.al 2000). According to Pandey (1989) in rural communities of the hill region of Nepal, domestic smoke pollution is a risk factor of ARI among infants and children less than 2 years spent near the fireplace. The health problems like, Conjunctivitis, Upper Respiratory Irritation, Inflammation, Acute Respiratory Infection (ARI), Acute poisoning (from carbon monoxide), Burns, Cataracts, Arthritis, Lung Cancer, Chronic Bronchitis are the adverse effects of biomass combustion on human health (WHO 1991).

Nepal Health Research Council (NHRC 2004) found that the prevalence of ARI among children aged below 5 was 38 percent (11 of 29 examined) comparing ARI by dual fuel types and children either unprocessed fuel in the kitchen had a higher prevalence (59 percent, 10 of 17) as compared with children with processed in the kitchen (33 percent, 1 of 3).

The airborne particles have been identified as an important factor of increased child mortality; another common particle related problem is eye ailments (Bajgain and Shakya 2005). Bates et al. (2005) confirmed that the use of solid fuel in indoor stoves is associated with an increased risk of cataracts in women.

The burning of firewood, dung cakes, straw and agricultural residue creates many hazardous particles. Since cooking is usually done indoors, this can lead to severe health problems. The particles from the smoke can give rise to acute respiratory infections among the people who are in contact with the smoke. These people are mainly women, children and infants. The dangerous particles have been identified as an important factor of increased child mortality. Another common particle related problem is eye ailments. (Bajgain, Shakya, 2005)

Energy from biomass can be very good if used in a sustainable way, something that arguably can help replace fossil fuels. The big problem in many developing countries is that the energy resources are used in an unsustainable way. The demand for energy is far greater than the availability. This can lead to many problems such as deforestation, health impacts and increasing climate change.

2.5 BENEFITS OF BIOGAS

2.5.1 BENEFITS FROM REPLACEMENT OF FIREWOOD

With the installation of biogas systems, the annual reduction of fuelwood was two tons per household and this provided an equivalent protection of 6,790 hectares of forest per year through 11,395 operational biogas plants (Winrock and Eco Securities 2004). Use of biogas for lighting benefit to study during the dark hours as well (Bajgain and Shakya 2005).

According to BSP (2006), with over 168,613 plants installed under the SNV/BSP programmed at the end of fiscal year 2006/07, of which 97 percent are operational displace the use of 328 thousand tons of fuelwood, 5.2 million liters of kerosene and replace chemical fertilizers with 280 thousand tons of bio-fertilizer annually and save approximately 1850 ha of forest annually. The use of fuelwood has reduced by 162 kg/month/HH which accounts for the saving of nearly 2 tons/year/HH (CMS 2007).

2.5.2 BENEFITS OF BIOGAS ON HEALTH AND SANITATION

Review of IEIA (2002) study carried out by SNV/BSP showed that the record of toilet construction is higher among biogas households. The study conducted in Kaski and Tanahun districts revealed significant percentage of reduction in cough, eye infection and headache after biogas installation (RUDESA 2002).

In Bhaktapur District, 67 percent of the households reported reduction in smoke related diseases (NGO Promotion Center 2003). The primary benefits of improved health among biogas households are due to reduced indoor smoke indirectly reducing health- related expenses (East Consult 2004). Indoor climate dramatically improved as a result of using clean biogas stoves instead of burning fuelwood, straw and dung cakes would mean that a lot of the problems with hazardous smoke particles would be avoided (Li et al. 2005).

The results of the biogas users' survey showed that there is significant improvement in the incidence of smoke-borne diseases such as eye infection, cough and headache after biogas installation (BSP 2007).Only 58 percent of households had toilet before biogas installation which have increased to 97 percent after biogas installation (CMS 2007).
Around 70 percent of biogas households have the toilet attached into the plant (AEPC 2008). The anaerobic fermentation of waste products, human excreta and cattle manure is a cheap way of getting energy and at the same time handling waste products (Gautam et al. 2009).

A study by NGO Promotion Center (2003) in Bhaktapur District found 30 percent have been involved in the income generating activities from the saved time. Biogas Users Survey Report of BSP, 2006/07 showed after biogas use rural women have more time for their children (94 percent against 51 percent before biogas use).According to CMS (2008), women are able to save 93.2 minutes per day after biogas installation and 30.8 percent of users are involved in income generating activities.

2.5.3 TIME SAVING AND WORKLOAD REDUCTION

A study by NGO Promotion Center (2003) in Bhaktapur District found 30 percent have been involved in the income generating activities from the saved time. Biogas Users

Survey Report of BSP, 2006/07 showed after biogas use rural women have more time for their children (94 percent against 51 percent before biogas use).According to CMS (2008), women are able to save 93.2 minutes per day after biogas installation and 30.8 percent of users are involved in income generating activities.

2.5.4 BENEFITS OF BIO-SLURRY

Slurry from one kilogram digested dung can yield up to an extra 0.5 kg nitrogen compared to fresh manure (Sasse 1988) and estimated the N: P: K content in the bio-slurry is 2.7:1.9:2.2 respectively (CMS 1996). According to Devkota (2001), the economic value of the bio-slurry shows that the investment can be gained back in three to four years. It is estimated that the use of bio-slurry annually saves 39 kg of nitrogen, 19 kg phosphorus and 39 kg potash per household (East Consult 2004). Bio-slurry use can solve problems of soil degradation in areas where earlier dung has been used as a burning fuel and can also mean that less artificial fertilizer have to be bought which bring revenue to the household (Li et al. 2005).

In Nepal also the trend of bio-slurry utilization in form of fertilizer is gradually increasing among the biogas user farmers. However, not all farmers seem to realize the importance of the digested slurry. It goes without saying that viability of biogas plant without slurry utilization is meager (BSP 2009).

2.5.5 ECONOMIC BENIFIT

Assuming a life span of 20 years, the base analysis conducted by East Consult (2004), which included only the saving of fuelwood and kerosene at the base price of NRs. 2 per kg for the hills showed that, biogas has reduced the expenditure of the household users on fuel purchase, thereby saving NRs. 2,125 monthly, which is equivalent to an annual saving of NRs. 25,499 (CMS 2007).

2.6 GHG REDUCTION

The substitution of traditional stoves and the kerosene stove by the biogas stoves will increase the cooking efficiency of combustion than the traditional biomass stoves and the fossil fuel stoves (kerosene / LPG stoves) and contribute by far the lowest to the greenhouse gases (GHG) (Smith et al. 2000).

According to Shrestha et al. (2003) the biogas plants of sizes 4, 6 and $8M^3$ mitigates about 3, 4 and 5 tons of carbon dioxide per plant per year in the hills. According to Winrock and Eco Securities (2004), the available carbon reduction per year per plant from the displacement of fuelwood, agricultural residues, dung and kerosene is nearly 4.6 tons of carbon equivalents. Biogas plant having size of $6M^3$ displace the use of three tons of fuelwood or 38 liters of kerosene annually and reduces 4.9 tons of carbon dioxide equivalent per year (Devkota 2007). Initially, it was estimated that each biogas system would reduce as high as 7.40 tons of GHG but the rate was capped at 4.99 tons of GHG per year per system due to limitation of a Small Scale Methodology of CDM (AEPC 2008).

2.7 CDM APPROACH

Biogas is the first CDM project in Nepal. In the context of CDM project of biogas in Nepal, an Emission Reduction Purchase Agreement (ERPA) for the two projects has been signed with the World Bank for trading of the Emission Reductions from the two projects for first seven years starting 2004/05 as the first crediting year. Annual reporting and verification for the two Projects for crediting years 2004/05 and 2005/06 have been completed and payment has also been made. From these two Projects, the annual carbon revenue (net of Project development and verification expenses) is around US$ 600,000 (BSP 2008).

2.8 INVESTMENT ASPECT AND PAYBACK PERIOD

For a plant with total investment cost NRs. 27,204, it will take 6.1 years to repay the loan whereas with subsidy NRs. 9,000, it will take only 4.1 years. The calculation was based on NRs. 3,240 saving from fuelwood (6 kg per day at rate of NRs. 1.5 per kg), NRs. 510, saving from kerosene (2.5 liters per month at rate NRs. 17 per liter) and NRs. 2,000 saving from chemical fertilizer (estimated 17,500 kg dung). The maintenance cost of the plant had been estimated at about NRs. 400 per year and the annual labour cost NRs. 800 (fifteen minutes per day at rate NRs. 70 per day) and miscellaneous cost NRs. 100 per year. The economic value of the slurry shows that investment can be gained back in three to four years (Devkota 2001).

The short payback time makes biogas plant affordable for most rural households, even in poor areas (Li et al. 2005).Calculations have shown that the payback time for a farmer scale Chinese type fix dome biogas digester depends on how the biogas digester is used, what substrates, size, price on fuelwood and without any subsidies would be around 3.6 to 5.8 years (Woods et al. 2006).

According to the 2006 Energy synopsis Report 6, the contribution of biogas systems in the residential energy consumption sector has been gradually increasing over the past few years (WECS 2006). For the Fiscal Year 2007/08, the cost of a Biogas Plant of $6M^3$ is estimated NRs. 35,156 for hills and a subsidy of NRs. 9,500 per plant. Majority of the plants constructed are of $6M^3$ and for the fiscal year 2007/08, the average cost of a biogas plant of $6M^3$ in hills is NRs. 35,156 and has a subsidy of NRs. 9,500 per plant.

The average cash incurred for the maintenance was within the range of NRs. 300 to NRs. 600 per year (BSP 2008).

2.9NATIONAL POLICIES AND ACTION PLAN

Renewable Energy Technologies have increasingly received due attention in periodic plans since the Seventh Plan (1985 -1990) where, for the first time, a targeted approach amongst other policy measures was established for its development. The Eight Plan (1992 - 1997) envisaged the need for a coordinating body for large- scale promotion of alternative energy technologies in Nepal and the Alternative Energy Promotion Centre (AEPC) were thus established as an executing body.

The Ninth Plan (1997 - 2002) formulated long term vision in the science and technology sector which has the fundamental goal of rural energy systems developed as to increase employment opportunity through gradual replacement of traditional energy with modern energy. Renewable Energy Subsidy- 2000 and the Renewable Energy Subsidy Delivery Mechanism- 2000 were formulated and implemented to realize the objectives set out in the plan. The Tenth Plan ((2002 - 2007) gave priority to suitable and relatively smaller size systems. It also encouraged research on expansion of biogas systems in the Himalayan region and towards reducing the cost.

The Perspective Plan (1991 – 2017) has recommended for development and promotion of alternative energy resources and technologies including biogas as an integral part of overall rural development activities. The proposed Renewable Energy Perspective Plan of Nepal, 2002 – 2020: An Approach (REPPON) prepared by CES/IOE has envisaged the development objective of biogas sector so as to direct the national biogas program from technical, financial and socio-economic sustainability perspective. The current three- year plan has targeted to install additional 100,000 plants.

The Government of Nepal has promulgated the Rural Energy Policy for the first time in 2006. The policy has envisioned linking renewable energy including biogas to economic activities. The GoN recently approved a new subsidy policy - Subsidy for Renewable (Rural) Energy Subsidy, 2006 and the (Rural) Renewable Energy Subsidy Delivery Mechanism- 2006 to ensure proper flow of subsidy.

The supportive government policy acknowledges the important role of biogas in meeting household energy requirements and also in mitigating environmental degradation.

From the aforementioned studies, it indicated that installation of biogas has positive impacts on farmers. However, it has also been heard that some of the users have experienced negative impacts as well. In order to encourage the installation of biogas plants, the subsidyhas also provided to the farmers. Government has aimed at addressing positive aspects of the biogas as an alternative source of energy.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 RESEARCH DESIGN

The study is based on both primary and secondary sources of data. The primary data were collected from structured questionnaire and interview technique. For the secondary data, Internet, books, journals, articles, the records of VDCs and DDCwere used**.** The main aim of the study was to find the impact of biogas plant installation on the household of Dhaijan VDC of Jhapa district.

This is the case study research and descriptive research design based on the opinions of the respondents has been used to conduct this study. Questionnaire has been set accordingly to meet the objective requirements.

Reliability and validity is the major concern of the case study research. To increase the degree of validity and reliability, researcher tried for the accuracy of the study. The degree of accuracy was maintained with the help of many reliable sources of information's from VDC, DDC, Biogas Company, carefully selected samples, multistage sampling framework, household survey, focus group discussion and so forth. The data have been tabulated, analyzed, presented and interpreted by using averages, percentages and other statistical tools as per the requirement. For these purposes computer software programs like Microsoft Excel and SPSS have been used.

3.2 DESCRIPTION OF THE SAMPLE

3.2.1 SAMPLE DESIGN

In the present study, the survey is based on multistage (3-stage) sampling. In the first stage, the VDC was selected purposively. The second stage was the selection of the wards of the VDC. The VDC consists of nine wards. Out of these, three wards were selected having large number of biogas plant. The third stage was the selection of the households. For the selection of the households, the total number of the households of the selected wards was collected from VDC office. Then, the sample size for each ward was determined according to the number of the households using biogas. Then, the households were selected purposively.

3.2.2 SAMPLE SIZE

Total sample size of our study in Dhaijan VDC was 26. The sample size was based on the density of the biogas using households of the wards. From the three selected wards4, 7 and 15 samples were taken purposively keeping in view the number of households using biogas in each of the three wards.

3.2.3 SAMPLE AND POPULATION DISTRIBUTION

According to the District Profile 2011, the total number of the households of the VDC was 2134. Out of this total, 64 households are biogas users which are 3 percent of the total households. Out of the total biogas using households, 26 households were surveyed, which is 40.62 percent of the total. This is not less than other similar types of studies. Setting the targets of Millennium Development Goals for Jhapa district in 2006, UNDP conducted a research based on 187 households, which was 0.13 percent of the total 137301 households.Table 3.1 shows the distribution of households and population in selected wards of the study area.

TABLE 3.1SAMPLE AND POPULATION DISTRIBUTION OF HOUSEHOLDS

Ward No	Number of HH	Biogas User HHs	Sample HHs
1	321	5	4
3	184	7	7
6	851	42	15
Total	1356	54	26

Table 3.1 shows the selected wards, total number of households therein, the total number of biogas using households, and the sample size of the study.

3.3 DATA COLLECTION PROCEDURE AND TIME FRAME

3.3.1 PRIMARY DATA

The study has been based on primary and secondary data. Questionnaire sheets were used for collecting primary data. The survey was carried out in September 2015. Two methods were used to collect the primary data, which were explained above. Before conducting the survey, researcher carried out the following steps: first, sample size was decided for the selected wards; second, sampling frame was constructed with the help of Village

Development Committee report and other similar types of research; third, for each ward, samples were selected purposively; fourth, questionnaire was pre-tested and revised; and finally, the revised questionnaire was directly administered to the respondent household. The chief merit of direct oral interview is that it makes crosschecking possible while the demerit is that there may be biasness from the interviewer.

3.3.1.1 HOUSEHOLD SURVEY

In the household survey, information was collected from the representative or a well informed member of the family. Different methods were used to check the validity of the data. Crosscheck was made in order to test the validity of the data. The questionnaire was divided into three parts: household identification, household income and consumption expenditure, and information on uses of biogas

3.3.1.2 FOCUS GROUP DISCUSSION

Focus Group Discussion was made in order to obtain further information about the uses of biogas. The members of the sampled households having sufficient information on various aspects of biogas were the participants in the discussion

3.3.2 SECONDARY DATA

Profiles of DDC and VDC, Journals, articles, booklets, newspaper and magazines, books on related topics and published sources of data on internet are important sources of secondary data considered. Though, both secondary and primary data are extensively used in the study, primary data (questionnaire and interview) serves as an integral part of the study.

3.4 ANALYSIS PLAN

The data have been tabulated, analyzed, presented and interpreted by using averages, percentages and other statistical tools as per the requirement. For these purposes computer software programs like Microsoft Excel and SPSS have been used. This study has followed descriptive method of analysis. Collected data have been tabulated and analyzed under before-after framework. Findings from qualitative information have also been presented.

3.5 VALIDITY AND RELIABILITY

As both primary and secondary sources are considered for the study, the validity of secondary sources of data are assumed to be more static compared to primary source of data. Published journals, articles, books and magazines, validated websites are some of the sources of secondary data, thus, as these sources are authenticated by the publishers, the data and sources of information are considered to be valid and can be trusted upon. On the other hand, as the key primary sources of data are questionnaire and interview, the data validity may be affected by the degree of consciousness of the respondents on the subject and their degree of zeal in the subject matter.

Similarly, as secondary sources of information/data are authenticated and already accepted in many fields, the reliability of secondary data is relatively higher compared to primary data, as in case of primary data, respondent are the sole source of information and the reliability of information vary upon their interest and participation/ seriousness towards the subject.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION OF THE STUDY AREA

Dhaijan is a VDC situated *in* Jhapa district, Mechi Zone, Nepal. With the total area of 15.49 sq. km., it shares its boundary with *DuwagadiVDC*in the south, *Budhabara ,Sintanagar*VDC and *Mechinagar*Municipulity in the north, *Mechinagar*Municipu;ity in the east and *Sanischare*VDC in the west. This area is 0.96 percent of the total area (1606 sq. km.) of Jhapa district. According to the District Profile 2011, the total number of the households in the VDC is 2134, with the total population of 11270. The population density of the VDC is 727.56 per sq. km. which is greater than the district average of 252.61 per sq. km and national average of 157 per sq. km. The male population is 5740 and that of female is 5530. Of the total household heads, 59.98 percent are male while only 40.02 percent are female-headed households. The major ethnicities residing here are *Brahmin, Chhetri,Tharu, Muslim, Dhimal,Rajbanshi, Majhi, Mecha, Koche, Satar, Rai , limbu, kami, Magar, Newar*and others.

This is a VDC with moderately developed infrastructure. There are three primary school, two lower secondary school, one secondary school, one higher secondary school and many other private schools. There is one sub-health post, one extra post office, and three community forest. The total length of the roads in the VDC is 58 km. Most roads are graveled and some are even tarred. According to the VDC profile 2011, of the total households, 1594 have access to electricity which amounts to 74.69 percent of the VDC house hold. But this scenario must have changed over the years due to rapid electrification program of the Government of Nepal. About one factory is located in the VDC. In the VDC, the total number of households having access to land line telephone is 115 which is 5.38 percent of the total households of the VDC.

The land here is fertile for cultivation. There is good facility of irrigation;this provision has made agricultural production easier. Agriculture, poultry farming, animal husbandry are common sources of livelihood. Nowadays many youths are attracted towards foreign employment. Service, business and wage labor are the other occupations besides agriculture.

4.2 SOCIO-ECONOMIC CHARECTARISTICS

The study area has heterogeneous characteristics in terms of social and economic facets. Different ethnic and income groups of the households and population are living together with different socio-economic situations, i.e. own social values, norms, religions and cultural attributes and different economic status. This study has tried to analyze the socio-economic heterogeneous nature of the biogas using rural population and households at the VDC level.

4.2.1 CATAGORISATION OF ETHNICITY/CASTE

In this research, the ethnicities were classified in three categories, which are the standard GoN classification and other similar types of research. The categories are Advantaged Group, Disadvantaged Group and Dalit & Others. The Advantaged Group consists of Brahmin, Chhetri, Newar, Thakurie; Rai, Limbu, Tamang, Gurung, Tharu, Rajbansi. belong to the Disvantaged Group; and Kami, Damai. Sarki, Musahar, santhal, munda, sunuwar. are kept under the category of the Dalit & Others.

TABLE 4.1 COMPOSITION OF SAMPLE POPULATION BY ETHNICITY AND SEX

Ethnicity	Total Households	Male	Female	Total Population	Average Family Size	Sex Ratio
Advantaged	16	46	53	99	6.18	0.86
Disadvantaged	9	23	25	48	5.33	0.92
Dalitsand Others	1	3	2	5	5.00	1.5
Total	26	72	80	152	5.84	0.9

Source: Field Survey, 2015

The table 4.1 shows that male population is lower than female population in Advantaged Group (sex ratio 0.86) and Disadvantaged Group(sex ratio 0.92). While the ratio is just opposite for Dalit and Others group (sex ratio 1.5) The possible reason is that son preference system is deep rooted in advantaged and disadvantage group while there is no such discrimination between son and daughter in the other groups in the study area.

4.2.2 POPULATION DISTRIBUTION OF HOUSEHOLD HEADS BY ETHNICITY AND SEX

TABLE 4.2SAMPLE POPULATION DISTRIBUTIONS OF HOUSEHOLD HEADS BY ETHNICITY AND SEX

Ethnicity of Household	Head of Household		Total
	Male (Percent)	Female (Percent)	
Advantaged	12(75)	4(25)	16
Disadvantaged	5(55.55)	4(44.44)	9
Dalits and Others	1(100)	0	1
Total	16(61.53%)	8(30.76%)	26(100%)

Source: Field Survey, 2015

Table 4.2 shows that the household head scenario is male dominated in all ethnicities. The only ethnicity in which we find some female headed households is the advantaged and disadvantage. This result is better than the national (74.27% male headed households) and district (70.33% male headed households) scenarios (CBS, 2011).

4.2.3 OCCUPATION OF HOUSEHOLD HEADS BY ETHNICITY /CASTE

TABLE 4.3 OCCUPATION OF SAMPLED HOUSEHOLD HEADS BY ETHNICITY

Occupation of household Head	Number of Households			Total	Percent
	Advantaged	Disadvantaged	Dalits and Others		
None	1	1	0	2	7.69
Agriculture	7	2	1	10	38.46
Business	1	1	0	2	7.69
Public services	1	0	0	1	2.84
Private services	1	1	0	2	7.69
Wage labour	2	2	0	4	15.38
Foreign Employment	2	1	0	3	11.53
Others	1	1	0	2	7.69
Total	16	9	1	26	100

Source: Field Survey, 2015

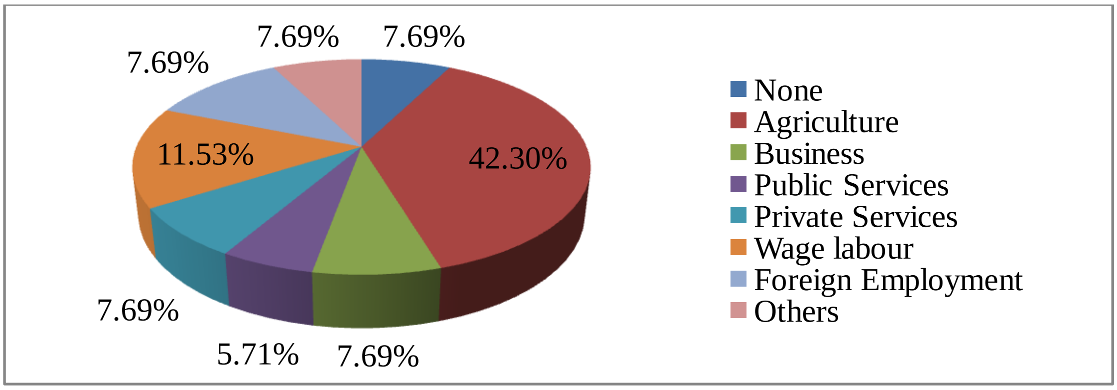


Table 4.3 shows that nearly one half of the total numbers of household have agriculture as their main occupation. The remaining households have other occupations. Second most common occupation is the wage labour. Only one household head was in Public Service. The population of household heads in Business, Private Services, foreignemployment is evenly distributed. A possible reason for this may be the fact that biogas and agriculture occupation are positively correlated.

4.2.4 DISTRIBUTION OF HOUSEHOLDS BY FAMILY SIZE

TABLE 4.4DISTRIBUTIONS OF HOUSEHOLDS BY FAMILY SIZE

Family Size	Number of Households			Total	Percent
	Advantaged	Disadvantaged	Dalitsand Others		
Small(Up to 4 members)	4	3	-	7	26.92
Medium(5 to 8 members)	8	5	1	14	53.84
Large(More than 8 Members)	4	1	-	5	19.23
Total	16	9	1	26	100

Source: Field Survey, 2015

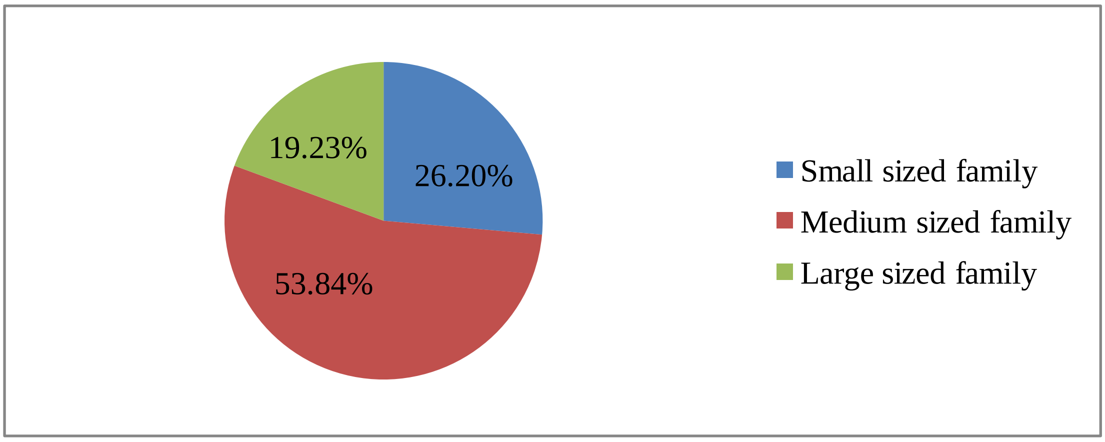


Table 4.4 shows that more than half of the households have medium size families. The households with small are more than large family size. The result is similar to the national average of the family sizes which is 4.88 (CBS, 2011).

4.2.5 EDUCATIONAL STATUS OF SAMPLE POPULATION

State of illiteracy is regarded as a proxy of poor quality of life. The discussion of educational status of sample households in the study area is based on six indicators namely, illiteracy, literacy, under SLC (secondary level), higher secondary level, graduate level and post-graduate level. Jhapa district is ranked at11th position based on whole development indicators of Nepal.

TABLE 4.5EDUCATIONAL STATUS OF SAMPLE POPULATION BY ETHNICITY

Level of Education	Advantaged	Disadvantaged	Dalits and Others	Total
Illiterate	9	3	2	14
Literate	18	9	2	29
S.L.C.	39	20	-	59
Intermediate	21	11	0	32
Bachelor	8	4	1	13
Master and above	4	1	-	5
Total	99	48	5	152

Source: Field Survey, 2015

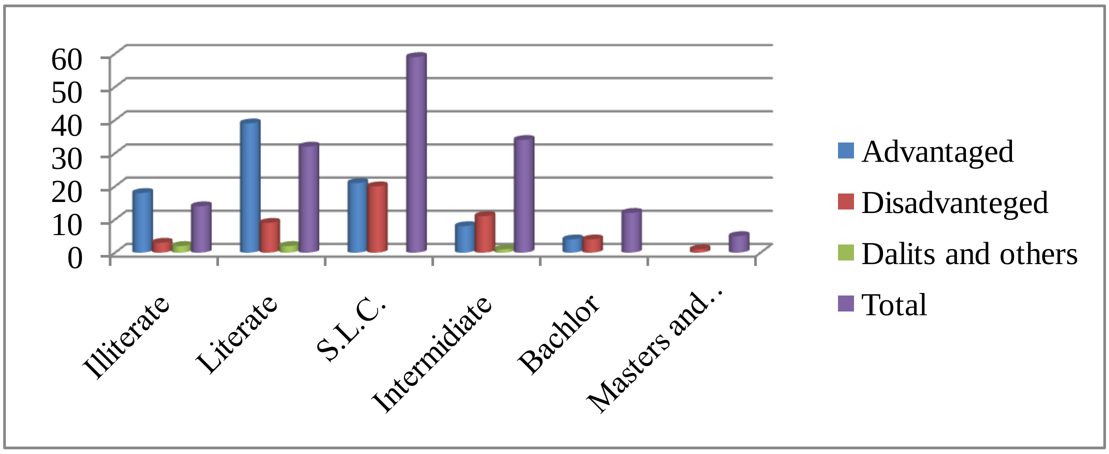


Table 4,5 supports the general belief that there is sharp ethnic gap in further successive levels of educational attainment for marginalized group compared to dominant ethnicity groups in the society.Table 4.5 shows education status by ethnicity. Within the ethnicity group, *Dalit* group has more illiterate people (40 percent) than other groups of people. Only one person is an intermediate educated and nobody has graduate and postgraduate level of education in *Dalit* group. The literacy rate of the Advantaged Group is found to be the highest.

4.2.6 TOTAL INCOME DISTRIBUTION AMONG HOUSEHOLDS BY ETHNICITY

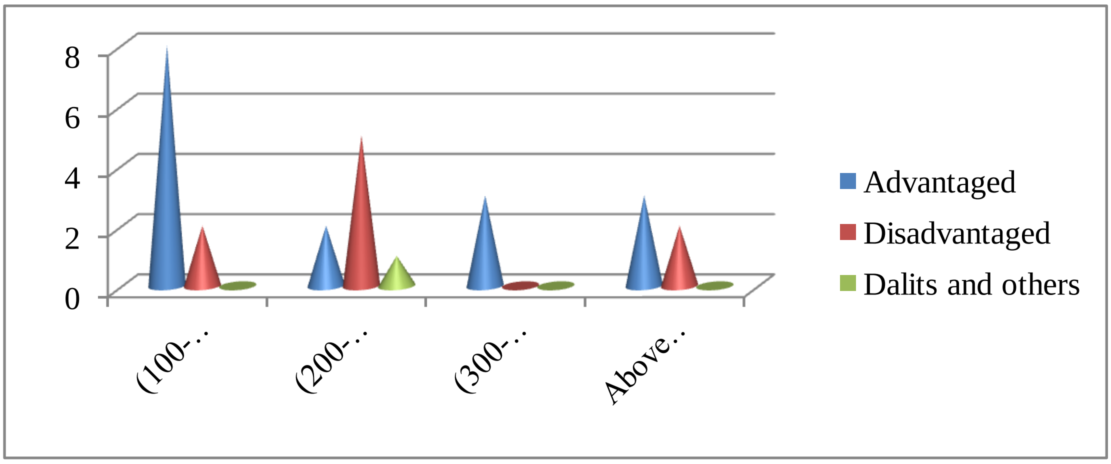
TABLE 4.6TOTAL INCOME DISTRIBUTION AMONG HOUSEHOLDS BY ETHNICITY

(Rs in ’00 thousand)

Level of Annual Income	Number of Households			Total
	Advantaged	Disadvantaged	Dalits and Others	
1 – 2	8	2	-	10
2 – 3	2	5	1	8
3– 4	3	-	-	3
4 and above	3	2	-	5
Total	16	9	1	26

Source: Field Survey, 2015

The diagram represents the annual income distribution among the households of different ethnicity



Nearly half of the surveyed households have their average annual income between one hundred thousand and two hundred thousand rupees. About a quarter of households have their average annual income between two hundred thousand to three hundred thousand rupees and remaining households' average annual income is above three hundred thousand rupees.

4.2.7 FREQUENCY DISTRIBUTION OF HOUSE TYPE BY ETHNICITY

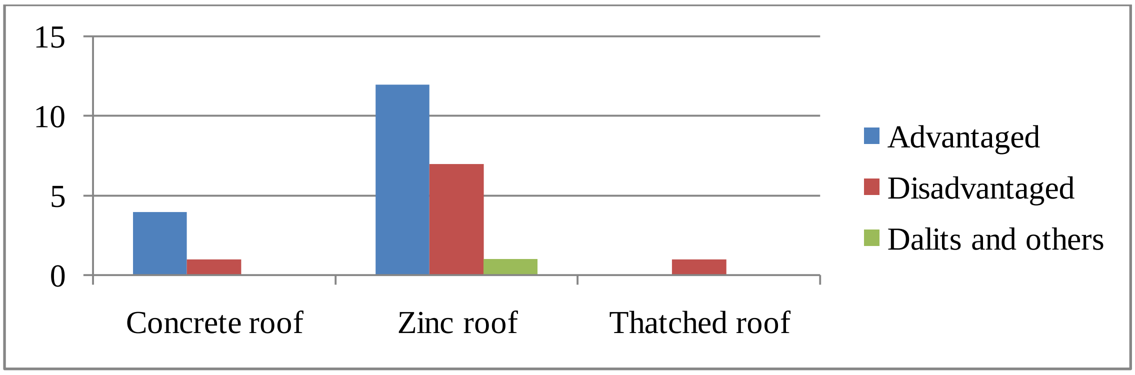
Type of the house generally serves as a symbol of social and economic status of the households (CBS, 2011).

TABLE 4.7FREQUENCY DISTRIBUTION OF HOUSE TYPE BY ETHNICITY

Ethnicity	Type of House			Total
	Concrete Roof	Tin Roof	Thatch Roof	
Advantaged	4	12	0	16
Disadvantaged	1	7	1	9
Dalits and Others	0	1	0	1
Total	5	20	1	26

Source: Field Survey, 2015

The diagram represents the type of house they owned by the sample households of different ethnic group



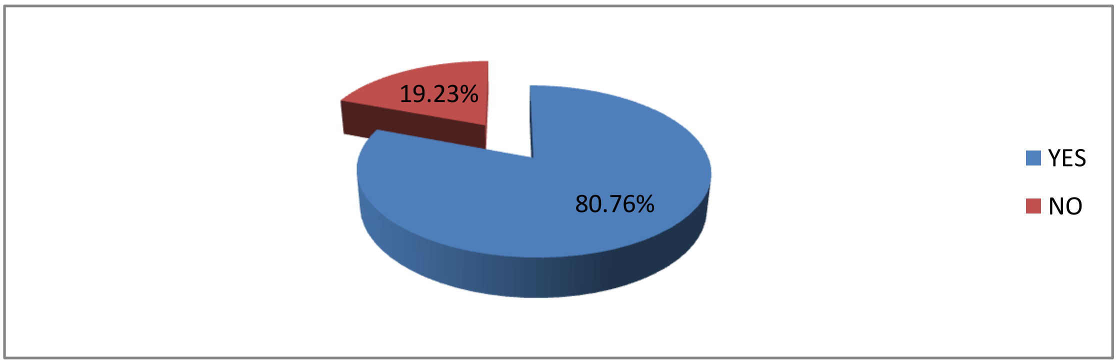
The table shows that among the households having concrete roof, advantaged households have the largest share. Again, the advantaged households occupy the largest share among the households having tin roof. The number of households having thatched roof is negligible. This is because biogas is an attraction mainly for the relatively richer households whose houses have either zinc roof or concrete roof.

TABLE 4.8 STATUS OF SEPARATE ANIMAL SHED IN THE SAMPLED HOUSEHOLDS

Ethnicity of Household	Separate Animal Shed		Total
	Yes	No	
Advantaged	13	3	16
Disadvantaged	7	2	9
Dalit and Others	1	0	1
Total	21(80.76%)	5(19.23%)	26(100%)

Source: Field Survey, 2015

The diagram represents the percentage of sample households having separate shed or not



The table implies that most households (80.76%) with biogas have separate animal sheds. It is also seen that all three ethnicity groups are almost homogeneous in relation to separate animal shed status.

4.2.8 OWNERSHIP OF PHYSICAL ASSETS BY ETHNICITY

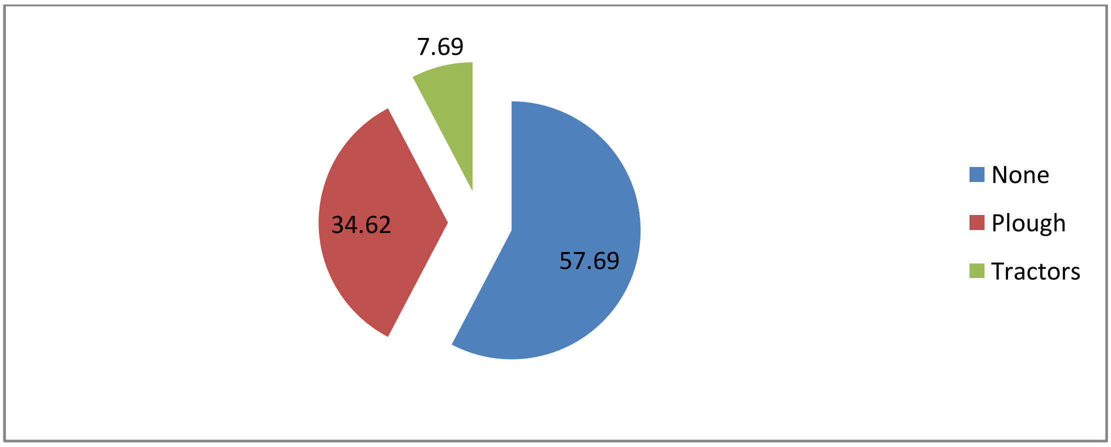
Possession of physical assets also reflects the socio-economic status of the households.

TABLE4.9 OWNERSHIP OF AGRICULTURE TOOLS BY SAMPLED HOUSEHOLDS

	Number of Households			Total	Percent
	Advantaged	Disadvantaged	Dalits and Others		
None	9	5	1	15	57.69
Plough	6	3	0	9	34.61
Tractors	1	1	0	2	7.69
Total	16	9	1	26	100

Source: Field Survey, 2015

The diagram represents the percentage of sampled households having different types of agriculture tools



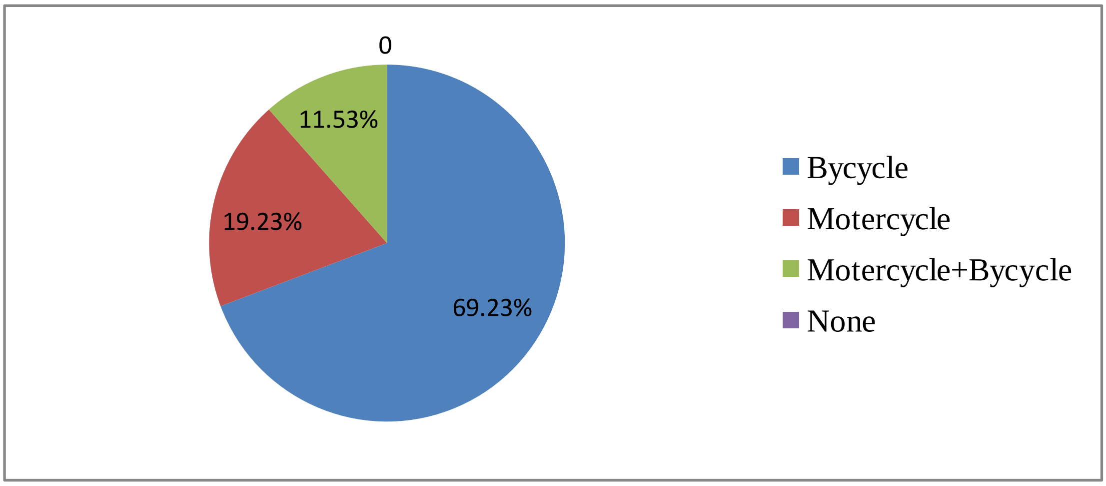
The table 4.9 highlights that majority (more than half) of households do not own any agricultural tools. Only a few households are found to have kept ploughs and tractors as agricultural tools. This is because most households in the study area have preferred to rare cows instead of oxen and he- buffalos in order to sell milk to the nearby dairy factory and also because tractors are readily available on hire to plough the field.

TABLE 4.10 OWNERSHIP OF VEHICLES BY SAMPLED HOUSEHOLDS

Vehicle	Number of Households			Total	Percent
	Advantaged	Disadvantaged	Dalits and Others		
Bicycle	11	6	1	18	69.23
Motorcycle	4	1	0	5	19.23
Motorcycle + Bicycle	1	2	0	3	11.53
None	-	-	-	-	-
Total	16	9	1	26	100

Source: Field Survey, 2015

The diagram represents the percentage of sampled households according to the type of vehicle they owned



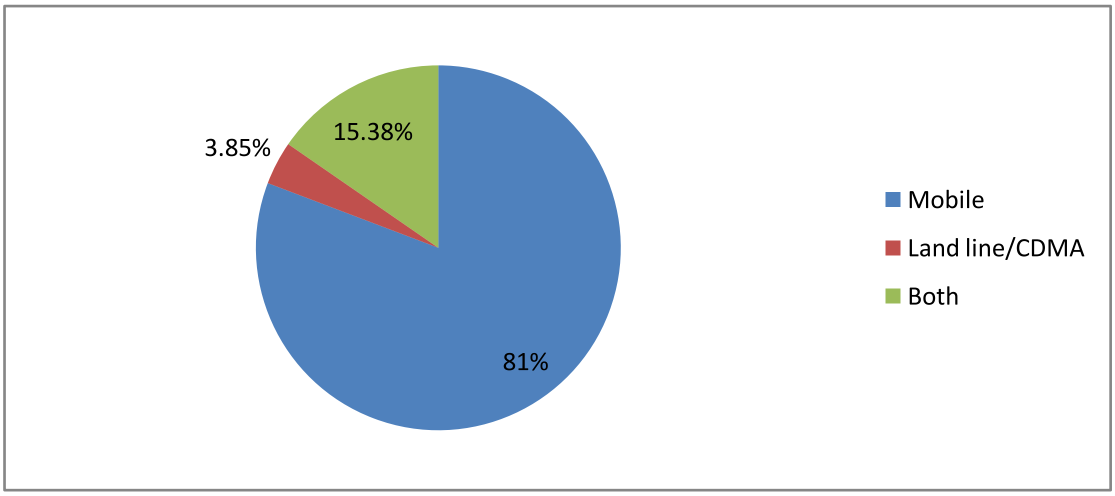
The table shows that each household has at least one form of vehicle. Most households (69.23%) are found to own a bicycle. This information proves the statement that "bicycle is the life of terai". A few households have possessed a motorcycle and very few have possessed both motorcycle and bicycle. This may be because the households possessing a motorcycle belong to the upper- middle income group which constitutes only a small segment of the total sample households.

TABLE 4.11OWNERSHIP OF TELECOMMUNICATION INSTRUMENTS BY SAMPLED HOUSEHOLDS

Instrument	Number of Households			Total	Percent
	Advantaged	Disadvantaged	Dalits and Others		
Mobile	12	8	1	21	80.77
Land Line/ CDMA	1	0	0	1	3.85
Both	3	1	0	4	15.38
Total	16	8	1	26	100

Source: Field Survey, 2015

The diagram represents the percentage of sampled households according to the type of telecommunication instruments they owned



It is seen from the table that all the households have access to telecommunication. The most popular mode of telecommunication is mobile phone. One possible reason for this is the easy availability of mobile phones with little administrative procedure to acquire them.

4.2.9 DISTRIBUTION OF CATTLE AMONG THE SAMPLED HOUSEHOLDS

TABLE 4.12 DISTRIBUTION OF CATTLE AMONG THE SAMPLED HOUSEHOLDS

No of Cattle	No. of Households	Percentage
1-3	17	65.38
4-6	7	26.92
Above 6	2	7.69
Total	26	100

Source: Field Survey, 2015

The diagram represents the percentage of sampled households according to the number of cattle's they have

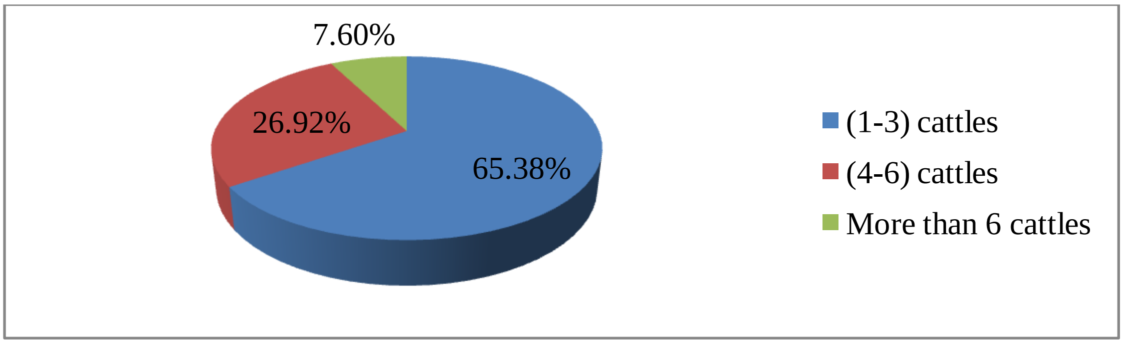


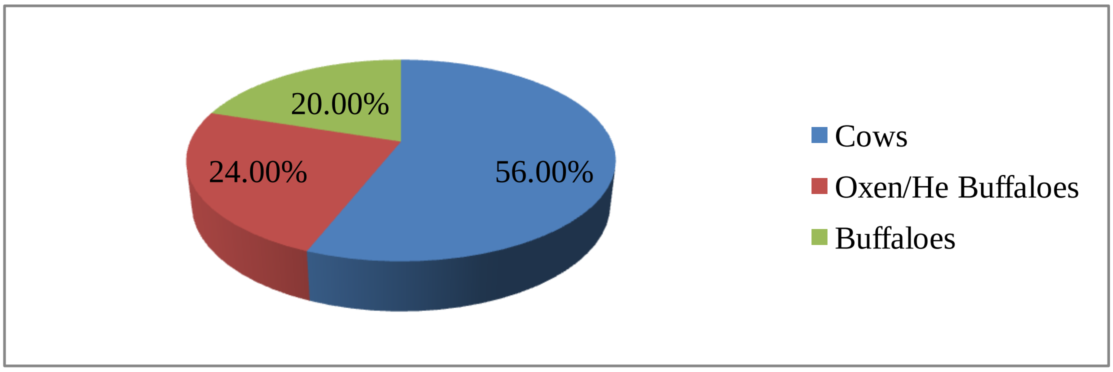
Table 4.12 shows that most of the households have kept a fewer number of the cattle while very few have kept more than six cattle. This may be because this particular VDC is adjacent to Mechinagar metropolitan city and people in the VDC are getting more and more urbanized favoring fewer numbers of cattle.

TABLE 4.13 CLASSIFICATIONS OF CATTLE

Cattle	Number	Percentage
Cows	42	56
Oxen/He Buffaloes	18	24
Buffaloes	15	20
Total	75	100

Source: Field Survey, 2015

The diagram represents the percentage of sampled households according to the type of cattle's they have



The table shows that the sampled households have mostly preferred cows as their cattle. Oxen/He Buffaloes have been the second preference while She Buffaloes have been least preferred. The possible reason for this is that Nepal is a Hindu dominated nation where cows have greater religious significance than oxen and buffaloes.

4.3 LANDHOLDING PATTERN

Land is a major subsistence economic resource for rural population. It is believed that larger size of land ownership offers economic security as well as high political and social prestige in the society. Size of cattle holding also depends on the size of land holding among the different ethnicity and wealth-ranked groups. Thus, those households who have occupied more land may likely have greater size of cattle holding too and hence the chances for biogas plant installation are also high. Traditionally, it is apparent that most of the Nepalese households have a strong stimulating connection to land in Nepal.

4.3.1 LANDHOLDING SIZE BY ETHNICITY

There is a wide disparity in the distribution of the cultivated and non-cultivated land among the ethnicity groups in the study area. Table 5.6 shows the distribution of total land among the different ethnic groups of household in the study area. That is based on five categories i.e. landless, marginal farm size (up to 5 Kattha), small farm size (5 to 15 Kattha), Medium farm size (15 kattha to 30 kattha) and large farm size (30 Kattha and above) in our study area.

TABLE 4.14 LANDHOLDING STATUS OF SAMPLE POPULATION BY ETHNICITY

Land Holding Size (in Kattha)	Number of Households			Total
	Advantaged	Disadvantaged	Dalits and Others	
Landless	-	-	-	-
Up to 5	-	1	-	1
5 – 15	3	-	1	4
15 – 30	9	5	-	14
30 and above	4	3	-	7
Total	16	9	1	26

Source: Field Survey, 2015

The diagram represents the landholding size of sampled household with different ethnicity

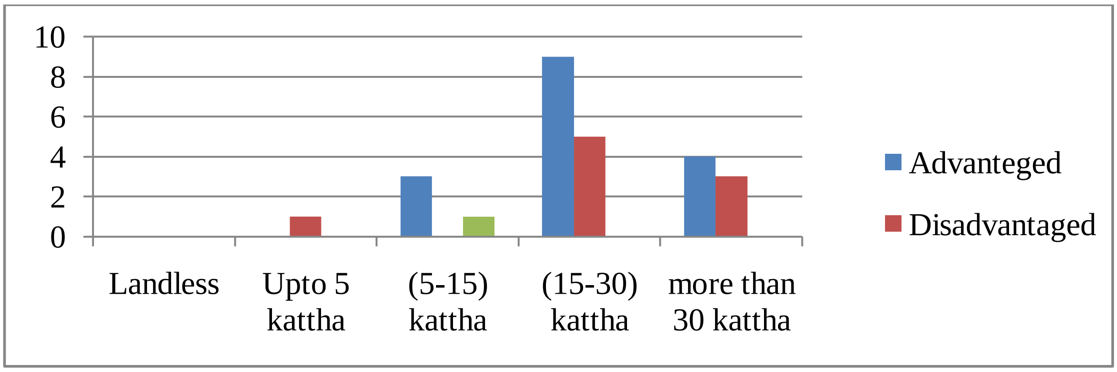


Table 4.14 shows that none of the surveyed households are landless. More than half of the total households surveyed have been medium size landholders. The possible reason for this, as mentioned above, is the fact that most biogas using households belong to the middle income group.

4.4 USES AND BENEFITS OF BIOGAS PLANT

This chapter is suggestive about the uses and benefits of the biogas plant installation. It highlights some selected uses and benefits from the use of biogas based on the information obtained from respondents who are the members of the surveyed biogas using households in the study area. It shows the positive as well as negative impacts of biogas plant installation.

4.4.1 REASONS FOR INSTALLING BIOGAS PLANTS

Scarcity of firewood, high prices of petroleum products and the frequent disruption in their supply, inadequate supply of electricity, clean and easy cooking, easy availability of cattle dung are the most visibly seen causes behind the installation of biogas by the households in the study area. The households use dung mainly from cattle and buffalos as raw materials to generate gas for cooking and lighting. Before installation of biogas, they had used fuel wood for cooking purpose and kerosene for lighting purpose. Many of the biogas owners said that they installed biogas because of shortage of firewood. Table No. 5.1 represents the reasons for the installation of biogas.

TABLE NO. 4.15 REASONS FOR INSTALLATION OF BIOGAS PLANT

Reasons of installing biogas plant	No. of households	Percentage
Shortage of firewood	15	57.69
High prices of petroleum products	8	30.77
Clean and healthy kitchen	3	11.54
Total	26	100

Source: Field Survey 2015

The diagram represents the percentage ofrespondent have the reason for installation of biogas

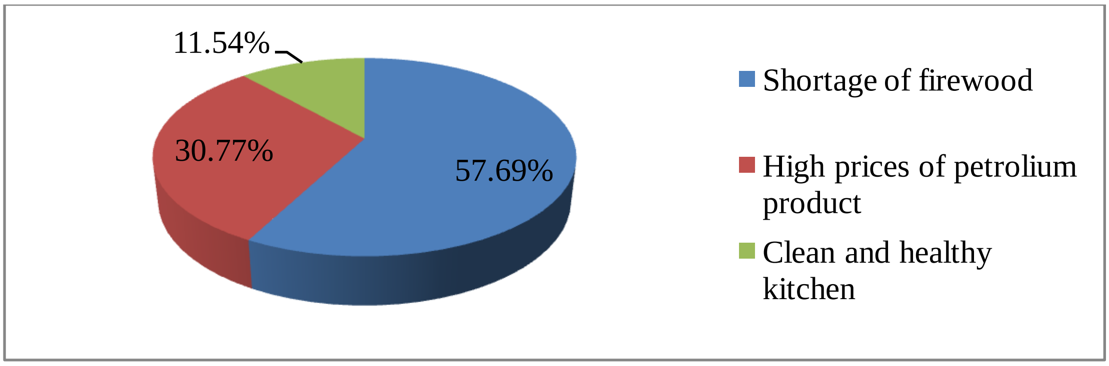


Table 5.1 reveals that for the majority of the plant owners the main reason for installing biogas was the shortage of firewood. Nearly 31 percent of the plant owners admitted that biogas is an effective substitute for expensive petroleum products. Very few cared about the clean and healthy kitchen provided by the use of biogas.

4.4.2 MOTIVATING FACTORS FOR THE BIOGAS PLANT INSTALLATION

Using biogas is much more beneficial than using other alternative energy sources like firewood and petroleum products. Due to this, most of the plant owners were self-motivated to install the biogas plant in their houses. The other motivating factors to install the biogas plant are staff members of the biogas company, Government agencies/offices, ADB/N, NGO's, INGO's and so on.

TABLE NO. 4.16MOTIVATING FACTORS FOR THE BIOGAS PLANT INSTALLATION

Factors	Frequency	Percent
Biogas Company	17	65.38
Neighbors	3	11.54
Radio/ T.V.	6	23.08
Total	26	100.0

Source: Field Survey 2015

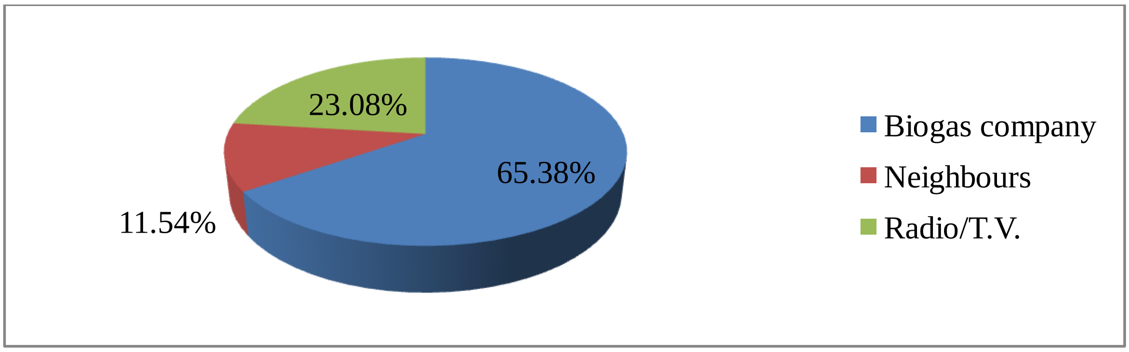


Table 4.16 reveals that 65.38 percent of the plant owners have installed biogas plant as suggested by the biogas company’s staff members. 23.08 percent of the plant owners have installed due to the radio/TV advertisement and news. 11.54 percent of the plant owners have been inspired by their neighbors who have already installed biogas plants.

4.4.3 SIZE OF THE PLANT

All the 26 households have adopted fixed done (GGC model) of biogas plant as approved by BSP. Plant size depends on the family size and the number of cattle because cattle dung is the main determining factor of the plant size.

TABLE NO. 4.17DIFFERENT SIZES OF PLANT

Size of Plant in M^3	Frequency	Percent
6	18	69.23
8	8	30.77
Total	26	100.0

Source: Field Survey, 2015

The diagram represents the percentage of different size of biogas uses

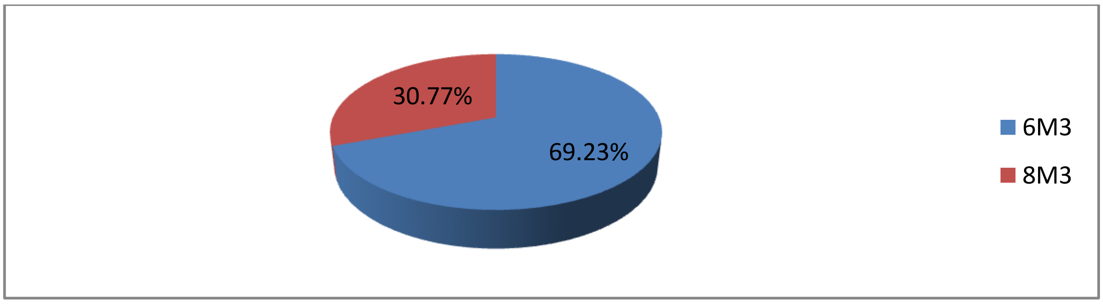


Table No. 4.17 shows that 69.23 percent plant owners have installed $6M^3$ plants. Likewise 30.77 percent have installed $8M^3$ plants. The reason for this is that for plant size greater than $8M^3$, the dung produced by the cattle per household is insufficient.

4.4.4. USE OF BIOGAS

The foremost purpose of installation of biogas is cooking and lighting. But in the study area, electricity from the national grid is available. So people of this area used biogas mainly for cooking purpose and very small number of the plant owners have used biogas for lighting purpose. But in places where electricity from national grid is not available, they used biogas for both cooking and lighting purposes as well. The total number of households using biogas in Jhapa district is 917 and that in the selected VDC is 64. Table 5.4 shows the use pattern of biogas by the selected households in the study area.

TABLE NO.4.18USE PATTERN OF BIOGAS

Purpose	Frequency	Percent
Cooking	25	96.15
Cooking & lighting	1	3.85
Total	26	100.0

Source: Field Survey 2015

The diagram represents the percentage of respondent for the purpose of using biogas

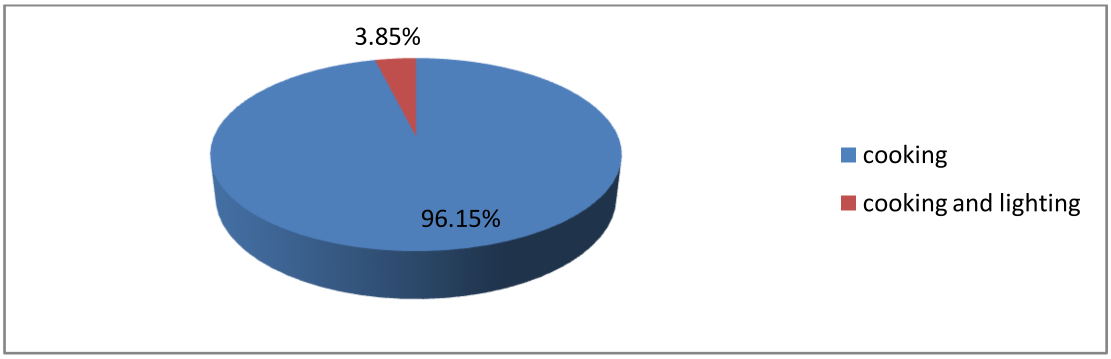


Table No 4.18 reveals that 96.15% of the households have used biogas only for cooking purpose and only 3.85% households have used biogas for both cooking and lighting purposes.

4.4.5 SAVING OF FIREWOOD

Among the various benefits from biogas, saving of firewood is one. It saves significant amount of firewood. Scarcity of fuel wood near the settlement forces people to install biogas in their houses.

TABLE 4.19 CONSUMPTION OF FIREWOOD BEFORE AND AFTER INSTALLATION OF BIOGAS PLANT

(In bhari)

Before Installation of Plant			After Installation of Plant			Saving
Consumption	HHs	Total consumption	Consumption	HHs	Total consumption	
18	1	18	5	6	30	
24	5	120	7	3	21	
25	1	25	10	5	50	
30	6	180	12	7	96	
36	11	396	15	2	30	
48	1	48	18	1	54	
52	1	52	20	1	20	
.	.	.	35	1	35	
	26	839		26	288	551
average	-	32.27			11.07	21.19

Source: Field Survey 2015

The diagram represents the total and average consumption of firewood before and after using the biogas.

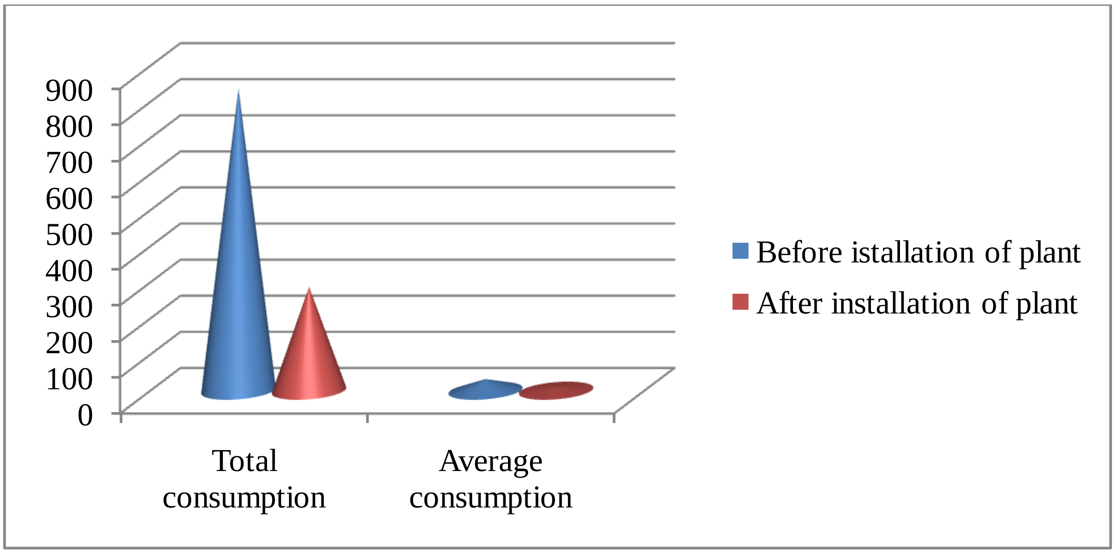


Table 4.19 shows the average annual saving of firewood by the sampled households after biogas installation. The total average saving of firewood for the sampled households has been 21.19*bhari*. This suggests that biogas is a substitute for firewood as fuel.

TABLE 4.20IMPACT OF BIOGAS ON FIREWOOD CONSUMPTION

(In bhari)

Consumption	Before Installation of Plant	After Installation of Plant
	No of HHs	No of HHs
0-10	0	9
10-20	1	15
20-30	6	1
30-40	17	1
40-50	1	-
50-60	1	-
	26	26

Source: Field Survey 2015

Table 4.20 shows the impact of biogas on firewood consumption. Before biogas installation, most of the households consumed a large amount of firewood, more than 30*bhari*. Only one household consumed less than 20 *bhari*. However, after biogas installation, only two households consumed more than 20 *bhari*. More than 92.3percent of the sampled households consumed less than 20*bhari*of firewood after biogas installation. This reinforces the belief that biogas is an effective substitute of firewood as fuel.

TABLE NO. 4.21 ETHNICITY-WISE SAVING OF FIREWOOD AFTER INSTALLATION OF BIOGAS PLANT

(inbhari)

Ethnicity	Yearly Consumption of Firewood					Saving of Firewood per Year	
	Before Plant Installation			After Plant Installation		Total Saving	Avg. saving
	No of HHs	Total consm ption	Avg. consmpti on of firewood	Total consmp tion	Avg.consm ption of firewood		
Advantaged	16	480	30	144	9	336	21
Disadvantaged	9	324	36	126	14	198	22
Dalits and Others	1	35	35	18	17	17	17
Total	26	839	32.27	288	11.07	551	21.19

Source: Field Survey 2015

Table 4.21 shows the yearly saving of firewood by different ethnicity groups after biogas installation. The average total saving for all ethnic groups has been 21.19*bhari*. Biogas installation has contributed to firewood saving by all ethnic groups. However, the largest positive impact of biogas on firewood saving has been on disadvantaged ethnic group in comparison to two other ethnic groups. This may be because this group has been more dependent on biogas than the other groups.

TABLE NO. 4.22 SAVING OF FIREWOOD AFTER INSTALLATION OF BIOGAS PLANT ACCORDING TO LAND HOLDING

(In bhari)

Land holdings (in *Kattha*)	Yearly Consumption of Firewood					Yearly Saving of Firewood	
	Before Plant installation			After plant installation		Total saving	Avg. saving
	No. of HHs	Total cons m	Avg.consm of firewood	Total consm	Avg. consm. of firewood		
Less than 5	1	30	30	15	15	15	15
5 – 15	4	128	32	52	13	76	19
15 – 30	14	471	33.64	158	11.28	313	22.36
30 and above	7	210	30	63	9	147	21
total	26	839	32.27	288	11.07	551	21.19

Source: Field Survey 2015

Table 4.22 shows the average annual saving of firewood by the sampled households which are categorized according to their land holding size. There is positive average saving for each different category. However, the greatest positive impact of biogas on firewood saving has been realized by the households possessing the highest amount of land. This is because the households with large amount of land are able to keep more cattle and are thus able to produce more biogas.

TABLE NO. 4.23 SAVING OF FIREWOOD ACCORDING TO HOUSEHOLD SIZE

(In bhari)

Household size	Yearly Consumption of Firewood					Saving of Firewood per Year	
	Before Plant installation			After plant installation		Total saving	Avg. saving
	No. of HHs	Total consmption	Avg.consmption of firewood	Total consmption.	Avg. consm. of firewood		
Small(0-4)	7	189	27	90	12.85	99	12.5
Medium(5-8)	14	434	30.04	154	11	280	17.56
Large(Above 8)	5	216	43.2	44	8.8	172	33.16
Total	26	839	32.27	288	11.07	551	21.19

Source: Field Survey 2015

Table 4.23 shows the average annual saving of firewood by the sampled households which are categorized according to their family size. There is positive average saving of firewood by each category after biogas installation. However, the greatest positive impact of biogas on firewood saving has been enjoyed by the households with large family size. This is because the households with large family size are normally combined family type having a large amount of land and a relatively large number of cattle, helping the households to produce more biogas. The scale effect of biogas as cooking fuel might also have worked in this case.

TABLE NO. 4.24 SAVING OF FIREWOOD AFTER INSTALLATION OF BIOGAS ACCORDING TO NUMBER OF CATTLE

(In bhari)

No of cattle	Yearly Consumption of Firewood					Saving of Firewood per Year	
	Before Plant installation			Afterplant installation		Total saving	Avg. saving
	No. of HHs	Total consm	Avg.consm. of firewood	Total consm.	Avg. consm. of firewood		
1-3	17	565	33.23	187	11	378	22.23
4-6	7	208	29.71	71	10.14	137	19.57
Above 6	2	66	33	30	15	36	18
total	26	839	32.27	288	11.07	551	21.19

Source: Field Survey 2015

Table 4.24 shows the annual average saving of firewood by the households categorized on the basis of number of cattle holding. There is positive average saving of firewood for each individual category of the households. However, the greatest positive impact on firewood saving has been found for the category of households with the smallest cattle holding size of 1-3. This is because households with fewer cattle are normally nuclear type. As a result biogas produced by their plants is almost sufficient to meet their demand for cooking fuel.

4.4.6 SAVING OF LP GAS AFTER BIOGAS INSTALLATION

TABLE 4.25 ANNUAL SAVING OF LP GAS AFTER BIOGAS INSTALLATION

Use of LP Gas (in Cylinder)	Before No. of HHs	Use of LP Gas (in Cylinder)	After No. of HHS	Saving (in cylinder)
1	-	1	16	-
2	8	2	6	-
3	13	3	4	-
4	5	4	-	-
Average Saving	-	-	-	1.65

Source: Field Survey 2015

Before the plant installation the average annual consumption of LP gas was 2.88 cylinders per household. After the plant installation, the average annual consumption of LP gas has been 1.23 cylinders. The average annual saving of LP gas consumption has thus been 1.65 cylinders per household.

4.4.7 SAVING OF KEROSENE AFTER BIOGAS INSTALLATION

The use of kerosene by the surveyed household has been found negligible. Almost all the households surveyed reported that they had stopped using kerosene since the year 2003 AD when the price of kerosene was abnormally hiked and also due to the frequent disruption in the smooth supply of kerosene.

4.4.8 COOKING TIME

Cooking in Nepali households is primarily done by the adult female members of the households. The information obtained from the households surveyed for this study also supported this trend. Cooking has been found to be a time consuming task for women, which also helps to explain why women normally cannot manage sufficient time for other socio-economic activities. Women were found to spend as many as six hours a day in cooking before biogas installation. However, this amount of time has been reduced to maximum four hours a day after the biogas plant installation. Biogas has thus significantly contributed to time saving for women, thereby enabling them to increase their participation in other socio-economic and income generating activities. Table 4.26 shows the contribution of biogas to time saving in cooking.

TABLE NO. 4.26 REQUIRED TIME FOR COOKING BEFORE AND AFTER INSTALLATION OF BIOGAS PER DAY

Time Allocated Before Installation (hrs.)	No. of Households	Time Allocated After Installation (hrs.)	Time Saving (Hrs.)
4	5	3	1
5	17	3.5	1.5
6	4	4	2
Total/ Average	26	3.5	1.5

Source: Field Survey 2015

The table reveals that the daily average time saving per household is 1.5 hours. At the current market wage rate of Rs. 300 per day (8 hour day), the per hour wage rate is Rs. 37.5. This shows that each household on an average could save Rs. 57.37 worth of time per day.

4.4.9 CLEANING OF VESSELS

In majority of the cases, cleaning of vessels was done by adult female members and in a few cases children were employed to do this. The households reported that women used to spend one and half hours daily on an average for cleaning vessels before installation of biogas. But after installation of biogas, they spent an average of 45 minutes for cleaning vessels. They felt much more relaxed and needed less effort during cleaning vessels because of the absence of black soot. The outcome of the study suggested that there was an average time saving of 30 minutes per day per family after installation of biogas.

TABLE 4.27 REQUIRED TIME FOR CLEANING OF VESSELS BEFORE AND AFTER INSTALLATION OF BIOGAS PER DAY PER FAMILY

Time allocated (in minute)	Before Plant Installation		After Plant Installation	
	No. of HHS	Percentage	No. of HHS	Percentage
0-60	4	15.38	17	65.38
60-90	16	61.54	6	23.08
90-120	3	11.54	3	11.54
120 and above	3	11.54	-	
Total	26	100.00	26	100.00

Source: Field Survey 2015

The diagram represents the percentage of sampled households and the time allocation perday for cleaning of vessels before and after installation of biogas plant

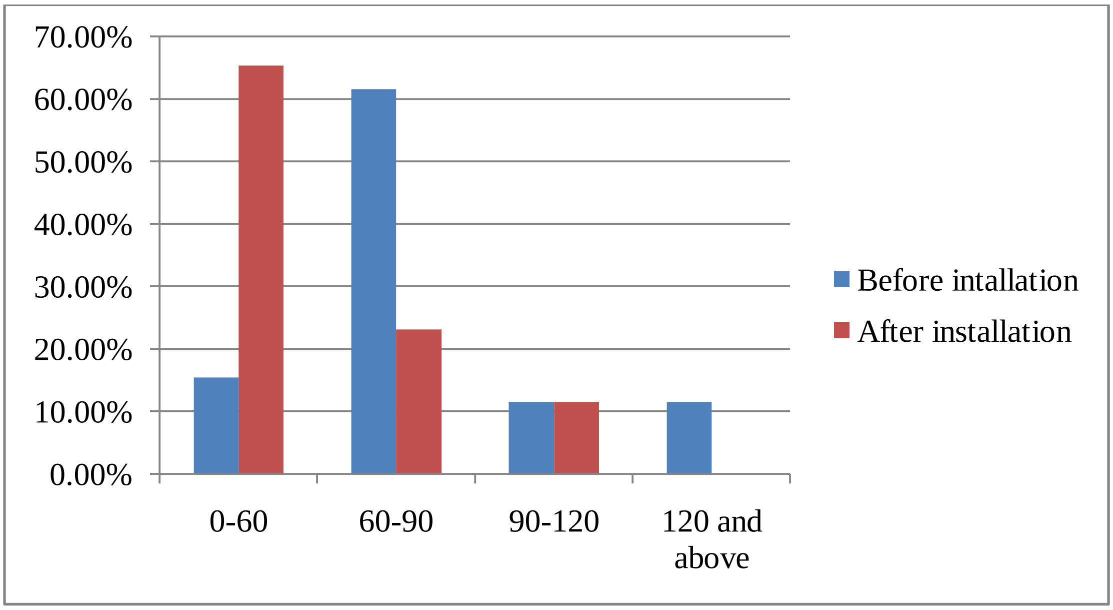


Table No. 4.27 shows the time requirement for cleaning vessels before and after the installation of biogas. Before installation of biogas only 4 households completed the work of cleaning vessels within 60 minutes. But after installation of biogas, the number of households completing the work within the same time period increased to 17. Similarly, 61.54% households allocated 60-90 minutes for cleaning vessels before the plant installation, but this number came down to 23.08% of households after installation of biogas. The number of households allocating 90-120 minutes for cleaning vessels remained same before and after the installation of biogas plants. However, no household allocated more than 120 minutes for cleaning the vessels after biogas installation.

4.4.10 SAVING OF TIME IN COLLECTION OF FIREWOOD

In this VDC there is a forest, so households do spent time 2-3 hr per day for collection of firewood is considered to be saved and they used this time for their family ,some other social works and other productive works.

4.4.11 CALCULATION OF PAYBACK PERIOD

At an average total investment of NRs. 48634 per plant, the payback period of the initial investment of a biogas plant installation was calculated to be 7.91 years.

The cost of installation was observed through three parameters: total cost of installation, subsidy provided by institution and self-investment from the Biogas Households. As per the company rules besides subsidy, the Biogas Households had to bear certain installation cost by themselves. Provision of loan was also available for this purpose and Agriculture Development Bank was most preferred by the respondent Biogas Households in the study. The average cash amount incurred for the maintenance was within the range of NRs. 1100 per year.

Particulars	**Amount in Rs.**
Average Saving of Fuelwood Per HH Per Year (21.19 bhari @ Rs. 400)	Rs. 8476
Average Saving of Kerosene Per HH Per Year	
Average Saving of Chemical Fertilizer Per HH Per Year	
Average Saving of LP Gas Per HH Per Year (1.65 cylinder @ Rs 1450)	RS. 2392.5
Annual Saving Per Plant	Rs. 10868.5
Total Investment Cost Per Plant	Rs. 48634
Labour cost (15 minutes a day @ Rs 300 perday)	Rs. 3421.87
Maintenance Cost Per Year	Rs. 1100
Miscellaneous Cost	Rs. 400
Annual Expenditure Per Plant	Rs. 4921.87
Subsidy Per Plant ($6M^3$. for Terai)	Rs. 9700
Payback Period Without Subsidy	**9.88 Yrs.**
Payback Period With Subsidy	**7.91 Yrs.**

4.4.12 PERCEPTION OF BIOGAS HOUSEHOLD ON BIOGAS

There was significant satisfaction in terms of reduction in fuelwood, improvement in health and sanitation and long term durability of biogas plants but had serious misconception regarding effectiveness of bio-slurry as fertilizer. The increased mosquito breeding after the biogas plant operation was mentioned by the Biogas Households.

TABLE 4.28 PERCEPTION OF BIOGAS HOUSEHOLDS ON BIOGAS

Remarks	No. of biogas households	Percentage
Fully satisfied	9	34.61%
Moderately satisfied	16	61.53%
Not satisfied	1	3.85 %
Total	26	100%

Field survey 2015

Table 4.28 reveals that most of the households are moderately satisfied on biogas plant they installed. The more number of households are fully satisfied in comparison to the number of dissatisfied household is a good sign about the perception towards the biogas even it is not satisfactory at a whole.

4.5 DISCUSSION

4.5.1 IMPACT ON HOUSEHOLD ACTIVITIES

The main direct positive impact is less time required for cooking food. Cooking has now become much easier and convenient after the biogas plant installation. It was realized that percent of the plant owners saved their time in cooking process after installation of biogas in their houses. They used their saved time in various activities, viz. social welfare, raring children and cleaning of house. Before installation of biogas, large space was required for dumping animal dung, which contributed to the increase in the spread of various flies and insects and made the household premises look untidy and ugly. However, these problems have been largely solved after the installation of biogas plants.

4.5.2 ENVIRONMENTAL BENEFIT

The immediate environmental impact of biogas is very difficult to assess at the household level. This should be seen in a wider context. Burning of firewood or agricultural waste is not sustainable. Biogas was installed due to the various reasons, such as scarcity of firewood near the surrounding, excessive increase in the prices of petroleum products coupled with frequent shortage of these products and another reason was the common belief that it reduces the incidences of various diseases like eye infection, lung infection, various respiratory diseases and so forth. It is also a smokeless technology for cooking and lighting purposes.

Pollution and global warming are much pressing problems these days. The use of fuel wood is a contributing factor to this global tension. In this context, the use of biogas will greatly help to reduce the rate of consumption of fuel wood. Installation of biogas in houses, therefore, contributes to green environment.

The environmental impact of biogas can be viewed from the following perspectives:

- 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 otherwise burnt, are available to sustain the fertility of soil.

- It helps to reduce the emission of CO_2.

The impact of the use of biogas on environment must be viewed from various perspectives, most of which relate to the conservation of biomass. Benefits of biogas could be seen in areas where trees and cow dung are used as primary cooking fuels. Installation of biogas has worked as a substitute for these traditional sources, allowing the forest to remain intact and green, and increasing the utility of cattle dung in two ways: first, as gas for cooking and lighting purposes; and second, as slurry, a replacement for chemical fertilizer in agricultural production.

4.5.3 SOCIAL BENIFIT

Social impacts of biogas are mostly intangible and these need to be assessed from the users' perception which is very difficult. The outcomes of the study showed that there were some positive impacts of biogas that directly influenced the social aspects of the beneficiary households.

- Majority of the plant owners (67.45%) said biogas plant raises social status of the family; it is also a symbol of prestige in society.

- There were some households (17%) who said that they have more time to visit relatives and engage in social activities which are also the matter of social prestige.

- There were still others (15.15% of the total households) who said that when female members of the households were engaged in social and political activities by utilizing the saved time, it resulted in increased social prestige.

4.5.4 ECONOMIC BENIFIT

In surveyed VDC, the installation of biogas plants reduced the annual fuelwood consumption by approximately 21.19bhari in average perhousehold, whichprovides each biogas Household an equivalent saving of NRS. 8476Per year at the local rate of NRs.400 per bhari.

On the other hand they save 1.65 cylinders of L.P. gas which is equivalent to NRS 2392.5 per year at the rate of NRS.1450 per cylinder. In total per household saves NRS.10868.5 in a monetary term.

Further, improving hygiene and thereby reducing diseases also has an economic value. If people can avoid diseases it also means their working time won't be reduced as a result.

4.5.5 INVESTMENT ASPECT AND PAY BACK PERIOD OF BIOGAS PLANT

The study in entailed as in the national context, in Dhaijan VDC, majority of plants (74.29%) were of $6M^3$. The total installation cost was compatible to NRs. 48634 per plant of 6 M^3 as quoted by BSP for the fiscal year 2011/12.

Majority (62.86 %) of the biogas plant under survey were installed in the past five to eight years which shows as stated by WECS (2006), the contribution of biogas in the residential energy sector is increasing. All the surveyed biogas plants were operational and 88.57 percent surveyed Biogas Households not incurred any repair and maintenance expenditure since the installation. The average annual maintenance cost per plant was below NRs.1100. The simple technology and high operational efficiency gives biogas its reliability.

According to calculation made by Devkota (2001), the payback period is 6.1 years without subsidy and 4.1 years with subsidy and as calculated by Woods et al. (2006) without any subsidies the payback period biogas plant would be around 3.6 to 5.8 years. In Dhaijan VDC, all biogas plants were installed under subsidy but the payback period was much higher (7.91 years). It was due to the reason that biogas is not used as the substitute for kerosene. And more importantly, the lack of knowledge about the use and storage of highly nutritious bio-slurry as potential fertilizer could not reduce the expense in chemical fertilizers among the Biogas Households. According to Devkota (2001), the economic value of the bio-slurry shows that the investment can be gained back in three to four years. Thus, generating awareness about bio-slurry could thereby further reduce the payback period of biogas plant installation. Furthermore, if the use of biogas could be extended for lighting purpose, biogas could significantly reduce the expense in kerosene.

The improvement in health and sanitation and ease in household works were perceived as benefits by the respondent Biogas Households.

4.5.6 POSITIVE IMPACTS OF BIOGAS

Biogas technology has the following advantages:

- Cleanliness and Neatness: In all biogas systems, garbage or animal manure decays under anaerobic conditions. No waste is found nearby since the manure or garbage does not have to be spread out. There is no bad smell. As a result, a neat and clean surrounding is maintained.

- Financial saving: The need for expensive energy sources is reduced and hence, the expenditure on fuel wood, petroleum products and other energy sources is reduced. This aspect is particularly important to point to the fact that many rural households are low income earners. Financial savings arising from the use of biogas can be directed to other vital areas like buying agriculture inputs to sustain the main stay of rural economy.

- Clean Kitchen: The flame produced during burning of gas is clean. Thus, the pots used on such fire are soot-free and no thorough and hard cleaning is required which prolongs the life span of the vessel, thereby making another saving to the household. Still another advantage resulting from cooking in clean flames is that chances of respiratory and eye diseases attributable to the exposure to the smoky kitchen are eliminated. A smoke-free kitchen also allows the kids to join their mothers while they are cooking in the kitchen. Improved sanitation and reduction in smoke in kitchen are two basic reasons that imply for better health status. The indoor climate among Biogas Households had improved as a result of using biogas stoves instead of fuel wood. This could have contributed to significant improvement in health among Biogas Households.

- Feed Stock Is Free: Feeding material is locally available and at no or little cost. Besides the financial savings, labor time spent on gathering dung is minimal.

- Continuous Supply of Gas: Biogas technology allows for the continuous supply of gas production which goes uninterrupted even during feedings. This assures smooth and continuous flow of gas as long as the operating conditions are neat and well maintained. This is unlike other fuel types like wood where there is need for drying the fuel wood prior to use.

- Job creation: An indirect benefit associated with biogas technology is that it creates employment for a farmer/technician who installs the digesters. A massive adoption of biogas technology will, therefore, to some extent reduce unemployment as people are contracted to build and attend to faults that sometimes occur.

4.5.7 NEGATIVE IMPACTS OF BIOGAS

The researcher also attempted to collect negative impacts of biogas. As stated above, most of the users appreciated the positive impacts of biogas. However, some negative impacts were also acknowledged. There are some negative impacts of biogas on health which were notified by the users.

- Incidents of mosquitoes and files increased.
- Health hazard during mixing of dung and water.
- Bad smell and so on.

Some of the plant owners reported that interior of the house became moist giving rise to the menace of *Dhamira*(white ant) and other insects. Some of the plant owners also complained that they had to spend more time to collect additional water for plant feeding.However, the so called negative impacts of biogas are not very significant.

4.5.8 OPERATION OF BIOGAS PLANT

After installation of the biogas plant, the owners of the plant have to do some regular work for production of gas that is collection of cow dung, mixing water and pouring into the inlet of biogas.

In some cases, plant owners had encounter technical problems. They were not only unable to solve these problems themselves, but could also not get the services of trained technicians in time. However, biogas companies would occasionally conduct two-day training for biogas users with support from BSP. By such training, users of biogas plants were highly benefited. All users reported that the operation of the biogas plant was easy. Once they fed the digester with the mixture of dung and water each day, the gas was produced due to anaerobic digestion process

CHAPTER 5

SUMARRY, CONCLUSIONS AND RECOMMENDATION

5.1 SUMMARY

Biogas is an appropriate alternative source of energy for household purposes. Forest resources have been the main source of fuel energy in rural areas of Nepal. Excessive use of firewood directly leads to deforestation and climate change. So, the promotion and development of biogas is very important in the context of Nepal. In this context, the present study on the impact of biogas in rural area was made.

This study was conducted in Dhaijan VDC of Jhapa District and was based on the limited rsample size of 26 households. Before conducting this study, a brief review on existing literature was made. The review focused mainly on the impact studies.

The major findings of the study are summarized as follows:

- Biogas plants with $6M^3$ size were more popular and more useful in this study area as compared to other sizes of the plant. This study found out that there were 69.23 percent households using the $6M^3$ biogas plant-size and remaining 30.77 percent households went for the $8M^3$ biogas plant-size.

- Most households (96.15%) said that they installed biogas as a substitute for firewood and to have ease in cooking. All households said that the use of biogas contributes significantly to firewood saving. The average annual saving of firewood per household has been found to be 21.19*bhari*.

- Use of biogas has also been found to have contributed to LP Gas saving. The average annual saving has been found to be 1.65 cylinders per household.

- The use of biogas is mainly for cooking these days, but before the unavailability of electricity, biogas was also used for the lighting purpose. However, in our study, the impact of biogas on electricity consumption has been found negligible.

- There is a considerable amount of average time saving for cooking, collection of firewood and cleaning vessels after biogas installation: 1.2 hours per day per family. Time thus saved has been mostly used in looking after children, and other social and income generating activities.

- Subsidies provided by the BSP were a very encouraging factor for the installation of biogas plants.

- Average cattle population size is 3.19 per household.

- Average family size is 5.84 per household.

- Landholding size is 23.17*kattha* per household.

- The users felt reduction in many health related problems such as lung disease, headache and eye problem.

- Most of the respondents felt that the menace of flies or mosquito has increased.

- Majority of respondents reported that the social status has increased after installing biogas.

- The payback period for biogas installation is 7.91 which is more than the calculation of payback period suggested by different organizations.

Majority of the respondents reported that the overall economic, environmental and energy conditions have improved.

5.2 CONCLUSION

The outcomes of the study suggest that the main benefits of biogas to its owners are cooking facilities that saved considerable amount of time and money. It also raises the socio economic status of the plant owners. Besides these, there are other benefits as well, such as convenience in cooking and reduction of indoor air pollution resulting in several health benefits. However, these benefits are not quantifiable and easily noticed from economic point of view. Furthermore, an economic and financial analysis is most necessary to examine the economic viability and financial soundness of the plant. The impact of biogas is a controversial topic and may remain so for many years to come because the working of biogas depends upon many factors. Whether a plant is economically beneficial or not depends upon the assumptions made while conducting an economic analysis which is not done in this study. The study mainly deals with the impact of biogas on firewood consumption. In general, biogas plants were found to have many positive impacts on the users, which were well appreciated by them. The total average time saving of 1.2 hrs per day per family suggests that the installation of biogas plant has been successful to reduce the family workload.

The role of biogas companies is very important in encouraging the households for plant installation. Similarly, the role of ADB/N in providing loan was also appreciated even though some other financial cooperative companies have also started to invest in this sector. However, there were some who complained that they were not satisfied with the role of ADB/N because they could not get loans from the bank due to non-possession of adequate land as collateral.

The outcome of this study pointed that most of the sampled plant owners were optimistic regarding the role of companies despite their ineffective after- sale-service. GGCs have to improve their service delivery keeping in view the customers' trust placed upon them. This study revealed that the subsidy is one of the major attractions for most of the users to install biogas plant. One of the encouraging facts noted is that the marginal groups or non biogas users too, are highly motivated to install biogas plants.

Conservation of forest has great role in protection of our surrounding environment. Forest plays important role in the formation and conservation of soil, and occurrence of timely and sufficient rainfall. Despite these positive impacts, reduction in gas production during winter season, frequent breakage and delay in the post-installation operation and maintenance works from companies are some of the problems that have to be addressed effectively in the days to come for more positive impacts from biogas.

6.3 RECOMMENDATIONS

This study reveals that there is sufficient room for improvement in the present role of GGCs, method of biogas plant construction and maintenance to achieve a qualitative product and provide more benefits to the plant owners. Based on the findings of this study, some recommendations are given below.

- Local manpower should be trained in the area of maintenance, construction and supervision and their salary, allowances should be fixed by the government. They should visit the plants regularly and provide the necessary service.

- BSP/Government should start various programs for the women so that they can utilize the saved time in income generating activities.

- The subsidy provided by the government should be increased and focused on those sections of people who are neglected and marginalized.

- It has been found that farmers do not know the proper utilization of slurry from biogas plants. Therefore, they should be properly advised about the method of preparing compost fertilizers.

- Supervision conducted by BSP should be made regular and effective because low quality construction may bring negative impacts on the users.

- Gobar Gas Companies should conduct women education program, awareness program and publicity campaigns and other useful programs to motivate the farmers towards the needs for biogas plant installation.

- Most of the plant owners were male but most of the users were female. So the training should be given to the users, not to the owners.

- Due to the lack of resource and manpower, the GGC may not be able to send technical manpower to all constructed plants, but this problem can be solved if the respective plant owners are provided with the operation and maintenance training.

- Present guarantee system needs some adjustments so that it will include a mechanism that forces the manufacturer to render the services as required.

- Promotional activities are required both at local and national level. At local level, companies should distribute the pamphlets with picture, documentary and arrange workshops which can easily educate the local people. Besides these, they should provide some advertisement through newspapers, radio and television so that people can be made aware at national level, too.

- Adequate resources should be made available to ADB/N for the purpose of advancing loans to biogas program.

- Loan procedures under biogas program should be drastically simplified. Farmers are mostly illiterate and they do not possess capabilities to face bureaucratic red tapism. So, simple and easy to understand procedures should be devised.

- With several direct benefits and indirect benefits of biogas in terms of social, health and environmental sector, biogas installation should be given priority.

- Public support is very important in the promotion of biogas. If the rural communities don't have confidence in investing in biogas they will continue to use fuelwood that is already available. Spreading information about biogas and it's positive effects should be promoted

- Slurry utilization prospects and use of biogas for lighting should be promoted to enhance benefits of biogas and reduce payback period of biogas installation

- Lack of financial capabilities to invest in biogas plants among poor farmers in rural areas is one of the biggest challenges. Possible solutions to this should be explored
- The Clean Development Mechanism (CDM) can help finance further biogas growth in developing countries. More research should be made in biogas and related aspects of CDM to obtain supportive data and information

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