CHAPTER-ONE

INTRODUCTION

People of Nepal still have to rely on traditional sources of energy to fulfill their energy needs. National Energy consumption in the present condition is 9,344 Tons of Oil Equivalent (TOE). In FY2007/08, consumption ratio of traditional, commercial, and renewable sources of energy remained at 87.8 percent, 11.5 percent, and 0.7 percent respectively. It proves the continued high dependency of Nepalese economy on conventional energy source. Of the total conventional energy consumption, share of fuel wood, agricultural residues, and livestock residue was 89.2 percent, 4.2 percent, and 6.6 percent respectively. Of the total commercial energy source consumed in FY2007/08, Petroleum products (POL), coal, and electricity had respective shares of 64.2 percent, 17.5 percent, and 18.3 percent. By the end of FY2007/08, various hydropower projects generated 650 MW of electricity. Of the total hydropower so generated, 645 MW is connected to the national grid, while rest of the energy generated from small hydropower stations and not connected to the national grid have been providing electricity services at local levels. The total electricity generated has reached 703 MW including 53.41 MW from thermal power stations and 100 KW from solar plants (Economic Survey: 2009)

More than 85% of national energy demands are still contributed by traditional energy sources (fuel wood, agricultural residue, animal waste, etc). Biogas popularly known as Gobar Gas in Nepalese society is a very promising sustainable source of renewable energy. Biogas is a combustible gas produced by anaerobic fermentation of organic materials (Gobar) by the action of methanogen bacteria. 60-70% of this gas contains methane and that of carbon dioxide 30-40%. The methane gas is odorless and burns with a clear blue flame without smoke. It produces more heat that fuelwood, kerosene, charcoal and dung-cakes.

This study focused on socio-economic impact of bio-gas plant in Patlekhet VDC of Kavre district. The study also deals with the impact of biogas on health and sanitation, time and money saving, special benefits from the saving. The study includes the effect of bio-gas slurry in terms of agriculture production as well as the benefits of biogas to the rural people of Patlekhet VDC of Kavre district. The benefits are categorized as gender benefits, environmental benefits, health benefits, economic benefits.

1.1 General Background

Historically, Nepal's rural population has been meeting their energy needs from traditional sources like fuel wood and other biomass resources. This is neither sustainable nor desirable from environmental considerations and the need to improve the quality of life. Therefore there is a need to substitute as well as supplement the traditional energy supply system by modern forms of energy in terms of resource and technology. About 84% of Nepal's population lives in rural areas, and agricultural work are the mainstay of the rural people.

There are several direct and indirect impacts of renewable energy technologies (RETs) on socio-economic development of any community. They indirectly help to improve social indicators like standard of living, health, education, agriculture production, drudgery etc. A major impact on the local economy can be realized by the creation of income generating activities through the use of RETs.

Traditional fuel plays a vital role in rural areas of Nepal. The heavy dependence on fuel wood has increased the rate of deforestation, soil erosion, flooding and landslides, and, in turn, has adversely affected agricultural productivity. Another main impact of fuel wood consumption is that it increases health hazards for people living in the villages, especially women and children, since women are the main users of fuel wood in the domestic sector.

Biogas has been identified as an integrated energy and an environmentally friendly technology for the villages of Nepal. This technology provides a clean and cheap source of energy in villages, in addition to producing enriched organic manure for supplementing the use of chemical fertilizers. It also improves sanitation and hygiene and relieves women of some drudgery.

Energy consumption has been considered as one of the human development indexes. In other words, energy is nowadays directly related to development of the people and the country. Energy need is realized in all spheres of human life and various forms and uses such as lighting, cooking, heating etc. It has been proved that Nepal has no significant amount of reserved fossil fuels and natural gases. Rural people mostly use fuelwood, animal dung and agriculture residue as sources of energy for cooking, heating and lighting purposes.

Rural households depend on traditional sources of energy and traditional type of cooking stove- *Chulo.* On one hand, the efficiency of the traditional stove is less and on the other hand, it is hazardous in terms of environment and health of the family members. The result is that rural people have to spend their life in poor condition in terms of social, cultural, economic and environment. Low efficiency of stove means it consumes more fuelwood for cooking that result in more time to spend to collect the fuelwood. Using firewood causes indiscriminate destruction of the forest resources. It shows that the deforestation results into natural calamities such as, landslides, flood, soil erosion etc. Though renewable energy sources such as solar and micro-hydro are very much popular in rural Nepal, people use these renewable energy technologies mainly for lighting and processing of agricultural products. These RETs are not popular for cooking purpose. So in this scenario of Nepalese society, Biogas popularly known as Gobar Gas is the only renewable energy technology that can be utilized in a sustainable way to solve the problem of clean energy demand for cooking and fertilizer. Feeding materials (cow dung) for biogas plant are readily available in rural areas. This means the technology is sustainable and can be used for long term.

1.2 Components of Biogas System

Biogas technology is a complete system in itself with its set objectives (cost effective production of energy and soil nutrients), factors such as microbes, plant design, construction materials, climate, chemical and microbial characteristics of inputs, and the inter-relationships among these factors. Brief discussions on each of these factors or subsystems are as follows:

1.2.1 Biogas

This is the mixture of gas produced by methanogenic bacteria while acting upon biodegradable materials in an anaerobic condition. Biogas is mainly composed of 50 to 70 percent methane, 30 to 40 percent carbon dioxide (CO2) and low amount of other gases as shown in Table (Yadav and Hesse 1981).

Table: 1.1 Composition of Biogas

Substances	Percentage
Methane	50-70 percent
CO_2	30-40 percent
Hydrogen	5-10 percent
Nitrogen	1-2 percent
Water vapour	0-3 percent
Hydrogen sulphize	Traces

Source: Karki, Shrestha & Bajagain (2005): BIOGAS As Renewable Source of Energy in Nepal Theory and Development

Biogas is about 20 percent lighter than air and has an ignition temperature in the range of 650° to 750° C. It is an odorless and colorless gas that burns with clear blue flame similar to that of LPG gas (Sathianathan, 1975). Its calorific value is 20 Mega Joules (MJ) per m3 and burns with 60 percent efficiency in a conventional biogas stove.

1.2.2 Methanogenic Bacteria or Methanogens

These are the bacteria that act upon organic materials and produce methane and other gases in the process of completing their life-cycle in an anaerobic condition. As living organisms, they tend to prefer certain conditions and are sensitive to micro-climate within the digester. There are many species of Methanogens and their characteristics vary. The different methane forming bacteria have many physiological properties in common, but they are heterogeneous in cellular morphology. Some are rods, some cocci, while others occur in clusters of cocci known as sarcine. The family of methanogens (Methanobacteriacea) is divided into following four genera on the basis of cytological differences (Alexander, 1961).

A. Rod-shaped Bacteria

(a) Non-sporulating, Methanobacterium

(b) Sporulating. Methanobacillus

B. Spherical

(a) Sarcinae, Methanosarcina

(b) Not in sarcinal groups, Methanococcus

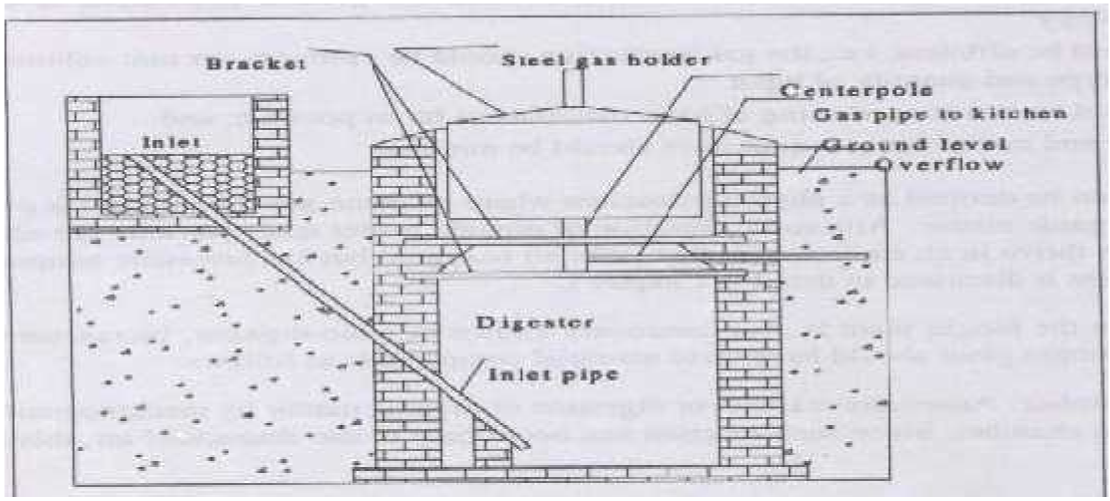
A considerable level of scientific knowledge and skill is required to isolate methanogenic bacteria in pure culture and maintain them in a laboratory. Methanogenic bacteria develop slowly and are sensitive to a sudden change in physical and chemical conditions. For example, a sudden fall in the slurry temperature by even T C may significantly affect their growth and gas production rate (Lagrange, 1979).

1.2.3 Biodigester

The biodigester is a physical structure, commonly known as the biogas plant. Since various chemical and microbiological reactions take place in the biodigester, it is also known as bio-reactor or anaerobic reactor. The main function of this structure is to provide anaerobic condition within it. As a chamber, it should be air and water tight. It can be made of various construction materials and in different shape and size. Construction of this structure forms a major part of the investment cost. Some of the commonly used designs are discussed below.

1.2.3.1 Floating Drum Digester

In 1956 Jasu Bhai J. Patel developed a design of floating drum biogas plant popularly known as Gobar Gas Plant. In 1962, the Khadi Village Industries Commission (KVIC) of India approved Patel’s design and this model soon gained popularity in India as well as in the sub-continent. In the KVIC design, the digester chamber is made of brick masonry in cement mortar. A mild steel drum is placed on the top of the digester chamber to store the gas produced. Thus there are two separate structures for gas production and collection. When methane gas is produced, the gas pressure pushes the mild steel drum upwards and as the gas is being used the drum gradually lowers down. By observing the level of drum, one can assess the gas volume available. Since the mild steel drum practically floats above the digestion chamber, the KVIC design is also known as the floating drum biogas plant.



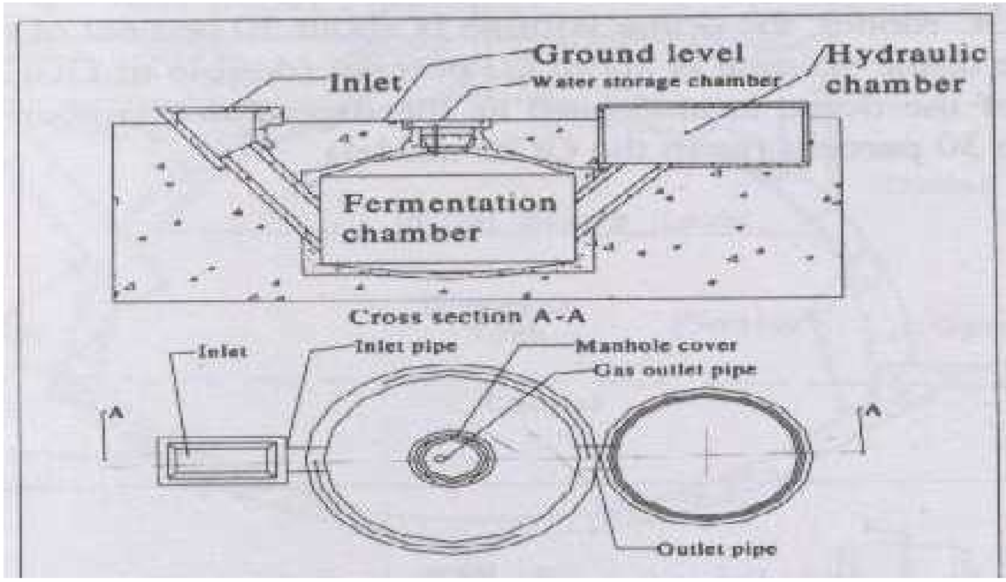
Source: Karki, Shrestha & Bajagain (2005): BIOGAS As Renewable Source of Energy in Nepal, Theory and Development

Fig:1.1 KVIC Floating Gas Holder System

With the introduction of the fixed dome Chinese model plant, the floating drum plants became obsolete due to comparatively high investment and maintenance cost along with other design weakness. For example, the mild steel drum corrodes and needs to be replaced within 5-10 years. Similarly, the drum has to be well anchored to prevent it from overtopping due to high gas pressure.

1.2.3.2 Dome Digester

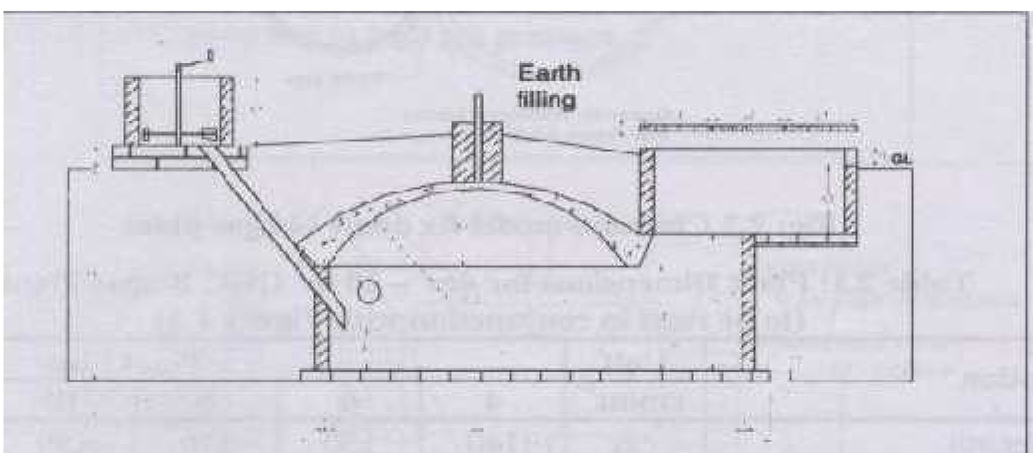
Fixed Dome Chinese model biogas plant is also called Drumless Digester. This type of plant was experimented in China as early as the mid 1930s. This model consists of an underground brick masonry (cement mortar) compartment for the digestion chamber with a concrete dome on the top for gas storage. Thus, in this design the digestion chamber and the gas storage dome are as one combined unit.



Source: Karki, Shrestha & Bajagain (2005): BIOGAS As Renewable Source of Energy in Nepal, Theory and Development

Fig: 1.2 Chinese Model Fixed Dome Biogas Plant

This design eliminates the use of costlier mild steel gasholder. The life of a fixed dome type plant is longer (20 to 50 years) compared to KVIC plant, as there are no moving parts and both concrete and cement masonry is relatively less susceptible to corrosion.



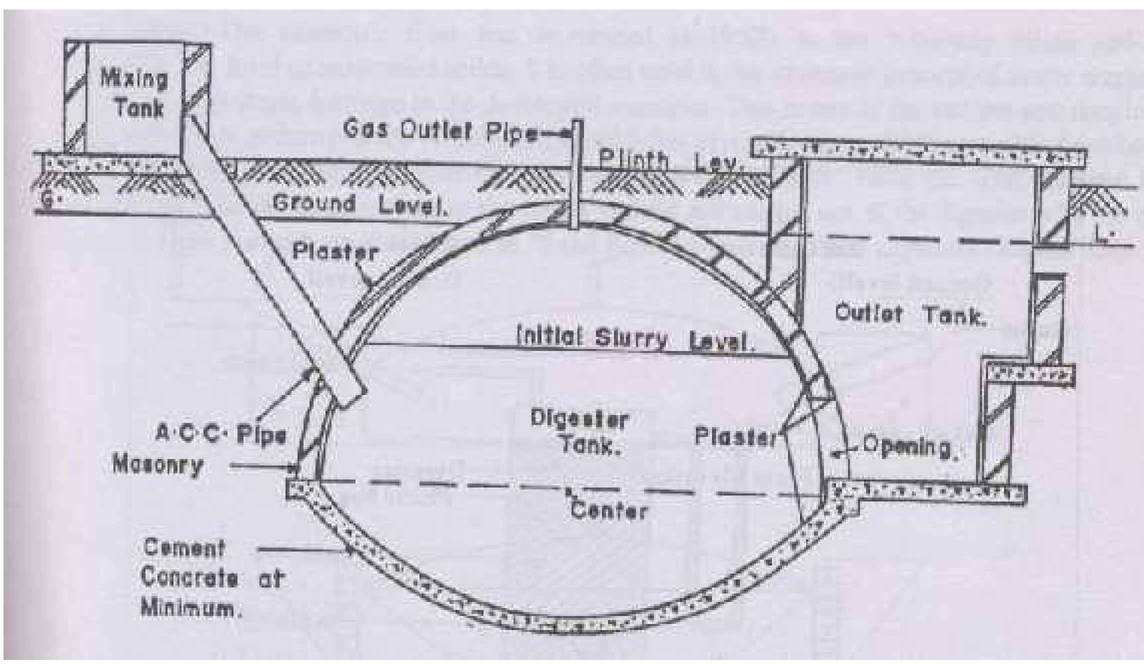
Source: Karki, Shrestha & Bajagain (2005): BIOGAS As Renewable Source of Energy in Nepal, Theory and Development

Fig: 1.3 GGC Concrete Model Biogas Plant

Based on the principles of fixed dome Chinese model, various countries have put forth modified designs to suit their local conditions. For example, Gobar Gas and Agricultural Equipment Development Company of Nepal have developed a design commonly known as the GGC model. Compared to the Chinese fixed dome model, the GGC model is easier to construct as this structure has less curved profiles (e.g. digester bottom is horizontal instead of concaved).

1.2.3.3 Deenbandhu Model

In an effort to lower the investment cost of the fixed dome plant, the Deenbandhu model was put forth in 1984 by the action for Food Production (AFPRO), New Delhi. Although the Deenbandhu plant is also based on the fixed dome model, the dome structure is constructed of brick masonry instead of concrete. Also, it has a concave bottom whereas the GGC model has a horizontal bottom. In India, this model proved 30% cheaper than the Chinese fixed dome model of comparative size.



Source: Karki, Shrestha & Bajagain (2005): BIOGAS As Renewable Source of Energy in Nepal, Theory and Development

Fig: 1.4 Deenbandhu Biogas Plant

However, in Nepal preliminary studies carried out by BSP did not find any significant differences between the investment cost of GGC and the Deenbandhu design of comparative size. This can be attributed to higher labour cost (and highly skilled masons) required to accurately construct the dome out of brick in cement masonry. It should be noted that unlike GGC model, the Deenbandhu plants are quoted in terms of the volume of biogas that can be produced in a day. For example, a 2 m3 Deenbandhu plant refers to the plant size, which can produce 2 m3 of gas in a day.

1.3 Site Selection

Once the decision is made to install a biogas plant at the household level, a careful site selection of the best site for the plant must be made to ensure its sustainability. The factors that influence the decision are:

- Distance between the proposed site and the location where gas will be consumed (i.e. kitchen). It should not overlook the cost of pipes
- Distance between the site and the supply of input materials (i.e. cowshed). Close distance saves the input carrying efforts.
- Distance between the site and the location where the effluent can be stored. Close distance helps to ensure that the effluent can flow into the storage pit without much handling.
- Distance between the site and sources of water such as wells. Distance should be far enough to prevent contamination (say 10 to 15 m). However, it should be noted if the water source is too far, it will take more time and effort to prepare the slurry since for given volume of dung an equal volume of water should be added.
- Distance between the sites and trees / bamboos. Distance should be far enough to prevent damage to the structures from the roots of the plants
- Suitable foundation condition. It should be noted that the ultimate bearing pressure of the foundation should be adequate to support the load of the biogas plant and the slurry inside

1.4 Design Parameters for Sizing of Biogas Plants

There are different designs of biogas plants but in Nepal fixed dome design is popularized. Biogas plants used in Nepal needs only cattle dung and water, which is available everywhere in the rural households of Nepal. Moreover, the materials used for the construction of biogas plants are stone, sands, gravels, cement and pipes, which are locally available and not very difficult to access them. One local simply literate person with one week training can easily construct biogas plant. It means technological expertise is within the local level. All the appliances necessary for the biogas plant (except main valve) are locally manufacture in the local workshops. We don’t have to import those items from other countries. Furthermore, repair & maintenance is very easy and any family member with one day training can operate and maintain the plant easily. Once plant is installed, plant gives more than 20 years without any major problems. After 3 years of installation, the total investment on biogas plant will be returned and after that one can get gas free of cost for years and years. There is no risk of burning, explosion and accident with biogas. The slurry, by-product of biogas can be a very good organic fertilizer, which eventually maintain the soil fertility and increase the crop production. Biogas also reduces the carbon emission because it is smokeless which is very good for environment. However, the design parameters should be properly followed for the effective and efficient biogas plants. The design parameters are given below in tabular form.

Table: 1.2 Design parameters

S. No.	Parameter	Value
1	C/N ratio	20-30
2	pH	6-7
3	Digestion temperature	20-35 deg C
4	Retention time (HRT)	40-100 days
5	Biogas energy content	6 kWh/m3
6	One cow yield	9-15 kg dung/day
7	Gas production per kg of cow dung	0.023-0.04m3
8	Gas production per kg of pig dung	0.04-0.059 m3
9	Gas production per kg of chicken dung	0.065-0.116 m3
10	Gas production per kg of human excreta	0.020-0.028 m3
11	Gas requirement for cooking	0.2- 0.3 m3/person
12	Gas requirement for lighting one lamp	0.1- 0.15 m3/hr

Source: Karki, Shrestha & Bajagain (2005)

Table: 1.3 Loading Rate for Various Plant Size

Plant Size (m3)	**Daily Loading Rate (kg)**	
	Hills	**Terai**
4	24	30
6	36	45
8	48	60
10	60	75
15	90	110
20	120	150

Source: Karki, Shrestha & Bajagain (2005)

The slurry inside the biogas plant needs to be consistent for optimum gas production. If the slurry is too thick, it will settle at the bottom of the digester and be pushed out by gas pressure before being completely digested. On the other hand, if it is too thin, additional dead space in the digester chamber is occupied by water. In case of cow / buffalo dung for a given volume of fresh input an equal volume of water should be added and the slurry should be will mixed.

1.5 Applications of Biogas

Biogas can be used for household and industrial applications. Various uses of biogas are explained below.

1.5.1 Cooking

Biogas is primarily used for cooking in the developing countries. Biogas burners or stoves for domestic cooking work satisfactorily under a water pressure of 75 to 85 mm. The stoves may be single or double varying in capacity from 0.22 to 1.10 m3 gas consumption per hour. Generally stoves of 0.22 and 0.44 m3 capacity are more popular. A 1.10 m3 burner is recommended for a bigger family with larger plant size.

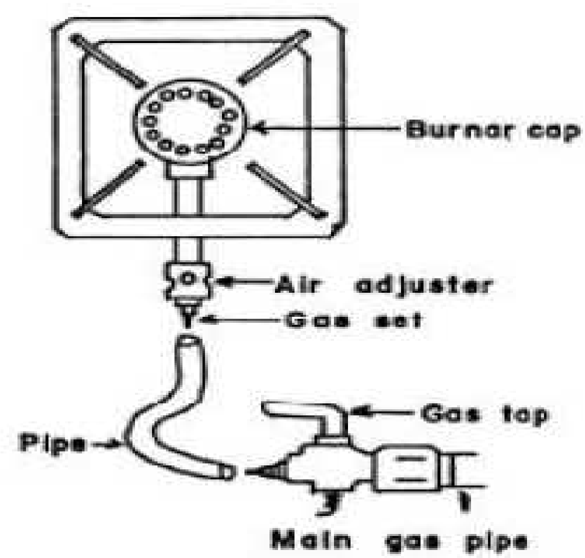


Fig: 1.5 Biogas Burner Manufactured by GGG Workshop at Butwal, Nepal

Source: Relevance of Biogas Technology in Nepal: http://ftp.fao.org

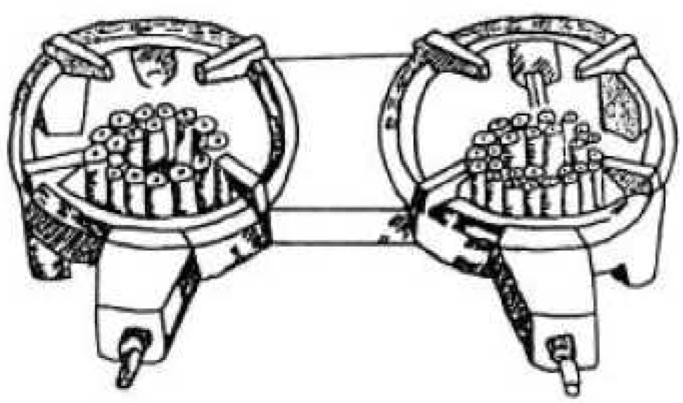


Fig: 1.6 Biogas Burners with two Moths Manufactured in India

Gas requirement for cooking purposes has been estimated to be 0.33 m3 per person per day under Nepalese conditions. If a family of 6 members owns a plant producing 2 m3 of gas per day, usually two stoves (one with 0.22 m3 and the other with 0.44 m3 per hour capacity) can be used for one and half hours each in the morning and the evening to meet all cooking requirements of the family (Karki and Dixit: 1984).

1.5.2 Lighting

Biogas can be used for lighting in non-electrified rural areas. However, it is not so popular in Nepal. Special types of gauze mantle lamps consuming 0.07 to 0.14m3 of gas per hour are used for household lighting. Several companies in India manufacture a great variety of lamps, which have single or double mantles. Generally, 1 mantle lamp is used for indoor purposes and 2 mantle lamps for outdoors. Such lamps emit clear and bright light equivalent to 40 to 100 candle powers.

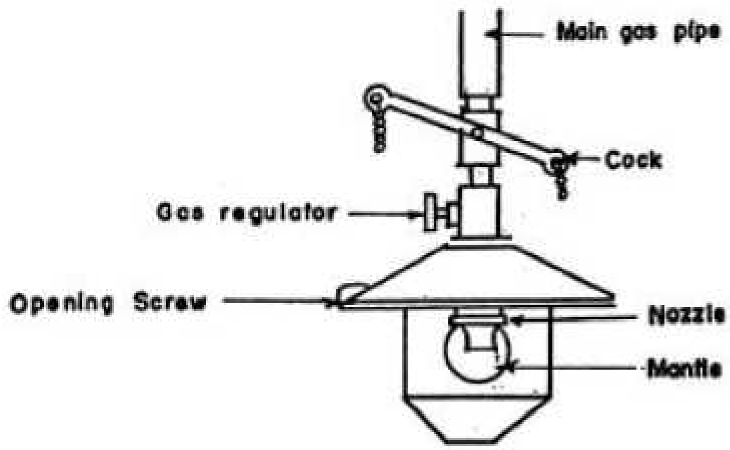


Fig: 1.7 Typical Biogas Lamp manufactured in India

Source: Relevance of Biogas Technology in Nepal

Compared to stoves, lamps are more difficult to operate and maintain. The lamps work satisfactorily under a water pressure of 70 to 84 mm (Karki and Dixit: 1984).

1.5.3 Refrigeration

Biogas can be used for absorption type refrigerating machines operating on ammonia and water, and equipped with automatic thermo-syphon. Since biogas is only the refrigerators external source of heat, the burner itself has to be modified. Refrigerators that are run with kerosene flame could not be adapted to run on biogas. In a country like Nepal, biogas run refrigerator could be of high importance for safe keeping of temperature sensitive materials such as medicines and vaccines in the remote areas. Gas requirement for refrigerators can be estimated on the basis of 0.6 – 1.2 m3 per hour per m3 refrigerator capacity (Updated Guidebook on Biogas Development, 1984).

1.5.4 Biogas Fueled Engines

Biogas can be used to operate four stroke diesels and spark ignition engines. Biogas engines are generally suitable for powering vehicles like tractors and light duty trucks as has been successfully experimented in China. When biogas is used to fuel such engines, it may be necessary to reduce the hydrogen sulphide content if it is more than

2%. Using biogas to fuel vehicles is not so much of an attractive proposition as it would require carrying huge gas tanks on the vehicle. One of the uses of biogas, which has wide application in Nepal, is to fuel engines to run irrigation pumps. A duel-fuel engine is available in India, which will run on a mixture of biogas and diesel (80% biogas and 20% diesel). In these engines, biogas is used as the main fuel while diesel is used for ignition. When gas runs out, the fuel engine can be switched back to run fully on diesel.

1.5.5 Biogas for Electricity Generation

Generating electricity is a much more efficient use of biogas than using it for gas light. From energy utilization point of view, it is more economical to use biogas to generate electricity for lighting. In this process, the gas consumption is about 0.75 m3 per kWh with which 25-40 lamps can be lighted for one hour, whereas the same volume of biogas can serve lamps for one hour (BRTC: 1989).

1.6 Utilization of Slurry as Feed and Fertilizer

1.6.1 Inter-relationship of Biogas Technology and Agriculture

More than 90 percent of the populations in Nepal are engaged in agriculture. Therefore, any technology that can influence agriculture or gets influenced by the agricultural practices becomes a subject of concern not only to the biogas user but also to the nation as a whole. By-products of agriculture, mainly animal wastes and crop residues, are the primary inputs for biogas plants. The digested slurry as one of the outputs of a biogas plant can be returned to the agricultural system. Proper application of the slurry as organic fertilizer increases agricultural production because of its high content of soil nutrients, growth hormones and enzymes. Dried slurry can also safely replace a part of animal and fish feed concentrates. Furthermore, slurry treatment also increases the feed value of fodder with low protein content. When the digested slurry is placed into the food chain of crops and animals, it leads to a sustainable increase in farm income. This close relation between biogas and agriculture can be taken as an indicator of "environmental friendly" nature of the technology as shown in below.

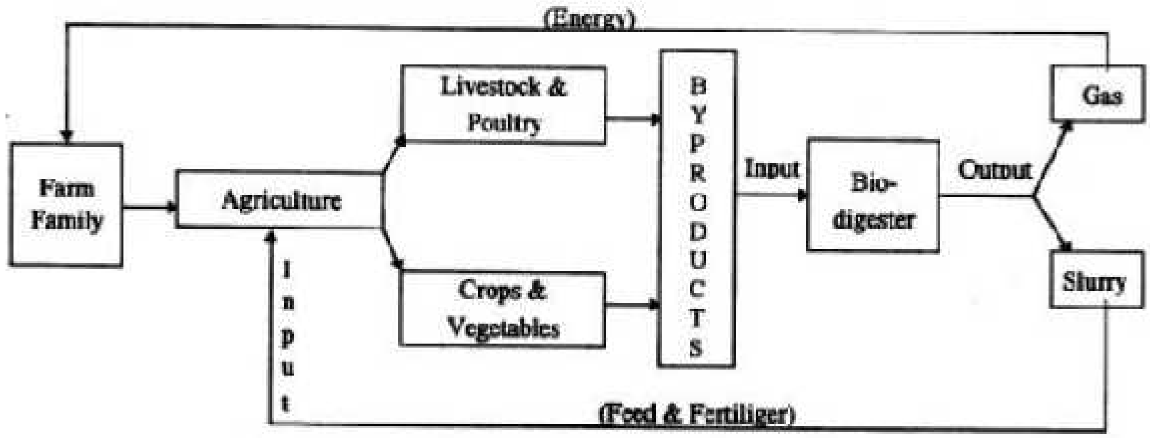


Fig: 1.8 Relationships between Biogas and Agriculture in a Farming Family

Source: Relevance of Biogas Technology in Nepal

1.6.2 Importance of Slurry for Crop Production

Organic matter plays an important role because of its beneficial effects in supplying plant nutrients, enhancing the cation exchange capacity, improving soil aggregation, increasing water holding capacity of soils, stabilizing its humid content and increasing its water holding capacity. Organic soil amendments support biological activities and also control root pathogens. Biogas slurry has proved to be a high quality organic manure Compared to FYM, digested slurry will have more nutrients, because in FYM, the nutrients are lost by volatilization (especially nitrogen) due to exposure to sun (heat) as well as by leaching. The farmer needs to use chemical fertilizer to increase his crop production. However, if only mineral fertilizers are continuously applied to the soil without adding organic manure, productivity of land will decline. On the other hand, if only organic manure is added to the soil, desired increase in crop yield can not be achieved. Fertility trials carried out in Nepal and elsewhere have revealed that optimum results can be achieved through the combined application of both chemical and organic fertilizers. In countries where biogas technology is well developed, for instance in China, there are evidences which support the fact that productivity of agricultural land can be increased to a remarkable extent with the use of slurry produced from biogas plant. In Nepal too, if properly managed, the biogas slurry could play a major role in supplementing the use of imported and expensive chemical fertilizers However, in the present context of Nepal, the focus has been only to increase the number of biodigester for its gas use and little attention has been paid on the proper utilization of digested slurry as organic fertilizer.

1.6.3 Characteristics of Digested Slurry

Only approximately 10 percent of the total nitrogen content in fresh dung is readily available for plant growth. A major portion of it has first to be biologically transformed in the soil and is only then gradually released for plant use. When fresh cow dung dries, approximately 30 to 50 percent of the nitrogen escapes within 10 days. While nitrogen escaping from digested slurry within the same period amounts to only 10 to 15 percent Therefore, the value of slurry as fertilizer, if used directly in the field as it comes out of the plant, is higher than when it is used after being stored and dried (Moulik, 1990). The short term fertilizer value of dung is doubled after being anaerobically digested while the long term fertilizing effects are cut by half. Under tropical conditions (i.e. where biogas plants are most effective) the short term value is of greater importance because rapid biological activities degrade even the slow degrading manure fraction in relatively short time. Cattle dung contains about one percent total nitrogen. Nitrogen is considered particularly important because of its vital role in plant nutrition and growth. During anaerobic digestion, 25 to 30 percent organic matter is decomposed and hence the nitrogen percentage is raised to 1.3. Although no new nitrogen is formed during anaerobic digestion, 15 to 18 percent nitrogen is converted into ammonia (NH4) whereas nitrogen in aerobically digested organic wastes (activated sludge, compost) is mostly in oxidized form (nitrate and nitrite). Increasing evidence suggests that for many land and water plants, ammonium is more valuable as a nitrogen source than oxidized nitrogen in the soil. Ammonium is less likely to leach away and hence more apt to become fixed to exchange particles like clay and humus (Satliianathan, 1975). Experiments in China have shown that compared to fresh dung, the ammonical nitrogen in the digested slurry increases by 260 percent whereas it decreases by 17.5 percent in the FYM. The slurry thus has more free ammonia than available in composted manure.

1.7 Benefits from Biogas

There are numerous benefits of biogas to rural people in various ways. Some of the benefits are:

- Gender benefits: Biogas provides a direct benefit, especially to rural women, as a result of the reduction of the workload when shifting from cooking on fuelwood to biogas. It saves approximately 3 hours time a day per family mainly due to reduction on time used for collecting fuelwood, cooking and cleaning of utensils.
- Environmental benefits: From individual perspective, the use of biogas significantly improves the indoor air quality. In addition, installation of biogas plants results in better sanitation due to the connection of toilets. More than 70% of the plants are connected with toilets. One biogas plant saves about 2.3 tones of fuelwood per year. It roughly saves about 0.03 hectors of forestland per year. Similarly one biogas plant produces approximately 30 tones of bio-compost per year of which 90% of the farmers use the bio-fertilizer (Bajagain, 2003. The bio-fertilizer has high fertilizer value, improves soil structures and contributes to maintain the content of organic matte in the soil.
- Health benefits: A big problem for the rural people especially to the housewives is indoor air pollution and smoke exposure inside the kitchen while cooking. Poor indoor air quality is one of the major risks factors for acute respiratory infections with housewives and children. Biogas reduces the smoke exposure and significantly improves the air condition inside the kitchen which ultimately the health condition especially eye infection, respiratory diseases, cough and headache. Improved sanitation with the construction and connection of toilets lead to better hygiene conditions. Better sanitation condition through biogas helps to reduce the infant mortality rate.
- Economic benefits: Biogas reduces the expenses on fuel for cooking and to some extent lighting. The high quality bio-fertilizer contributes for high yield of crop and vegetables, which eventually help for generating income. The Internal Rate of Return (IRR) of biogas plant is about 49% (Bajagain, 2003).

Potential of Biogas in Nepal

BSP has constructed more than 172,858 biogas plants by the end of June 2008. The distribution of biogas plants by geographical areas is as follows:

Table: 1.4 Distributions of Biogas Plants by Geographical Areas

Geographical Region	Number of plants constructed	Coverage Percentage
Terai	86,260	49.4%
Hills	87,533	50.13%
Remote Hills	798	0.46%
TOTAL	174,591	100%

BSP-Nepal aims to install additional 73,537 biogas plants by June 2009 increasing the access of biogas to remote and poor people. For this purpose, necessary and appropriate strategies shall be applied. 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 were estimated to be 2.7 million in 2001, based upon the study of technical biogas potential of Nepal out of which 57% in plains, 37% in hills and rest 6% in remote hills or in mountain region.

Table: 1.5 Potential of Biogas in Nepal

Potential of Biogas in Nepal	
Technical Potentiality of biogas plants (2001)	1.9 Million
Total Economic Potential	1 Million
Total no. of biogas plants construed	189, 122

Source: BSP Nepal: http://www.bspnepal.org.np/

1.8 Subsidy Policy in Biogas in Nepal

Among all the Renewable Energy Technologies, biogas has occupied an important role and in order to provide maximum benefit to rural households and to mitigate the environmental degradation and to meet the household energy requirements, the GON, German Government (KfW) and the Netherlands Government (SNV/Nepal) have been providing the subsidy to biogas plants since 1992. As per the objective of timely revision of the subsidy and increase the access of this technology to low income population, the subsidy for family biogas plants will be as follows:

- An additional subsidy of NPR 500 for those districts, which have low penetration of biogas plants
- In order to increase the access of rural poor in the technology, subsidy to the rural areas higher than in the urban areas.
- The currently followed subsidy delivery process has been simple and internationally accredited (ISO 9001 – 2000), the procedure will be continued.

Table: 1.6 Subsidy Policies in Nepal

S. N.	**Geographical Distinction (Districts)**	**Subsidy Rate per Plant**
1	20 districts of Terai as specified by GON - Annex 2 (1)	NPR 6,000
2	40 hilly districts with road access as specified by GON - Annex 2 (2)	NPR 9,000
3	15 remote districts without road access as specified by GON -Annex 2 (3)	NPR 12,000
4	Specified low penetrated districts will be provided with additional subsidy of NPR 500 per plant -- Annex 2 (4)	
5	To encourage small users, 4-6 cu. m. capacity plants will be provided with additional of NPR 500 per plant	

Source: www.aepc.gov.np

Due to usefulness of biogas programme, high potential and benefits of the technology, the policy to subsidize biogas will be continued even after the completion of the current programme by mobilizing new donors and investors. The current subsidy policy is applicable to only GGC 2047 Model of capacity 4-10cu.m. Feasibility study and pilot projects of the community biogas plants will be undertaken to explore possibility of using solid waste and other vegetable waste feed stock in addition to cattle for biogas generation.

1.9 Statement of the Problem

Energy consumption has been considered as one of the human development indexes. In other words, energy is nowadays directly related to development of the people and the country. Energy need is realized in all spheres of human life in various forms and uses such as lighting, cooking, heating etc. It has been proved that Nepal has no significant amount of reserved fossil fuels and natural gases. Rural people mostly use fuelwood, animal dung and agriculture residue as sources of energy for cooking, heating and lighting purposes.

Rural households depend on traditional sources of energy and traditional type of cooking stove- *Chulo.* On one hand, the efficiency of the traditional stove is less and on the other hand, it is hazardous in terms of environment and health of the family members. The result is that rural people have to spend their life in poor condition in terms of social, cultural, economic and environment. Low efficiency of stove means it consumes more fuelwood for cooking that result in more time to spend to collect the fuelwood. Using firewood causes indiscriminate destruction of the forest resources. It shows that the deforestation results into natural calamities such as, landslides, flood, soil erosion etc.

Though renewable energy sources such as solar and micro-hydro are very much popular in rural Nepal, people use these renewable energy technologies mainly for lighting and processing of agricultural products. These RETs are not popular for cooking purpose. So in this scenario of Nepalese society, Biogas popularly known as Gobar Gas which is the only renewable energy technology that can be utilized in a sustainable way to solve the problem of clean energy demand for cooking and fertilizer in rural areas. Feeding materials (cow dung) for biogas plant are readily available in rural areas. This means the technology is sustainable and can be used for long term.

1.10 Objective of the Study

The general objective of the study is to analyze the impact of bio-gas plant to its users. The specific objectives are as follows:

- To assess the socio-economic impact of bio-gas users
- To find out the impact of bio-gas
- To find out the attitude of biogas users

1.11 Significance of the Study

It is well realized that bio-gas technology is very much suitable for rural areas of Nepal. This renewable energy technology (RET) contributes to mitigate the indoor air pollution that has a direct impact on health of rural people, to mitigate the deforestation, and greatly to supply clean energy for cooking and lighting. The introduction of bio-gas technology will reduce the dependency of rural people on forest resources for household purposes. It also helps to save money and time in collecting fuelwood and cooking activities. The byproduct of biogas plant is the production of good quality manure (slurry as a fertilizer). This fertilizer increases the soil fertility on one hand and increases the agriculture productivity and saving of money for not using chemical fertilizer. The ultimate benefit of biogas technology is that it improves the quality of life of rural people. This highlights the importance and significance of biogas. Therefore, the biogas technology has a great significant for rural households of the study areas.

1.12 Limitations of the Study

This study has some limitations due to various factors such as lack of time, money etc. The limitations of the study are as follows:

- The study focuses on socio-economic impact of bio-gas
- This study deals with domestic bio-gas plants only
- The study area covers only Patlekhet V.D.C. of Kavre district.

1.13 Organization of the Study

The study consists six chapters. The first chapter includes introduction, brief history of biogas and its potentiality in Nepal, statement of the problem, objectives, significance and limitation of the study. In second chapter, literature review is presented. The third chapter includes methodology part. Socio-economic and demographic characteristics of the respondents are given in chapter four whereas chapter five discusses the use and impact of biogas. Conclusions and recommendations are given in chapter six.

CHAPTER: TWO

LITERATURE REVIEW

The literatures reviewed for the study are books, booklets, thesis, bulletin published in the subject of bio-gas plant.

Marsh gas was discovered by Shirley in 1667. In 1670, Van Helmont pointed out the existence of an inflammable gas in putrefying waste and in the rumen of animals by examining 15 different gases. For the first time, it was only in 1776 that Volta recognized the presence of methane gas in the marsh or swampy place. Pristely mentioned about this gas in 1790 and Dalton tried to find out its chemical formula in 1804 (Karki, Shrestha, Bajagain: July 2005)

In 1808, Humphrey Davy studied the fermentation of the mixture of water and cow dung and collected one litre of gas. The gas so collected contained 60% carbon-dioxide and the rest comprised of a mixture of gas which was rich in methane and nitrogen. But Davy was interested only in the fertilizer aspect but not in the potential of this gas as energy. After a lapse of 60 years that is in 1868, Reiset indicated the presence of methane in the heap of farm yard manure (Karki, Shrestha, Bajagain: July 2005)

In Feb 1884, Louis Pasteur presented the work of his student Ulysse Gayon in the Academy of Science and concluded fermentation of animal dung could become a source that could be utilized for heating and lighting. Thereafter, many other scientists namely Schloesing, Omeliansky, Deherain and Dupoint made valuable contribution about the production of methane through fermentation of organic materials (Lagrange, 1979)

It took over hundred years to use the gas for man kind: The plant for methane generation was set up in 1900 in leper asylum in India. Another plant was installed in Indonesia in 1914. Interest in biogas rose very high at the time of beginning of 2nd world war. By 1950, about 1000 biogas plants were built by French German converted their some 90,000 automobiles to run on biogas to save petroleum fuel during the world. The energy crises followed after that drew attention of many countries towards biogas (Karmachrya: 1992).

The first bio-gas plant was constructed in Nepal by B.R. Saubolle, a school teacher in 1995 at St. xaviers school, Godavari. For his personal interest in the technology; he used two 200 litre metal oil drums, one as a digester and the other as a gas holder. In

1968, Khadi and Village Industries Commission (KVIC). India built a plant for an exhibition in Kathmandu. The agriculture department of HMG/N launched bio-gas plants construction programmes in a systematic way. During fiscal year 1975/76, which was declared as the “Agriculture year” by His Majesty’s Government of Nepal (HMG/N) The Agriculture Development Bank (ADB/N) provided free of interest credit to install 196 plants against a target of 250 of the “drum type” bio-gas plants (New ERA 1985:7).

The development and dissemination of biogas technology in Nepal was initiated in an organized way after the establishment of Gobar Gas Tatha Krishi Yantra Vikash (P.) Ltd. (Gobar Gas Company – in short) in 1977 with three main shareholders, the Agriculture Development Bank (ADB/N), the fuel corporation of Nepal (FCN) and United Mission to Nepal (UMN). In 1974, Development & Consulting Services (DCS) built four floating drum plants of KVIC design. Ever since its establishment the Gobar Gas Company has been solely responsible for promoting and installing Gobar gas plants all over Nepal. However, the result of the programme of the company in the initial years was not so encouraging in comparison to its national potentials.

Research on various design of biogas plants such as floating steel dome design, concrete fixed dome design, breasted tunnel design plastic bag bio-digester. Ferro cement gas holder, brick mortar dome and mud dome were tested and experimental at Butwal. Fixed dome design a Chinese modification plant was introduced in Nepal in 1980. After several modifications, fixed dome design, this is more popular in Nepal.

During the period of 1981 to 1986, GGC developed and tested various designs of biogas plants such as floating drum design, fixed dome design, tunnel design. Plastic bag design bio-digester and so on. Similarly, various types of biogas appliances such as gas pipes, mixture machines gas taps, stokes, lamps, water drains, gas meters, agitators, manometers etc were developed modified and tested. Slurry coming from the plant was applied to various croup, e.g. vegetable and cereals. It was also used for feeding fish and animals. However, most of the research on the subject was limited to experiments and papers.

Research was also conducted in the application of gas for running engines for agro-processing, pumping water for irrigation generating electricity especially on community basis until 1986, GGC (Gobar Gas Company), installed 60 such plants. But most of them could not continue functioning due to some special problems.

In 1992 BSP was introduced at different stages for massive dissemination of the technology in the country. In 1995, Nepal Biogas promotion group (NBPG) was established as an umbrella organization of all the construction companies.

For the promotion and extension of the program. In 1996, His Majesty's Government of Nepal (HMG/N) setup Alternative energy promotion centre (AEPC) under the Ministry of science and Technology (MOST). The role of AEPC is as the networking at the central level policy making (GGC profile 2001).

Biogas plant installation is increasing over the years with the government initiation. Government has promoted credit facilities to the people in the provision of land ownership certificated through ADB/N. Government are supporting to various organization and agencies for its development.

As the forest resource is decreasing, threatening the environmental problem, government is being aware to develop the biogas installation activities, including national planning process. Biogas installation program was incorporated in the seventh plan (1986-90) period and the emphasis has been continued even in the tenth plan (2002-2007). In this course, HMG/N has made strategies for the further development of biogas. Privatization Policy is becoming the key efforts to the government to increase biogas plants in the country (WECS: 1994/95).

Biogas is a combustible gas produced by anaerobic fermentation of organic materials by the action of methanogenic bacteria. This gas is principally composed of methane and carbon dioxide (Karki, Shrestha, Bajagai: 2005).

Biogas is the mixture of gas produced by methanogenic bacteria while acting upon biodegradable materials in an anaerobic condition. It is mainly composed of 50-70 percent methane, 30-40 percent carbon dioxide, and some other gases. It is about 20 percent lighter than air. It is an odorless gas that burns with clear blue flame similar to LPG gas (BSP: 2008).

Biogas which is popularly known as Gobar gas in Nepal, is a combustible gas produced by anaerobic fermentation of organic materials (gobar) by the action of methanogenic bacteria. This is mainly composed of 60-70% methane and carbon dioxide

(30-40%). The methane gas is odorless and burns with a clear blue flame without smoke. It produces more heat than kerosene, fuelwood, charcoal and dung-cakes (Bajgain, 2003).

In villages of Nepal, more than 98% of domestic energy consumption is derived from firewood, agricultural waste and animal dung. In activities like collection of wood, animal dung, agricultural residue, women's effort and time involvement is significant. In the above context, use of alternative sources of energy such as biogas and fuel efficient cooking stoves, saves women's time and protects their health (Shrestha, 2003).

Biogas technology is one of the most trusted and popular alternative energy sources used for cooking and lighting in Nepal (Singh, Karki and Shrestha: 2006, RETRUDE).

Dr. Poornakanta Adhikari (1996) in report entitled effects of bio-gas on family health, sanitation and nutrition: has evaluated both positive and negative impacts of bio-gas. The positive impacts on health were most significantly reduction on eye diseases, headache, coughing and throat ache. The negative impacts of bio-gas were increased prevalence of mosquito and loss of warmth in house in winter, sanitation conditions and practices were improved and the study reported 62 percent reduction in firewood collection.

Biogas technology is a complete system in itself with its set objectives (cost effective production of energy and soil nutrients), factors such as microbes, plant design, construction materials, climate, chemical and microbial characteristics of inputs, and the inter-relationships among these factors (System Approach to Biogas Technology FAO, 2008).

Biogas is the mixture of gas produced by methanogenic bacteria while acting upon hide gradable materials in an anaerobic condition. It is mainly compassed of 60-70 percent methane, 30-40 percent carbon dioxide, and some other gases. It burns with clear blue flame similar to that of LPG (BSP 2005).

Biogas is a wet gas as it picks up water vapor from the slurry. Biogas is about 20 percent lighter than air. The main component of biogas is methane which is colorless odorless and tests less. But due to the presence of other gases, it gives some smell similar to that of garlic of rotten eggs (GGC profile 2001:7).

According to bio-gas support program Phase III, the bio-gas technology is one of the viable devices among alternative energy source in the country. It can fulfill about 10 percent of the country's total energy requirement without adversely effecting the production of the agriculture. Based on the estimated that a total number of 1.9 million domestic bio-gas systems can be installed in Nepal.

According to the final report of bio-gas use survey 2000/001, A Bio-gas user household saves 990kg of firewood & 6 liter of kerosene oil per year. The gas production was insufficient of in the winter as reported by majority of the respondents one third of the household are attached their latrines to the bio-gas plants. Above half of the respondents used the slurry in the cultivated land and other uses in gardens. The decrease in occurrence of disease was the positive benefit of bio-gas plant installation. However negative part of installation was increased prevalence of mosquito and some even reported occurrence of typhoid. Most of the household were in the value of male. The major problem in the bio-gas plant in the value problems, high rate of interests, high cost and non-availability of spares, increased prevalence of mosquito.

CHAPTER- THREE

METHODOLOGY

This chapter deals about different methods and techniques employed to carry out the research. The study is based on primary as well as secondary data. Following methodologies were adopted to fulfill the objectives of the study.

Related literatures were collected from various institutions, Government offices, Non Government Organizations (NGOs), International Non- Governmental Organizations (INGOs), websites of various organizations related to biogas, Internet etc. Those literatures encompass magazines, manuals, brochures, books, journals, test reports of research institutions, thesis reports.

3.1 Selection of the Study Area

For the study, Patlekhet VDC of Kavre district was selected. Tamang, Damai, Kami, Brahman and Chhetri are the groups residing in the VDC. So far, no research of this type has been conducted in the selected VDC

3.2 Brief Introduction of Study Area

This study is related to Patlekhet V.D.C. of Kavre district. The total area of this district is 1376 sq. km. According to the census 2001 the population of Kavre is 385218 including female 196620. Of the total population, 62% are Buddhist, 32% are Hindus. The population growth of the district is 1.72%. There are 87 VDC, 3 municipalities in Kavre district.

3.3 Research Design

The research has been carried out with exploratory research design. In order to fulfill the objectives, information has been collected from the field study. Household survey, interview and observation are the main technique that has been utilized to obtain the information from bio gas users. The families of bio gas users were also taken into consideration for interview. Primary as well as secondary data has been utilized. Analysis of data has been made from the averages and percentage.

3.4 Universe and Sample Size

The universe includes all the bio-gas users of the Patlekhet V.D.C. of Kavre district. A sample refers to a part chosen from the population. Therefore, sample has been taken as the representative of the biogas plants in Patlekhet V.D.C. There are altogether 150 biogas plants in Patlekhet V.D.C. A total of 25 households with biogas plants have been taken as the sample for the study using simple random sampling from 8 wards. Sample size of each ward is not homogenous. The name of the owner of biogas plant has been obtained from the field survey and interview. The minimum sample size was one each in ward no. 1 and 2. Similarly, the maximum sample size was 6 in ward no. 5.

Table: 3.1 Ward wise Distribution of Sample Size

Ward No	Household with Biogas Plant	Sample Size
1	7	1
2	8	1
3	26	5
4	27	5
5	32	6
6	18	3
7	16	2
8	16	2
Total	150	25

3.5 Sources of Data

This study aims to bringing the socio-economic information for the Bio-gas users in Patlekhet V.D.C. Primary as well secondary data/information has been used for the research. Primary data has been collected through field survey, interview and observation. Secondary data/information has been used for reviewing the status of previous study. That has been collected from various published and unpublished sources.

3.6 Techniques and Tools of Data Collection

The data used in the study has been collected from field survey conducted in July 2009. The researcher has followed the certain methods or techniques to collect data/information. According to the nature of problem, topic, information and data vary. These techniques and tool or method has been adopted to carry qualitative information.

3.6.1 Household Survey

The household survey was conducted in order to collect qualitative and quantitative facts about socio-economic aspect of the users due to impact of bio-gas. Information was also collected through interview and discussion with users and their families. The primary data was collected from the selected users of houses of the V.D.C. Questionnaire was used as a tool for interviewing the users of biogas plants and their family members.

3.6.2 Interview

The primary data was collected from key informant using the structured or unstructured interview method as well as open and close ended questions. The interview was taken as cross-checking for data obtained from interviewing those key informants. The key informants are social worker, school teachers, staff of Biogas Company, intellectuals of biogas, local biogas users of the VDC who are not included for household survey.

3.6.3 Field Visit and Observation

Each household was selected randomly. The researcher visited the VDC and observed directly. Data was recorded while observing the households who are participants in the programme.

3.6.4 Tools Check List

It helps to remember what information s/he has to collect and verify in the field. Here the respondent is not asked to make a choice but to respond to each item on the list.

3.7 Data processing and Analysis

Information collected from questionnaire was transformed into a master sheet and data is tabulated on the basis of master sheet. Information was then grouped, sub-grouped and classified as per the necessity so as to meet the objectives. After the completion of data collection, was processed with the help of computer (MS word and Excel were used for data processing). It has been analyzed by using manual chart, diagram and classifications of the variables. After analyzing data, it has been carried out to maintain consistency.

CHAPTER: FOUR

DATA PRESENTATION AND ANALYSIS

4.1 Socio-economic Status of Biogas Plant Owners

This chapter deals with the socio-economic aspect of the biogas plant owners in Patlekhet V.D.C. Caste ethnicity, occupation, family size, land holding pattern, livestock population are the main variables considered in this study.

4.1.1 Caste / Ethnicity

Caste is divided in the past by their occupation and it is also social division. There are different castes and ethnic groups in Patlekhet VDC. The data on ethnicity/caste of sampled biogas households is given in Table 4.1

Table 4.1 Ethnicity of Sampled Households

S.N.	Ethnicity/Caste	Number	Percent
1	Brahmin	18	72
2	Chhetri	5	20
3	Tamang	2	8
	Total	25	100.00

Source: Field survey, 2009

Table 4.1 shows that the majority of the sampled households under study are Brahman (72 percent), Chhetri (20 percent) and Tamang (8 percent). The reason behind the higher percentage of biogas users (Brahmin) was found that they are socially & economically forward in every field.

4.1.2 Occupation

The main occupation of biogas plant owners was found to be business (selling vegetables and milk in nearby markets: Dhulikhel and Banepa). Agriculture and service were other occupations of samples biogas owners.

Table 4.2 Occupation Distribution of Plant Owners

S.N.	Occupation	No. of Household	Percent
1	Business (vegetable and milk selling in small scale)	12	48
2	Agriculture	10	40
3	Service	3	12
Total		25	100.00

Source: Field survey, 2009

This table shows that higher percentage of plant owners are engaged in small business sector. About 48 percent of the plant owners are involved in vegetable and milk business, 40 percent in agriculture 12 percent in service besides agriculture, some of the households has secondary source of income as well. They are pensions and teaching job etc. These support them for fulfill their needs and increasing quality of life.

4.1.3 Family Size

Family size shows about the number of father, mother and children. Small size of family is indicator of happiness in life. Distribution of sampled household by family size is given in Table 4.3.

Table 4.3 Distributions of Households by Family Size

S.N.	Family size	No. of Household	Percentage
1	1-4 person	7	28
2	5-8 person	15	60
3	9 and above	3	12
	Total	25	100

Source: Field Survey, 2009

Table 4.3 shows that 15 household (60 percent) have 5 to 8 members which is categorized as medium size family. 28 percent household founds in 1-4 member group and only 12 percent households founds in 9 and above size group. The percent of people are high in 5-8 family size, group.

4.1.4 Land Holding

The main occupation of plant owners are vegetable business and agriculture, all of them have their own land to cultivate. Only operational land holding has taken into account. It was found that land is cultivated by owners themselves. All the plant owners have their own little land. Land distribution is given in the Table 4.4

Table 4.4 Distribution of Land holding among Sample Households

Land area in Ropani	No of Household	percentage
Below 5	4	16
5 to 10	14	56
10 to above	7	28
Total	25	100

Source: Field Survey 2009

Land holding pattern is not equal. So, the table 4.4 shows that the land distribution of below 5 Ropani is 16 percent. 5 to 10 are 56 percent and 10 to above be 28 percent.

4.2 Use and Impact of Biogas Plants

4.2.1 Size of the Biogas Plant

Many types of Bio-gas plants were introduced in the world. Properly used sizes of bio-gas plants are $4m^3$, $6m^3$, $8m^3$, $10m^3$. The factors e.g. capacity of Land holding, capacity of livestock are the source for determining the size of the plant. Size of the bio-gas plant is given in the Table 5.1

Table 4.5 Size of the Biogas Plant

S. N.	Size of biogas plant	No of Households	Percent
1	$6m^3$	23	92
2	$8m^3$	2	8
	Total	25	100

Source: Field Survey 2009.

Ninety two percent people in this study area installed $6m^3$ Biogas plant. 8 percent people in the study area installed $8m^3$ Biogas plant. So, the $6m^3$ biogas plants were popular in this area.

4.2.2 Reason for Biogas Installation

Biogas technology is being widely used in both the developed and developing economics in agricultural, industrial and municipal waste systems. The main reason for the installation of biogas was to get rid of the firewood collection and to have easy and smokeless cooking. About three-fifth (60 percent) of the respondents installed biogas to get rid of firewood collection. While rest of the respondents replied that they installed for easy and smoke less cooking as well as to increase crop production. The cost of installation can be observed through three parameters; total cost of installation subsidy provided by institutions and self-investment of the users.

4.2.3 Cost of Installation

The respondents were asked about the cost of installation. The total cost consisted of two factors:

- Subsidy
- Self-investment.

The cost for installation of biogas plant was in the range of NRs. 10,000 – 12,000 without subsidy. The reason for slight variation in cost may be the personal contribution made by the respondent during the construction work in the form of labour and construction materials. The cost of plant made included two factors-subsidy and investment by owner.

4.2.3.1 Subsidy

In the end of 1999 in Hills rate of subsidy was Rs 10,000. In the end of 2001 in Hills rate of subsidy was Rs 9,000. In the end of 2003 in Mid Hills subsidy Rate for 4 and 6m3 – Rs 9500. In the end of 2003 in Mid Hills subsidy Rate for 8 and 10m3 – Rs 8500.

4.2.3.2 Self Investment of the Users

Beside subsidy, the respondents had to bear rest of the cost by themselves. Provision of loan was also available for this purpose through banks. But all of them had constructed biogas plants through their own investment. Subsidy was found the encouraging factor for installing the biogas plants. ADRA Nepal and LOVEGREEN Nepal have coordinated for the installation and subsidy delivery of biogas plants in the selected area.

4.3 Livestock

Livestock serves as the source of dung for biogas plants. Livestock dung is considered as the main raw material for biogas plant in rural areas. All of the biogas users have their own livestock.

4.3.1 Livestock Population

Cow, buffalo and goat were considered in the livestock population. However, dung of cow and buffalo were dominant in use in biogas plants as raw material in Patlekhet VDC. Livestock population found and observed were given in Table

Table 4.6 Livestock Population

S. N.	Livestock	Number	Percent
1	Cow	40	25.15
2	Buffalo	32	20.12
3	Goat	87	54.71
	Total	159	100

Source: Field Survey 2009

Table 5.2 shows that among the animals in livestock population, goat has the greatest share. However, during the survey it was found that the dung of goat was found not in use in biogas plants in the selected VDC.

Table 4.7 Distribution of Livestock among the Households under Study Area

No of livestock	Total household	Percent
1-4	7	28
4-10	18	72
Total	25	100

Source: Field Survey 2009

The table shows that the 28% of sampled HH has livestock in the range of 1 -4 and that of 72% samples HH have livestock in the range of 4-10.

4.3.2 Dung Produced

The raw material for bio-gas plant is dung. Quantity of dung as a feeding material is responsible for generation of biogas. Amount of dung feeding found during the survey was as follows.

Table 4.8 Dung Feed in Bio-gas Plant

S.N.	Plant size	Average dung fed kg / per day	High/low
1	6 m3	35	average
2	8 m3	47	Slightly low

Source: Field Survey, 2009

4.3.3 Ratio Mixing

Dung has to be mixed with water at the time of feeding in the biogas plant. The recommended amount of water is equal part to the dung. Production of the gas will be affected if the amount of water mixed is too low or too high. The observed ratio of water to dung in the field was 1:1.

4.3.4 Use of Biogas

From the survey in the field, it was found and observed that all the households have been using biogas for cooking purpose. It was also found that most of the sampled households have been using one burner in their kitchen. Only one user had biogas stove with two burners. On an average, it was observed that one household uses biogas for 3 hours per burner. The minimum use was 2 hrs while maximum was 4 hrs. This cooking time is less than firewood cooking time.

4.4 Social Impacts of Biogas Installation

This section highlights the positive impacts of biogas in terms of gender, environment, health and sanitation and economics.

4.4.1 Impacts on Reduction in Workload and Time Saving

Biogas provides a direct benefit, especially to rural women, as a result of the reduction of the workload when shifting from cooking on fuelwood to biogas. After installation of biogas there is reduction in workload of the family members especially for women. The reduction of workload was measured in terms of saving in working time. Observation was made on 3 categories of works namely firewood collection, cooking activities and working utensils.

Table 4.9 Reduction in Workloads and Time Saving

S. N.	Category of work	Average time taken hours/day		Reduction in workload (saving in time hrs/day)
		Before installation	After installation	
1	Firewood collection	4.5	2.5	2.5
2	Cooking activities	3	2	1
3	Washing utensils	1.5	0.5	1
	Total	8	4	4

Table 5.7 shows that saving in time was considerable. It shows that after biogas installation, time saving in firewood collection is 2.5 hours day whereas it is 1 hour per day in cooking and washing activities. On an average, time saving is 4 hours per day. In other words, time required for daily activities was found reduced by half.

4.4.2 Time Saved in Cleaning Utensils

All the users responded the positive impact of biogas in terms for cleaning of utensils. Because of nature of biogas that it is smokeless, almost all the users have experienced the easiness and quickness in cleaning utensils. Because pots do not become black while biogas is used for cooking. Before installation of biogas plant, time taken for cleaning utensils was 1.5 hours per day. However, after installation biogas plant, the time reduced to 1 hour per day. It was very much interesting to observe that almost all the users spend their saved time on vegetation farming and child education.

4.4.3 Time Saved in Cooking

From the field survey, it was found that the time required for cooking was 3 hours per day (average). After use of biogas, the cooking time has reduced to two hours a day. During the interview, the respondents highlighted the ease of cooking with biogas in comparison to firewood. Moreover, they expressed that the technology is easy to use and handle for rural people.

4.4.4 Use of Gained Time

After installation of biogas, people of Patlekhet VDC have experienced the saving of time significantly. Time saved was in terms of firewood collection, cleaning utensils, cooking activities. Most of the users have used the saved time for vegetation farming and child education. This vegetation farming has greatly enhanced the income of users in the study area.

Table 4.10 Specific Benefit of the Gained Time

S.N.	Benefits	No of household	Percent
1	Vegetable farming	18	72
2	Rest	2	8
3	Educate children	4	16
4	Household work	1	4
	Total	25	100

Source: Field survey, 2009

This table shows that 72 percent of the respondents used their saved time in agricultural purpose (mainly vegetable farming). 16% of them use the time for child education and that of 4% use for household work.

4.4.5 Health and Sanitation

A big problem for the rural people especially to the housewives is indoor air pollution and smoke exposure inside the kitchen while cooking. Poor indoor air quality is one of the major risks factors for acute respiratory infections with housewives and children. According to the users of biogas plants in Patlekhet VDC, biogas has reduced the smoke exposure in a considerable way and significantly improved the air condition inside the kitchen that results in reducing of eye infection, respiratory diseases, cough and headache. Improved sanitation with the construction and connection of toilets has led to better hygiene conditions. Better sanitation condition through biogas has also helped to reduce the infant mortality rate.

4.4.5.1 Use of Latrine

Among the survey household, 90 percent of the households were found having latrine. But 10 percent households were without any latrine.

Table 4.11 Use of Latrine

S. N.	Have latrine	No of Households	Percent
1	Yes	23	92
2	No	2	8
	Total	25	100

Source: Field survey, 2009.

Out of 25 households, only two households have no latrine till date. They use open place as a toilet.

4.4.5.2 Connection of Latrine to Biogas Plant

Table 4.12 Latrine Connected to the Biogas Plant

S. N.	Connection of latrine to Biogas plants	No of Households	Percent
1	Latrine connected	21	84
2	Not connected	2	8
3	Do not have latrine	2	8
	Total	25	100

Source: Field survey, 2009

- Beside dung of animals, various other materials such as vegetables, kitchen waste, human excreta, grass etc. can be used as feeding material for biogas plants. Out of 25 HH, two have no latrine. Out of 23 HH having latrine, 21 HH have connected their latrine to the biogas plants. The connection of latrines to biogas plants means the use of human excreta for production of biogas. The reason for two HH not connecting their latrines to biogas plants are due to the misconcept that cooking in the kitchen should not be done with the biogas generated by the use of human excreta. This is somehow the tradition and cultural view that it is unholy. However, it was not found the caste as the barrier or constraint to join latrines in biogas.

4.4.5.3 Reduction in Disease

From the interview, it was found that there is improvement in the smoke borne problems and diseases such as eye infection, respiratory diseases, cough and headache. Improved sanitation with the construction and connection of toilets has led to better hygiene conditions. Better sanitation condition through biogas has also helped to reduce the infant mortality rate.

Table 4.13 Reduction in Disease

S. N.	Illness	No. of households	Percent
1	Eye burning & Headache	7	28
2	Respiratory problems	15	60
3	No change	3	12

Source: Field Survey, 2009

From the interview with users, it was noticed that 15 HH have experienced the reduction in respiratory diseases. 7 HH clearly expressed their experience of finding of reduction of eye burning and headache after installation of biogas plants. However, 3 HH expressed that there is no change in positive impact on health after use of biogas.

4.4.5.4 Insect Prevalence

Fly and Mosquito are taken for prevalence of insects. Most of the household reported the change in prevalence of insects. 3 HH did not report about the change.

4.4.5.5 Fly

Production in the prevalence of fly has been reported from the study. 14 HH reported decrease in fly population. However, 8 HH reported about increase and 3 HH reported about no change as shown in the table.

Table 4.14 Effect on Prevalence of Fly

S. N.	Fly prevalence	No of households	Percent
1	Little increased	3	12
2	Much increased	5	20
3	Little decreased	4	16
4	Much decreased	10	40
5	No change	3	12
	Total	25	100.00

Source: Field Survey 2009.

4.4.5.6 Mosquito

The status of mosquito prevalence after biogas plant installation is shown in table below.

Table 4.15 Effect on Prevalence of Mosquito

S. N.	Mosquito prevalence	No of Households	Percent
1	Little increased	13	52
2	Much increased	7	28
3	Little decreased	2	8
4	Much decreased	2	8
5	No change	1	4
	Total	25	100

Source: Field Survey 2009.

Out of 25 HH, 20 HH reported for increase in Mosquito in the area after installation of biogas. However, 4 HH reported for decreased prevalence of Mosquito after installation of biogas. Moreover, 1 HH reported for no change in prevalence of Mosquito after installation of bio-gas plant.

4.5 Economic Impacts of Biogas Installation

This section discusses about the saving of firewood; specific benefits of the saving, use of slurry for increase in agriculture productivity; and operation and maintenance of biogas plants.

4.5.1 Saving of Firewood

Before installation of biogas plants, firewood was used for cooking using traditional Chulo. However, after installation of biogas plants, firewood was not in use for cooking. This implies the saving of firewood as shown in the below table.

Table 4.16 Saving of firewood

S. N.	Quantity of firewood saved per month	No of Households	Percent
1	5 to 10 Bhari	17	68
2	11 to 20 Bhari	8	32
Total		25	100

Source: Field Survey, 2009

- 1 Bhari is equivalent to 30 kgs.
- Cost of 1 Bhari is equivalent to NRs. 150 (local price).

Table 5.12 depicts the amount of firewood saved after the installation of biogas. It is apparent from the table that the minimum saving of firewood per month is 5 Bhari (150 Kg). In terms of monetary value, it equals to NRs. 750. The maximum saving is 20 Bhari (600 Kg) with monetary value of NRs. 3000.

4.5.2 Specific Benefits from Saving

Patlekhet VDC of Kavre district has direct road access to Dhulikhel and Banepa city and therefore market is nearby the VDC. Users of biogas plants in Patlekhet VDC have taken advantages of these accesses to road and market. Users have used benefits of biogas plants in various ways. They have effectively utilized the saved time and used the slurry as good organic fertilizer that has resulted in increase in productivity of vegetables and milk. The incomes generated by vegetable farming and milk production have been used for different purposes as shown in the table below.

Table 4.17 Specific Benefits from Saving

S. N.	Specific benefits	No of Households	Percent
1	Educate children	10	40
2	Buy ornaments	3	12
3	Invest in vegetable farming	9	36
4	Construct house	2	8
5	No benefits	1	4
	Total	25	100

Source: Field Survey, 2009

4.6 Impacts of Slurry

Slurry is the byproduct of biogas plant. However, this slurry is considered as a valuable organic fertilizer. As per norms established by the GGC, the slurry produced from the biogas plant contains 1.6% nitrogen, 1.2% phosphorous and 1.0%t potash against 0.5% phosphorus and 0.6% potash in livestock dung. Biogas slurry is high quality organic manure. The organic contain of the digested slurry improves the soil texture, stabilizes its humid content, intensifies its rate of nutrient depot formation and increases its water holding capacity.

4.6.1 Methods of using Slurry on Farm

Application of byproduct of biogas plant- slurry is different from place to place and user to user. The observed methods are given below:

Table 4.18 Methods of Bio-slurry Applied

S. N.	Method of Application	No of Households	Percent
1	In liquid form	1	4
2	In dried form	3	12
3	By re-compositing	21	84
	Total	25	100

Source: Field survey, 2009

It was found that 21 HH use slurry by re-compositing, that of 3 HH in dried form, whereas 1 HH use in liquid form. Best practice from the point of view of conservation of plant nutrients is to use slurry in liquid form. However, this practice has a limitation for wider adaptability due to difficulty of transporting to the fields.

Table 4.19 Reason for not using Slurry in Liquid Form

Reason	No of household	Percent
Too wet, difficult to transfer	15	60
Not aware of fertilizing value	3	12
Toilet attached, too dirty to handle	7	28
Total responses	25	100

Source: Field Survey, 2009

The table depicts that out of 25 HH, 15 HH (60%) have not used liquid slurry as they felt difficult to transfer to the field, 3 HH (12%) were not aware of fertilizer value of slurry. 7 HH (28%) not used the slurry because of the toilet connections of the plants and think the activity is against traditional norms and values.

4.6.2 Bio Slurry Generation and its Agricultural Application

The digested slurry can be used as manure in the fields. Many of the farmers used slurry for increasing crop production. The fact calculations are not possible. Use of slurry saved money; otherwise it saves money for buying chemical fertilizer.

Table 4.20 Slurry and Production

S. N.	Agriculture	No of households	Percent
1	Increased	20	80
2	Decreased	1	4
3	Remained the same	4	16
	Total	25	100

Source: Field Survey, 2009

The above table shows that 20HH (80%) responded that agricultural production (crop production) has been increased with the use of biogas slurry. 4 HH(16%) responded for no change in agricultural production whereas 1HH (4%) responded for decrease in the production. In various crop productions, biogas slurry has changed the vegetable production in a drastic way in the selected VDC including surrounding areas. Next to vegetable production is the production of maize. The rest are wheat, millet, paddy and mustard.

4.7 Operation and Maintenance

Biogas energy has many merits. However, it has some demerits as shown below.

Table 4.21 Problems of Bio-gas Plant

S. N.	Problems	No of household	Percent
1	Less Dung availability	9	36
2	Gas Generation not sufficient (Winter)	15	60
3	Operational	1	4
	Total	**25**	**100**

Source: Field Survey 2009

This study shows that 9 HH (36%) responded the problem of dung availability, 15 HH (60%) responded the problem of gas production in winter season. Only one HH reported the problem of operational.

Alternative for the Insufficiency

25 HH (100%) responded the use of firewood in case of insufficiency of biogas. None of them responded the use of dung, LPG, kerosene in that case.

CHAPTER: FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATION

5.1 Summary

From the field survey and data analysis, it was found that major occupation of the households were business (selling of vegetables and milk produced by themselves). Users had easy access to road and market (Dhulikhel and Banepa) to sell their production. All the biogas plants under study were of Dome Type. Almost all biogas plants (92%) were of 6 m^3 in size. The biogas was found in use only for cooking and not for lighting. All biogas users had access to national grid for electricity. Dung of cow and buffalo were found in use as feeding materials in all biogas plants. Loading rate of feeding material (dung) was found in the range of 30 kg to 40 kg per day for 6 m3 and 50 kg to 60 kg per day for 8 m3.

Mixing of water and dung was found in the ratio of 1:1. Majority of biogas plants (84%) were connected to toilet and all plants were found in satisfactory working condition. All biogas plants were constructed by self-investment of the users. Subsidy was very encouraging factor for installation of biogas plants in the study area. The cost of installation of biogas plants was in the range of 10,000 to 12,000 (excluding subsidy). Biogas plants were installed as a substitute to firewood and due to ease and comfort cooking. Biogas plants were installed by GGC and institutions like ADRA and LOVEGREEN Nepal coordinated for the installation of biogas plants.

The study revealed that women were benefited after the adoption of biogas technology. There is considerable reduction in workloads of the family member, especially for women. The saving of time was daily 2.5 hrs for firewood collection, 1 hr for cooking activities and 1 hr for cleaning utensils. Improvement of indoor air pollution and smokeless environment in the kitchen were the appreciable changes found due to biogas plants. Decrease in diseases and infections such as eye burning, headache, cough, respiratory diseases due to use of clean energy obtained from biogas plants. Decrease in fly prevalence because of clean environment at the surrounding. Increase of breeding of

Mosquito was reported. This is the negative impact of biogas plants observed by the users. Decrease of production of biogas in winter season due to low temperature. Saving of firewood was in the range of 5 Bhari to 20 Bhari. The monetary value of the saving was from NRs. 750 to NRs. 3000.

Byproduct of biogas plants i.e. slurry was in use as an organic fertilizer in various forms such as liquid form, dry form and by re-composting. However, use of slurry as a fertilizer by re-composting was dominant in the areas i.e. 84%. Increase in agricultural productivity was experienced by biogas owners. 80% of the respondents answered for increase in productivity. Biogas production was found low in winter season

5.2 Conclusions

Following conclusions can be drawn from the findings of the study:

- Energy generated from biogas plants is clean & smoke free renewable energy and can be used as a substitute to firewood for cooking in a sustainable way
- Biogas provides a direct benefit, especially to rural women, as a result of the reduction of the workload when shifting from cooking on fuelwood to using biogas
- Biogas saves approximately four hours a day per family mainly due to the reduction on time used for collecting fuelwood, cooking and cleaning utensils
- Use of biogas significantly improves the indoor air quality and better sanitation due to the connection of toilets
- Loading rate of dung and mixing of water with dung are at par with the recommended ones
- Biogas production becomes low at low temperature in winter season
- Biogas technology reduces indoor air pollution in a drastic way, which improves the health condition especially eye infection, respiratory diseases, cough and headache
- Biogas slurry can be used as a good fertilizer as a substitute to chemical fertilizer. The high quality bio-fertilizer contributes for high yield of crop and vegetables.

High quality manure can be used for income generating activities such as vegetable farming.

- Biogas technology has improved the quality of life of rural people

5.3 Recommendations

The following are the recommendation based on the conclusions:

- Detail study about the impact of income generating activities of selling of vegetables and milk in nearby markets should be carried out
- All plant owners should be encouraged to do income generating activities
- Subsidy should be continued for promotion of biogas technology
- There should be a special policy of the government to encourage poor of the poor people of rural areas to use the clean, smokeless renewable energy like biogas
- Detail study about the impact of biogas on various diseases should be carried out
- Awareness programme about proper use of slurry as a fertilizer should be conducted
- The impact of use of human excreta on biogas generation should be carried out
- Importance and benefits of the biogas plant should be broadcasted regularly by media such as newspaper, radio, T.V. etc
- Cause for increase of mosquito population due to introduction of biogas should be investigated with necessary solution for the control of mosquito.
- Detail study about effect of low temperature at winter season on biogas generation should be carried out

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Annex I

Household Survey Questionnaire

1. Demographic Information's

Name of HH head: ……………………………………………. Sex: M / F

District:…………………………VDC: ….……………........... Ward No:…

Name of Respondent: ……………………………………………. Sex: M / F..

Ethnicity: ……………………….Religion: …………………………..

Land Holding: ……Ropani Family Size: [ ] M [ ] F [ ]

Main occupation of family:

a) Agriculture b) Business c) Service

d) Wage earner e) others

2. Information on Biogas

2.1 Do you have biogas plant? Yes [ ] No [ ]

2.2 Size of that plant [ ] m3

2.3 Type of Gobar gas plant?

a) Dome [ ] b) Drum [ ]

2.4 What is the name of installing Biogas Company?

2.5 Reason for installation

a) For Easy and smokeless cooking
b) To get rid of firewood collection/dung cake
c) For Lighting
d) For Saving time
e) To increase crop production
f) To conserve environment

2.6 Cost of Bio-gas plant

a) Total cost of installation Bio-gas plant: Rs.
b) Source of your finance:
c) Subsidy amount:

2.7 Livestock Holding

Animal	Number	Dung Produced per day (kg)	Used in Biogas Y / N
Cow			
Bull			
Goat			
Buffalo			
Other			

2.8 Dung feed per day ………………..kg

2.9 Water used for mixing ………………..liters

2.10 Source of water for mixing

a) Well b) River c) Stream

d) Canal e) Tap water f) others

2.11 Application of biogas

Purpose	Number of Burner/mantles	Use hrs/day/unit
Cooking		
Lighting		

3. Impact of Biogas on Saving

3.1 Source of energy used before biogas installation

a) Firewood b) Agriculture residue

c) Electricity d) Kerosene

e) Dung cake f) L.P. gas

g) Others

3.2 Source of the energy used after installation

a) Firewood b) Agriculture residue

c) Electricity d) Dung cake

e) L.P. gas f) others

3.3 Energy consumption

Sources of Energy	Consumption per month		Saving per month	
	Before installation	After installation	Quantity/kg/d/w/m	Local cost/unit

3.4 Yearly income of family? Rs …………………

3.5 What specific benefits do you get from the saving?

4. Workloads

4.1 How frequently do you feed the biogas plant?

a) Daily
b) Alternatively
c) Once a week
d) Twice a week

4.2 Saving of time

Household Activities	person responsible	Time allocated		Time saved/day
		Before inst.	After inst.	
Firewood collection				
Cooking				
Washing utensils				

4.3 If yes, what do you do in the gained time?

a) Social work
b) Vegetable farming
c) Household work
d) others

5. Health and Sanitations

5.1 If there any visible change in health and sanitation?

Yes [ ] No [ ]

5.2 Do you have latrine?

Yes [ ] No [ ]

5.3 If yes, when was it constructed?

a) Before installation b) After installation

5.4 Is it connected to the biogas plant?

Yes [ ] No [ ]

5.5 If not, why?

5.6 Has there been reduction in occurrence of disease?

Yes [ ] No [ ]

5.7 If yes, which disease

a) Respiratory b) Gastrointestinal

c) Skin d) others

5.8 Change in insect prevalence

Insects	Change in prevalence		Extent of change		
	Increase	Decrease	Little	Much	Altogether

5.9 What improvement did you find in your surrounding after installation of biogas plant?

5.10 Do you have any water problem?

a) For household use b) For biogas

5.11 Beside Biogas stoves, do you have traditional Chulo/other stove/Ageno?

a) Yes b) No

6. Slurry use

6.1 Do you use slurry as fertilizer?

a) Yes b) No

6.2 Slurry production

D	W	M	Y

6.3 How do you use it?

a) Directly b) By re-compositing

c) In dried form d) others

6.4 Use of slurry

Crops	Crop Yield		Increment
	Before Slurry Use	After Slurry Use	
Paddy			
Wheat			
Maize			
Oil seed			
Others			

6.5 Do you face any problem with slurry application/management?

7. Problems

7.1 What problems do you have now a days?

a) Operational　　b) Maintenance

c) Water availability　　d) Dung availability

e) Gas production　　f) others

7.2 How do you manage in case the biogas produced is not sufficient?

a) Use firewood　　b) Use kerosene

c) LPG　　d) others

7.3 What is the most problematic component in your experience?

7.4 How much you spend monthly for maintenance?

7.5 Does Biogas Company provide after sales service and maintenance service after the installation of plat?

7.6 If yes, what is the number of visit so far?

a) One time　　b) Two times

c) Three times　　d) more than three times

7.7 Are you satisfied with the service of Biogas Company?

a) Yes　　b) No

7.8 If no, do you have any complain about Biogas Company?

7.9 Do you have any problem in paying the loan?

8. Perception and Suggestions

8.1 What is your perception about biogas/energy?

8.2 Do you like to give any suggestion about biogas technology?

Annex II

Check List

1) Participant caste

i) Brahmin ii) Chhetri

iii) Tamang iv) Other

2) Size of the biogas plant?

i) $4m^3$ ii) $6m^3$

iii) $8\ m^3$ iv) $10\ m^3$

3) Type of Biogas plant

i) Dome ii) Drum

4) No. of livestock population

i) cattle [ ] ii) buffalo [ ]

iii) other [ ]

5) Environment of surrounding

6) Prevalence of insect and fly

7) Have latrine or not

i) Yes ii) No

8) Connection of Latrine to Biogas plant

i) Yes ii) No

9) Slurry using method

i) Re-compositing form ii) Liquid form

iii) Dry form

10) Impact of slurry in agriculture

i) Positive ii) Negative

11) After installation of biogas plant socio-economic condition of the bio-gas user.

Annex III

Subsidy in Biogas in Nepal

Annex 2

S. NO.	CATEGORY	DISTRICTS
1	20 Terai Districts as specified by GON	Banke, Bara, Bardiya, Chitwan, Jhapa, Dang, Dhanusha, Kailali, Kanchanpur, Kapilvastu, Mahottari, Morang, Nawalparai, Parsa, Rautahat, Rupandehi, Saptari, Sarlahi, Siraha and Sunsari.
2	40 accessible districts in Hills as specified by GON	Achham, Dailekh, Myagdi, Okhaldhunga, Ramechhap, Rukum, Terhathum, Arghakhanchi, Baglung, Baitadi, Dadeldhura, Bhaktapur, Dhading, Dhankuta, Dolakha, Doti, Gorkha, Gulmi, Ilam, Kaski, Kathmandu, Kavre, Lalitpur, Lamjung, Makwanpur, Nuwakot, Palpa, Panchthar, Parbat, Pyuthan, Rasuwa, Rolpa, Salyan, Sindhuli, Sindhupalchowk, Surkhet, Syangja, Tanahu, Taplejung and Udaypur.
3	15 remote districts in Hills as specified by GON	Bhojpur, Darchula, Jajarkot, Khotang, Sankhuwasabha, Bajhang, Bajura, Dolpa, Humla, Jumla, Kalikot, Manang, Mugu, Mustang, and Solukhumbu.
4	18 low penetrated districts as specified by GON	Achham, Dailekh, Okhadhunga, Rukum, Baglung, Baitadi, Dadeldhura, Doti, Panchthar, Rolpa, Salyan, Taplejung, Dhanusha, Mahottari, Parsa, Rautahat, Saptari and Siraha.