CHAPTER - 1

INTRODUCTION

1.1 Background of the study

Biogas has been gaining popularity nom a day as a good alternative source of domestic energy. Looking back over the origin and development og this technology we find the history of biogas was started in 18th century.

The Encyclopedia Britannica defines energy as, "the equivalent of a capacity of doing work."The word itself is derived from Greek, 'energine ':'en' means 'in' and 'ergon' stands for work, thus meaning, "in-work". The modern society would be paralyzed without the use of energy. Exploitation of these sources and their utilization in human activities has helped in accelerating the development of human society.

The meaning of energy indicates various forms as according to different faculties of study. In physical science energy is referred to capacity of doing work, which includes the potential, kinetic, thermal, electrical, chemical and nuclear forms of energy. But, in socio-economic, the rather circumscribes the kinds of fuel derived from renewable and non-renewable sources. And, this is what the term refers to, in the present study.

Realizing the uses and importance of energy, the extraction of various types of fuel started a long time back. Much technological development started depending on these extracted fuels. Affordable or not every nation consumes all types of fuels, be it an imported commodity like petroleum or otherwise.

Nepal is no exception to the energy crisis. Nepal is nursing chronic energy related problems. With no oil reserves, nuclear power and traditional sources to sustain it's increasing energy need.

Energy consumption in fiscal year (FY) 2007/08 increased by 1.35%to 8616 Tons of oil Equivalents (TOE) compared to fiscal year 2006/07. It is expected to increase by 3.34% to 8904 TOE in FY 2007/08 in comparison to previous year.

Energy is divided into three categories according to its source via, traditional, commercial and renewable. Traditional, commercial and renewable energy occupied 87.7%, 11.75% and 0.53% respectively of the total energy consumption in FY year 2007\08. The share of traditional, commercial and renewable energy is expected to remain 86.71%, 12.72% and 0.56% respectively in FY 2008\09 (Economic Survey; 2008/09). This shows that this year too, Nepalese economy heavily relies on traditional sources of energy as in the previous year.

Of the total traditional energy consumption in FY 2007\08, share of fuel wood was 89.0%, agriculture residue 4.34% and cattle residue 6.75%, while in FY 2008\09 (Economic Survey; 2008/09) too the share of agriculture and cattle residue is expected to remain the same. Similarly, of the total commercial energy consumption in FY 2007\08, the share of petroleum products was 69.6%, coal 15.0% and electricity 15.4%. Whereas in FY 2008\09 (Economic Survey; 2008/09), the share of petroleum products, coal and electricity in total energy consumption is expected to be 63.6, 21.4 and 14.8% respectively.

Under the very recent development, in the course of the search of alternative sources energy, biogas technology has proved to be very appropriate and technically simple. This seemed feasible under the conditions of the developing world.

There are many advantages of biogas technology for people living in the rural areas of the developing world since their major occupation is agriculture and they have a tendency of high cattle holdings. This plant can digest material that are readily available on small farms such as animal dung and crop residue. The digestion not only produces a clean, high grade fuel gas but it also gives residue that can be used as fertilizer in the fields. The quality of this residue is often better than that of the same materials composted by traditional method.

The gas is clean and smokeless, hence does not dirty the pots. The operation is simple and the technology can be understood by any layman. The residue of the plant does not smell bad and it's odorless feature so pollution is controlled to some extent.

1.2 Statement of the problem

With the development of various technological factors, the energy sector is seen to have served as the backbone of the modern society. Without energy, any technically advanced society would be paralyzed. Many developing countries are facing energy related problems such as the rising prices of fossil fuel and the high rate of depletions of the forest resources. And, Nepal is no exception.

Under the Nepalese context, the sources such as solar and wind energy have not been fully utilized and exploited. Though with very high potentiality, water resources of Nepal have been very minimally explored. The energy problem of a country leads to the search and study of the alternate sources of energy, such as biogas.

Nepal is a country of predominant of agriculture. But the agriculture of the Nepalese economy faces problems such as traditional technology and lack of appropriate fertilizers to increase the productivity of the existing land.

Biogas plant installation is one of the most appropriate methods of substitution for other energy sources. It requires animal dung, human excreta and vegetable wastes along with water as raw materials, which is usually available within the country; and the produced fuel to some extent curtails the imports of the petroleum products. Moreover, the output slurry of the plant serves as a better fertilizer than the other usually used chemical fertilizer, since it contain more nutrients. Furthermore, the use of slurry curtails the use of chemical fertilizer and hence the import of previously consumed chemical fertilizers. However, the installation biogas is also not free of difficulties. Some of the constraints are:

The initial installation investment is very high for the subsistent Nepalese farmer, through subsidies are provided by the government.

The uneducated farmers take long to be convinced to use their manure fertilizer in the plant and moreover, to convince that gas would really substitute fuel wood and\or kerosene which would curtail their monthly expenditures.

The gases of methane producing bacteria are greatly affected by temperature, when the slurry temperature is low, production is low and it almost stops producing around 10 degree c.

Another problem faced by the rural population is the inadequate livestock holding to sustain a plant on its own.

People face the problem of repairing the plant without a technicians' assistance.

Another problem is the inadequate slurry output collapsed with the impatience of the farmers, which tend to discourage the farmers and make them think about their traditional manure.

Hence, the problems faced in the energy field and moreover in the installation of biogas plant is eminent and steps must be taken with all efforts to solve those problems.

1.3 Objectives of the study

The general objective of the study is to assess the social and economic impact of the biogas plant to its users. However the specific objectives are:

1. To find out the socioeconomic characteristics of biogas users.
2. To study the usefulness of biogas plant with respect to health sanitation and education.
3. To find out the problems related with biogas plant.
4. To collect users' suggestion for possible improvement in the biogas program.

1.4 Significance and justification of the study

Biogas technology has no doubt a good contribution in the energy sector of Nepal. A technology which tries to save the alarming deforestation and many other bad consequences and moreover, a technology which helps in curtailing the imports of oil products, so as to bring the balance of product of the country. A delay in the implementation of such a plant may lead to deforestation of the total existing forest resources thus resulting to natural calamities such as floods; soil erosion and landslides, which would further diminish the percent of cultivated land from the total available cultivated land. The installation of such a plant would further help in increasing the agriculture productivity. The waste- product of plant, which can be used as an excellent fertilizer. This further would help in curtailing the import of expensive fertilizers as it substitutes the use of chemical fertilizers. Further the increase in agricultural products would develop the living standard of farmers.

Therefore the curtail of kerosene use, fuel wood use and chemical fertilizer use are the very eminent contribution of biogas plants. Further more, the gas product is a clean source of energy as it is smokeless and less time consuming than the traditional fuels. Thus, it further controls pollution, especially, with the shortage of kerosene oil and its hiking prices, and the high rate of deforestation, the demand for such technologies have eventually increased.

During the course of the study it was found that people who installed plants had problems with the loan system and most of the people who did not install one but knew about the technology indicated the fear of loan complications as one of the main reasons for not installing such plants. Hence a detail investigation on the bank loan systems and interest rate systems along with the peoples' willing rate of interest is made, in order to analyses the appropriate rate. Further the detail investigation on the use of output slurry is done in order to understand the actual advantages from slurry, since this aspect has been in the highest propaganda. The study on this aspect would help, advocate the advantages of slurry fertilizer so as to substitute the use of chemical fertilizers to the farmers who constitute the highest percent of the total Nepalese population.

Under all this circumstances, this detailed impact analysis of biogas plant seems very viable and justifiable. This study has help to the concerned field at the appropriate time.

1.5 Limitation of the study

There is the limitation of the study:

a. The study will only be confined on the plant installation in Birendranagar-3, Surkhet district. Thus it cannot represent the country as a whole.
b. This study only deals the problems, prospects and importance of biogas in Surkhet district
c. This study will only take the economic, sanitation and health as well as educational aspect of biogas plant.
d. The analysis of the slurry production or use has completely been based on the approximation made by the respondents as per their memory, since exact record was not kept and exact measurement was not possible.
e. Inclusion of all sized plant in the study is avoided to simplify the presentation. Further, only dome type plants

are analyzed, keeping in view, its popularity. Furthermore, community biogas plants are also excluded.

f. The analysis of data is mainly based on averages and percentages. As more complex and sophisticated tools have not been adopted.

g. All the data mentioned in the study based on secondary as well as primary.

CHAPTER II

Literature Review

2.1 Introduction

Energy has been associated with the human society from the time the society came into existence. Energy has played an eminent role in developing the human world ever since. The first few sources of energy realized was the energy from the woods and from the fuels under mines. As the use of these energy forms caught their popularity, the demand for such sources increased. Moreover, along with the increase in population the consumption of energy and hence the demand for these sources increased. This demand resulted to the high degree of deforestation and the massive excavation of mines. As the demand for these energy sources increased, the shortage in their supply was realized. As time passed, there was a noticeable gap between the demand and supply of these energy sources, thus resulting to the energy crisis

Along with this crisis other calamities such as soil erosion, landslides, draught were the bad consequences then the world was threatened. These threats would overcome only by curtailing the consumption of these forests and mining resources or by decreasing the population pressure. The second alternative seemed near to impossible, so the world went for the first alternative and opted for the curtailment of fuel wood and oil consumption. Thus, the search for the alternative sources of energy came into existence.

As a result of this search many alternate sources were explored. Solar energy, wind energy, hydro electricity, biomass and energy generated from human and animal wastes. Biogases are few of the alternate sources of energy that came into existence as the result of the search for alternate energy sources.

Amongst theses, solar energy generation involved sophisticated and expensive technology whereas the wind energy generation proved to be very conditional. Biogas technology proved to be the most simple, convenient and reliable alternate source of energy.

Many attempts were made in the innovation and development of this technology. Many research works and investigation were carried out to reach the present stage of development of this technology. These research works, seminars etc. concerning the technology were held in national and international level.

Literature on historical, technological and other general aspects were found in various published and unpublished volumes.

David Fulford, in the very recently published handbook. Running a Biogas programmed, "analyses almost every aspect of biogas plants under various conditions. Different types, sizes and conditions of operation are analyzed along with the economy and politics of these plants. There are many advantages of biogas technology for people living in the rural areas of a developing country. A biogas plant can digest materials that are readily available on small farms such as animal dung and crop wastes. Biogas digestion not only produces a clean, high grade fuel gas but it also gives a residue that is a good fertilizer. Biogas can also be used in engines to drive machinery and water pumps."

Some research studies have been conducted at the various places of the country to monitor the impacts of biogas on the respective users. The summary of outcome of these studies has been illustrated here after.

According to the outcome of a study carried out by Gobar Gas Company (GGC) in Surkhet district in 1999. Biogas has very positive impacts on the workload of women. They are liberated from difficult tasks of cooking in smoke filled kitchen, collecting of firewood from dangerous jungles and cleaning cooking vessels with black shoots. They now feel comfort in cooking and enjoy it. GGC the pioneer company in the field of the biogas technology has also carried out various studies from time to time.

Marileke Van Oliet had carried out a study in Madanpokhara village Development committee in Palpa district during 1993, to monitor the impacts of biogas on the workload of women of 21 households who have installed the biogas plants. According to her, all the plant owners had taken loans from the banks to install biogas plant. According to the users, installation of biogas plants has provided various positive impacts such as time saving, relief from collecting firewood from jungles, easy to cool food etc. A total of one to two hours of time was saved per day for each family which was used in some other income generating activities.

Another study carried out by biogas support program during 1996 in Khumaltar that the production of vegetable and other crops increased by 30% when slurry coming out of biogas plant was used in the field which was used for farming. Similarly, a report issued from Biogas support program in 1997, illustrated that most of the biogas company have not constructed defect free plant. The quality standards are not followed properly. It is stated that Manashanti Gobar Gas Company , Chitwan Gobar Gas Company and Pashchimanchal Gobar Gas Company have prohibited from getting subsidy to install biogas plant.

Another study carried out by Dr. Poorna Kanta Adhikari entitled impact of biogas plant of family health, sanitation and nutrition – February 1996, has suggested that most of the owners do not feed cow dung to the biogas plant everyday because of various reasons. They used to collect and deposit the cow dung in the plant inlet for two or three days. This practice might be favorable for diseases causing organisms. It is suspected that deposition of dung in inlet for longer period (two to three days could be one of the reasons for increased.)

The evaluation of on-going projects, final report, 1998 by David Fulford, Joy Roque and Mr. T.R. Poudyal, centralizes its attention on the on going of biogas plant in Nepal. The project implementation results are visualized, wherein the delivery of inputs, financial managerial aspects, production of outputs and benefit cost analysis for biogas plants are included. An assessment of the achieved project results is done as well; under which, efficiency, project impact, project preparation and design along with some critical issues are presented. The report analyses the impacts of installing a plant as follows:

Has a definite effect on fuel wood consumption in Nepal. It is estimated that 1854 medium sized trees will be saved a year, about 1200 cubic meters of wood from plants already built under UNCOE.

The actual impact on kerosene and fertilizer import savings is estimated to be Rs. 940210 per year from built plants. This is considered less and savings would be higher if the owners would use slurry more effectively.

The process of selling biogas plants is making people conscious of the problems of deforestation.

The women of the families owning these plants save half the time they used for cooking on wood fuel.

Cooking in an atmosphere without smoke helps the health of women.

This report further included summarizes of other works done in this field by various students and researches.

It includes the following :

Bulmer A. & Schkorholtz A. – "Gobar Gas Survey", Development and Consulting Services, Butwal Nepal 1999

A total of 50 plants were taken under observations from three districts, Rupandehi, Kapilvastu and Nawalparasi. The thorough survey was conducted and certain conclusions drawn. This survey concludes by stating that gobar gas is very suitable for cooking but where available, electricity was found to be preferred for lighting. Biogas naturally saved forests as fuel wood came less in use. If the cost of plant reduced, then the economy would improve along with the rise in the price of fuel wood. The benefit of the plant was found to have lied to the female section since their time was saved.

Temperature constraint was realized along with the lack of knowledge on the use of slurry in the part of the plants owners' .the dream; plants faced major problems - which the drums would rust.

But all in all these plants were found socio-economically viable

But all in all these plants were found socio- economically viable in the Nepalese context.

L.K. SHRESTHA, "Impact study of Biogas installation in Nepal", ADB/N, KATHMANDU, June 1986.

This study had a survey of 60 plants in total 15 plants owners each from Kavre and Kaski hills and Rupendhehi and Jhapa districts. After the survey it was found that the matching of plant sizes as according to the gas needs and dung available was sufficient. Plants were running in a condition of under capacity as animal went out for gazing and dung availability lessened .The temperature constraint was still realized along with high construction cost and water constraints as well. Lack of knowledge on the part of the owners has become the most important constraint for the operation of a plant.

Conclusively this study states that biogas has national benefit, reduced deforestation , reduced kerosene imports etc. Hence Government subsidy is very essential. .

S.K. Sigdel And AK DAS , "Biogas development in Kaski district", Project report , T.U., Institute of Forestry, Pokhara Campus 1990.

This report surveys plants in a rural context. A total of 13 plants from Lecknath village near Pokhara was taken into consideration. It was found that there was a growing awareness in this technology as a forest saver. People felt that it would be more applicable in a semi-urban area where people were richer, since the village people suffered from problems of finding capital to repay loans and installation cost was found to be high. Realization of temperature constraint and the strong need for government subsidy could be observed.

K Ojha – "Survey of Biogas Plants in Biratnagar, ADB/N Biratnagar Branch Office.

This survey covered nine wards of Biratnagar town development committee. A total of 98 plants was taken into consideration; all constructed in the Fiscal Year 2041/42 to Fiscal Year 2045/46. It was found that plants of sizes 6 cu.m. were more popular in this area, in spite of its non-cash earning character. On the basis of fuel substitution, the total firewood saved for 6 cu.m. and 10 cu.m. were found to be around Rs.291 and Rs.321 per month, respectively. Around 81% of the plants had attached toilets. The basic problems faced by the owners in this area were the inadequate supply of dung to run the plants, lack of knowledge about the optimum use of slurry and faulty construction. i.e. in around three percent of the plants the slurry outlet was beneath the ground level so the plant was flooded by rains.

The observed benefits were the time and energy saved, cleanliness and healthiness due to the smokeless technology involved in biogas techniques.

B.D. Neupane & W. van Ness – "Gobar Gas Company Plant Survey" (2007).

A random survey of 150 dome type plants across Nepal was considered, it has taken over a year, including

130 man-days of fieldwork and is not completed as yet.

The initial conclusions derived recognizes the temperature constraint, the problems of non-availability of adequate to feed the plants, poor use of slurry as fertilizer and the major technical problem of leaking gas valves and taps, and the high maintenance cost. This plant was found to have been popular and satisfying to the female section of the family who actually gain the direct benefits from its operation.

In the course of the study of the impact of biogas plants the context concerning the uses and impact of these plants become important.

In "Gobar Gas Plant", a booklet published by Dr. A.B. Karki and Mr. S.B. Pradhan, (2005)

They analyze various aspects on these plants. As analyzed, it states that gober gas can produce effective manure, which contains about 2% nitrogen whereas only 0.5% of nitrogen is contained in fresh cow dung. They have further proved from their analysis in the research work done in India, that by using the manure produced by gobar gas plant, agricultural production will increase between 15 to 35 percent. Similarly, they have proved that the gas produced is very useful for cooking purposes. It is also estimated that cooking requirement of gobar gas for two meals per day approximates 12 to 15 cu.ft. per person.

In the course of explaining the advantages of installing biogas plants; Mr. P.P. Adhikari in his paper, "Planning Energy need for future", presented at a symposium on Water and Energy Resources Development; expresses that – in the context of whole nation, making every family self-sufficient in fuel, there could not be any quicker media than gobar gas plants. Planning to get some achievement through mini-hydel local development or though extension of high voltage transmission lines would take about a hundred years or more with the same amount of expenditure. The construction period of gobar gas plant is only a few months. The initial investment and the foreign exchange component of mini-hydel scheme is much higher than that of a gas plant. Hence, as a subsidiary scheme to mini-hydel, bringing up gas plants reduces financial burden on annual budget.

The first principal benefit is fuel value of gas. If used for cooking it may displace kerosene, fuel wood of dried dung. For lighting it substitutes kerosene. And at times it displaces diesel fuel or grid electricity, if used for small engines and generators. The slurry or dried sludge represents the second principal benefit in terms of its value as fertilizer.

In the financial analysis of costs and benefits, the evaluation of the digester over the lifetime of 15-20 years is done. The value of gas in terms of fuel substitution is rarely done whereas the measurement of slurry as fertilizer substitute poses complications.

There are other economic benefits besides these benefits, which includes destructions of pathogen in the raw dung, health benefits to households from using a smokeless fuel, reduction of pressure on the forests from fuelwood collection, employment generation, reduction of uncertainty in fuelo supply and a reliance on indigenous rather than imported energy sources.

The guidelines further discuss the various factors influencing the installing of a plant. As categorized under four headings;

Economic factors include interest on loan for biogas plant; current/future cost of alternative fuel and chemical fertilizer and of materials needed for plant construction; saving of saving currency, current/future labor cost and inflation rate.

Social factors include the effect on the health of the farmers and their health of the farmers and their health bills; advantage of having cleaner villages specially when toilets are attached; employment created in biogas construction and related industries; better lighting and time saving components.

Technical factors include construction, maintenance as repairs of the plants; availability of materials required and suitability of local materials. Environmental factors include the utilization of a cleaner source of energy and conservation of forests, thus preventing soil erosion, flash floods etc.

A three-stage discussion on the advantages and disadvantages of installing a plant is done.

Domestic Level

Advantages

1. Clean and fast cooking fuel.
2. Better lighting
3. Improved health by eliminating smoky fuels
4. Improved sanitation
5. Better fertilizer
6. Less time consuming.

Disadvantages

1. High initial capital outlay
2. Requires enough livestock to give sufficient dung for the plant installed.
3. Requires lump sum amount of water is not always available.
4. Reduced gas production during cold months.

2. Community Level

Advantages

1. Reducing pollution from animal and human waste, resulting in improved community health,
2. Creating employment in biogas plant construction and related industries
3. Possible power sources to village industry
4. Improvement to stay in the community and prohibit the city, town migration.

Disadvantages

1. Helps the richer farmer than the poor, who do not own cattle's, thus possibly the gap between the rich and the poor.

3.National Level

Advantages

1. Saving foreign currency normally on kerosene and fertilizers.
2. Reducing the need for expensive distribution of energy in rural areas and saving non-renewable energy resources,
3. Conserving forests hence preventing the consequent natural calamities,
4. Minimizing environmental pollution.

Disadvantages

1. Foreign currency required for any biogas plant if construction materials are no available in the country itself.

2. Proceedings of the workshop on Biogas and other Rural Energy Resources held at Suva, and the Seminar on Rural Energy Development, held at Bangkok, Manila, Tehran and Djakarta under the Energy Resources Development Series: No. 19,

UN Publication, New York 1979

Deals on the biogas and the Integrated Farming Systems and centralizes its attention on the biogas plants-possible affects on rural life. This portion analyzes the direct benefits and indirect social benefits as well. As analyzed these plants supply an efficient, clean fuel for cooking and frees the rural women from smoke and diseases caused by traditional fuels like firewood, dung cakes etc. further, it provides extra time for these women, giving them opportunity to earn other incomes, further, the manure from these plants is superior to ordinary form manures. There is almost double as much humans in biogas plant manure as the contained in farm yards manure. Further this manure does not contain germinative weed seeds, thus, the cost of weeding is minimized. And, the yield of field fertilized with biogas plant manure increases from 25% to 33% depending in the crop.

The indirect social benefits include advantage of residue from the plant not attracting mosquitoes and flies. Further, these plants provide a means of hygienic disposal of night-soil.

Monthly Biogas Bulletin – Vol. 7, Baisakh – Ashad 2046 has an article "Methods to increase gas production during winter", by Mr. Ganga Ram Dahal, mainly discussing the various methods of overcoming the temperature constraint. As discussed the main ways are:

by creating a bulk of compost over the plant. For this 15 meters or more compost is needed and this secures about 30% of the gas productivity increment.

By using the heat exchange; this is more applicable in plants used for multi purposes by rich farmers, since this method is comparatively expensive. This contributes to about 5-7 degree centigrade increase in the slurry temperature.

The most convenient way is to let the slurry heat up in the day's sun inside the inlet, for the whole day, before placing it in the digester. This increases about 9 to 10 percent of gas production.

Placing rice straw and other agricultural wastes over the plant, which increases the gas production by 10 to 12 percent.

Gas production by night soil, piggery wastes is greater the gas production by cow dung.

Mixing urea in the mixture of cow dung and water i.e. the inlet slurry increases gas production.

Construction of plastic green house also over the plant also increases the gas production.

A combination of selected microorganism that use a mixture of cow dung and agricultural by products such as straw has been proved efficient. This combination produces 25% more gas as compared to that produced from cow dung alone. Moreover, the gas is richer; it contains 72% methane compared to 56% methane produced from cow dung alone.

"An Analytical Study of Biogas in Nepal", a dissertation submitted to the Department of Economics. T.U. 1980 by Gulson Pradhan.

The piece of literature contribution to the sector of biogas in the Nepalese context. Holding the objectives of accessing the energy requirement of the country, exploring the relation between biogas plants and change in agricultural productivity, finding out the role and applicability of these plants in Nepal and suggesting certain policy measures, this work is carried out. Further, this context provides certain historical development of the plants.

It has introductory of Biogas plants as well.

The main work is carried along the use of slurry and change in agricultural productivity. This study has further proved the positive relation between the two variables i.e. use of slurry increases agricultural productivity.

Nepal faces the problems of both the energy supply and the increment of agricultural productivity and installing a cheap version of biogas plant can be a solution to both the problems.

The main objective of this work was to explore the present performances of the installed plants of Birendranagar Municipality, Ward No. 3, Surkhet and suggest approaches for expansion of the plants all over the country.

The study concludes on a realizing note of the general benefits received from installation of biogas plants. The main benefits analyzed are the conservation of forest resources hence saving the place from the natural calamities that would prevail, otherwise. Further, it realizes the increase in agricultural productivity via the use of biogas slurry as fertilizer. But the important conclusion it derives is the self-sufficiency gained in the energy sector by developing nations like Nepal.

The most important portion of this study is the various impacts of the plant, amongst which the economy of the plant is the most important one. In the operation cost, items such as depreciation, interest, repair and maintenance and labour are considered; while in the benefit, since there is no direct cash return from the operation, savings item such as saving in firewood, kerosene and saving in nutrient loss are considered. Increase in the level of production due to use of slurry has not been considered as it is not possible to isolate incremental effect in level of production due to use of slurry.

2.2 Historical Development of Biogas

2.2.1 Introduction to Biogas technology

Definition

The answer to the query "what is biogas?" can be expressed in many ways. Whatever may be the answers, it summaries the same ideas. Biogas is a gaseous product (mainly methane) obtained in the anaerobic (oxygen free) digestion of organic wastes such as livestock dung human wastes and farm residue. The decomposition of these wastes due to the effect of methanogyenic bacteria evolve methane gas which can be used as fuel. The gas is colorless, clean, odorless and smokeless and burns with clear blue flame, which is invisible under the bright sunlight.

Biogas is produced by certain types if bacteria, microscopic organisms, that break down the complex molecules contained in the feed stock into simpler molecules in a way that releases energy and the chemicals they need for growth. The bacteria that are used in a biogas digester are the same or similar to those that lives in the gut of ruminant animals, such as cattle. Cow dung is a good source of suitable bacteria. These bacteria are adapted to the conditions found inside a cow, so a biogas digester must have similar environment i.e. the exclusion of air and light and a temperature close to blood heat (between 20 degree centigrade).

The only technology involved in biogas production is the anaerobic formation of the organic wastes. Methane gas is produced along with the decomposed residue known as slurry, which can be further used as organic manure on the farm. The slurry is very fine semi – liquid and without any order, hence attracting no insects and could be handled bare footed as well.

2.2.2 Composition

Biogas is a mixture of gases. The principal ones affecting the gas plant are:

Methane (CH_4)	50-60%
Carbon dioxide (CO_2)	40-50%
Hydrogen (H_2)	1-2%
Nitrogen (N_2)	-
Water vapor (H_2O)	0.3%
Hydrogen Sulfide (H_2S)	traces
Carbon monoxide (CO)	very negligible
Oxygen (O_2)	very negligible.

Methane is the wanted gas :- $CH_4 + CO_2 + H_2S$ = Biogas

Methane + Carbon dioxide + Hydrogen Sulphide = Biogas, where methane is the produced gas along with carbon dioxide which settles down and hydrogen sulphide produced in a very slight amount.

The percentage of methane in the total gas production is affected by the biological process and the type of dung or vegetable matter used in the gas plant. The means of measuring the methane content has not reached many places, but the burning intensity higher is the methane content. In case the plant is overfed with fresh slurry the percent of carbon dioxide increases which decreases the burning intensity and moreover the gas may not burn.

Hydrogen sulphide, the rotten egg gas with the very unpleasant smell, has both advantages and disadvantages. It's pungent smell warns people if there is a leak. It is very difficult and therefore is weak.

Biogas is a wet gas since it picks up water vapor from the slurry. This vapor condenses in the pipes and has to be removed.

2.2.3 What is Biogas Plant?

Biogas is a device for conversion of fermentable organic matter, such as cattle dung, into combustible gas and fully matured organic manure. This is achieved by subjecting the material to anaerobic fermentation. What goes on inside the plant may be explained as follows. A mixture of animal dung and water, called slurry is filled in the digester. Fresh slurry is prepared daily in a mixing pit and fed into the digester. Owing to the principles of hydrostatics, some of the spent slurry comes out through the outlet pipe. This spent slurry is known as effluent. Inside the digester there are many million bacteria, which feed on the dung, produce gas and leave a residue of organic matter and water.

The produced gas bubbles float upwards and are caught inside the gasholder and lift the holder up. When the gas of the plant is used the holder comes down again. The effluent is stored in a composite pit until it is needed as a fertilizer.

2.2.4 Types of Biogas Plants

There are many types of biogas plants designed along the development path of this technology. Whatever be the type or design, there are mainly two categories, classified as:

The drum type

The dome type

The drum type:

Biogas plant of a drum type consists of an airtight digester at the bottom and a gasholder (drum) above it. The digester is constructed by digging a big circular pit in the ground.

Inlet and outlet pipes are inserted in it. The drum made of galvanized iron sheet is placed on the top of the digester for collecting the gas. Organic wastes are collected from the yard, mixed with equal amount of water and fed daily as per requirement through inlet, after thorough mixing in the mixing pit. It takes about five weeks to start producing gas after complete fermentation. As the gas is produced, the drum rises and floats. The gas is tapped from the gasholder through a hole and then piped out to be used for cooking and lighting. It is used also as a fuel for combustion engines such as in the operation of mill; lifting water etc. the slurry comes out daily through outlet pipe because of pressure created due to production of gas and also due to dung feeding through inlet. The outlet is at a slightly lower level than the inlet.

The dome type :

Biogas plant of a dome type has a fixed structure. The digester pit is similar to that of a drum type. However a dome is constructed above the digester. It works itself, as a gasholder since it involves no drum to transport it is comparatively cheaper than the former type.

2.2.5 Process of Biogas Production

Biogas is produced by certain types of bacteria, microscopic organism. Several different bacteria living in a biogas digester do different jobs. Many types of bacteria can be classified. But considering their response to oxygen three categories exist. Aerobic bacteria require oxygen to survive. They start functioning as soon as oxygen is removed. Facultative bacteria are able to use oxygen if it is present, but can use alternative digestion process if it is absent.

When a feedstock is placed in an anaerobic digester the facultative bacteria begin to break down the complex molecules using up the oxygen in the feed. These bacteria continue breaking down foodstuffs using oxygen from water once the free oxygen is finished so this process is called hydrolysis.

The second stage, the liquefaction stage, is the formation of volatile fatty acids as well as CO_2 and some H_2. Acetic acid (CH_3 COOH), is the commonest acid formed. If there is some air present the digestion process stops at this point and digester gives off the distinctive smell of these acids usually associated with decaying food.

The third stage, methanogenic stage in the anaerobic digester, is continued by methanogenic bacteria which break down these fatty acids into simpler molecules, water, carbon dioxide and methane, removing the smell and producing biogas. Methanogenic bacteria can function only in the absence of oxygen. About 70% of the methane in biogas is estimated to come from acetic acid (CH_3 COOH CH_4 CO_2).

Construction of Biogas Plant

The construction of various types of biogas plants vary as according to the designs and materials used for the construction.

Digesters and associated masonry work can be made out of any usual building materials except unburnt bricks and mud mortar, which are not satisfactory, as both of these deteriorate over time. But the right choice of construction materials are the most easily available and with a reasonable cost.

The basically needed construction materials are as discussed. Bricks, which are unburnt, is one of the basic essentials. Clean stones, clean and pure sand, cement, gravel or broken stones, cement mortar, concrete (this is one of the Chinese traditional building materials, composed by volume 1:3:6 of lime, sand and crushed stones or bricks), lime clay (another traditional Chinese building material and usually a compose of one part lime to 9-19 part clay is used for construction), are the basically required materials for constructing a digester.

Besides these the required materials for the complete construction of a plant includes the materials required for gasholder and gas pipe.

Mild steel, galvanized iron and plastics are needed for constructing the gasholder. Gas pipe may be chosen between plastic pipe or galvanized iron pipes. The construction of digester with floating gasholder can be discussed as follows. The floors are constructed at the very initial stage. The common materials used are concrete and masonry. Concrete should only be used where it is cheaper or where the ground condition is bad thus making it essential. Otherwise, it is much cheaper to use masonry materials. If the bottom of the hole for the gas plant is muddy or soft sand, a layer of broken bricks or stones must be pounded in until the ground is firm. The floor should be reasonably level. Bricks for the floor including wall foundations are set on their edge, not on their faces. This method gives sufficient strength, except in the case of installations build above ground level, since the weight of the walls is not significantly greater than the weight of the soil removed.

Thus, this method spreads the load of the walls over a greater area to give added strength.

The sidewalls might be of a square or rectangular design, especially where concrete is used, since it is the cheapest way. However, for brick and stonewalls a circular design is appropriate as this requires less material and is stronger and quicker to construct. It is essential to backfill the walls and the sides of the holes after every 30cm have been added to the walls. Sand is best or else dugout materials may be used. The digester walls are not retainer walls and must have a firm support, failure in which is the major reason for gas plant walls breaking.

Normally, digester walls rise not more than 30-35 cm above ground level, therefore in certain cases it is necessary to build more than this above ground level. A big disadvantage is that the dung and water have to be lifted up to be put into a plant built above ground level.

In bigger plants of about 100 cubic ft. partition walls are built in order to control the flow of the slurry, thus it requires no structural strength. A half brick wall i.e. 5 to 7 cm, is adequate. It is built up to the level of the top surface of the deflector ledge.

In digester without a sealing deflector ledges are important. It deflects gas forming on the sides of the plant into the gasholder. This is made of protrude about 100 mm inside the gas holder circumference. Concrete rings or concrete sections may be used. This should be leveled on its top surface. It can then be used as a convenient datum for measuring.

When the slurry enters the plant daily, the level of the slurry in the digester rises. It lowers slowly as the effluent comes out of the plant.

A center guide is constructed and must be vertical, otherwise the gasholder may not move up and down freely. A gap of 2 inches is normal between the gasholder and the wails.

A mixing pit is essential to mix dung and water and is constructed to hold the correct amount of daily slurry, plus a margin of about 6 inches in height to prevent the slurry being spilt when it is being mixed. There must be no obstructions from any side. The floor should have a distinct slope away form the inlet pipe.. a hole and plug need to be fitted at the lowest point. This is to collect any gravel, sand or earth and prevent it from entering the gas. This also facilitates the washing out of the inlet tank. This must not be built on backfilled ground as this might sink in time and break the inlet pipe.

Regardless of the plant size inlet/outlet pipes of 4 inches diameter is the most appropriate. Smaller pipes than that tend to have frequent blockages whereas larger pipes add unnecessary expenses. Any low cost pipes can be used. eg. Asbestos, cement, concrete, burnt clay pipes etc. There should be no bends in these pipes. The lower end of the inlet pipe is placed about the center of the compartment. The mouth of the pipe is set about 14 inches above the floor. Pipe outlets usually have some bricks around the mouth to prevent accidental damage or breakage of the pipe.

The mixing machine is usually only justified for larger plants of 350 cu.ft./day and more. The mixing machines is normally designed so that it holds ½ of the daily dung input filled up to the level of the top of the slope beside the beater. Too much or too little slurry will make the machine difficult to operate well.

Slurry collecting tanks can be dugged in the ground or lined with masonry. The latter prevents weeds frin growing but is not an essential. For the sake of safety it is suggested the compost pits are not more than 80 cm deep. The volume should be sufficient to receive the amount of slurry put in per day multiplied by the number of days between emptying pits.

The construction of dome type plants vary in method, cost and materials used. This involves a very simple technique and hence easily and commonly installed. This usually has an underground, circular, small and shallow digester.

There are both advantages and disadvantages of this type of a digester. Saving of farmland, making use of the earth framework in construction, providing better thermal insulation thus avoiding the erecting of digester tank walls, which may occur in view of uneven temperature and moisture distribution, facilitating the connection of toilets to the digester pits, are some of the mentionable advantages. While, on the other hand, underground digester need more excavation work and present some difficulties in high water table areas. Plus, the work up becomes tedious discouraging the motivation to install a plant.

Therefore, certain pre-construction surveys must be done. The soil should be well examined first and the following measures and precautions must be considered:-

Since the clay-soil expands and contracts easily as moisture content of the soil increases or decreases, the construction work can be promoted with no disturbance to the primitive soil but taking precautions against excess or loss of water. The drainage of surface water must be taken care of.

If rocky soil and soft soil is mixed, then uniform find of soil under the digester should be provided.

If the water table is high then the digester should be built in a low water season with a trench dug around the digester to collect water, which should be pumped put regularly. The ground water should be diverted to certain well points or other places. The thickness of the backfilling over the digester tank should be increased.

In this type of plant, the bottom is usually constructed of concrete but the walls and dome are constructed of bricks.

First the lay out of the digester diameter is important before excavation, and then the center is determined. An over all excavation is made. The pit should be round and the walls straight and vertical.

In the bottom construction after the excavation the earth should be well rammed. A bed of pebbles of 15 to 20 cm in thickness should then be laid and tightly packed. The concrete is then poured, plastered and rammed.

For the wall construction a movable arm gauge is to be fixed to assist the construction. Wall construction begins when bottom has attained certain strength. The bricks are soaked in water before constructing the walls. The horizontal bricks should be laid flat and the vertical ones straight with a full application of mortar. The mortar lines should be properly cleaned on both sides of the wall. The wall should be sprinkled with water for preservation.

The water content in the earth used for backfilling should be in the range 20-25 percent. The backfilling should be tamped evenly and symmetrically each time a layer of about 15 cm is added. The construction and backfilling work of the inlet/outlet should be carried out at the same time as the construction of the digester tank.

A dome support is constructed to support the ring beam of the dome. This ring beam should be poured and tamped in sections using two pieces of wooden arch boards placed and held normally at both sides of the wall for pouring the low flow ability concrete. Stone blocks with mortar should be placed between the ring beam and the primitive soil to transmit the thrust uniformity.

For the construction of the dome, bricks of regular shapes should be chosen, soaked in water and kept wet on the inside, dry on the outside, thus capable of absorbing more water. Masonry mortar with good bonding capability should be used. A mixture of cement lime sand in a ratio 1:1:4 is the most appropriate. Bricks must be laid in interlacing courses with sufficient mortar. When each circle of bricks is laid flat, pebbles should be pressed into the gaps between the bricks. This gives the dome the form of a round shell and achieves a certain integral strength. Backfilling should follow after every after 3 or 4 courses of bricks are laid, in order to facilitate the work later, and to increase the stability of the shell structure. Bricks cut in halves should be used for the course next to the central opening of the dome (manhole).

All the interior of the digester tank, outlet, inlet and the movable cover should have a layer of sealing coat. Plastering of the bottom layer, a layer of cement, lime and sand in the proportion of 5:1:15 of 5mm thickness is done and pressed after 2-3 hours. In the same manner layer is also plastered. The surface layer plastering is done with a mixture of cement, lime and sand in a ratio of 1:2:15 with the same thickness as before.

The inlet pipes should be straight to feed without clogging. It may lead approximately to the middle of the digester i.e. the opening at the lower and is about half way down the digester wall so that a certain degree of stirring can be achieved. Normally, no mixing pit is used and the inlet pipe is about 250 mm in diameter.

This type of plant usually has human faces put into it. As pathogens and parasites in faces are known to stay in the lower third of the digester and die in time, the outlet pipe is about half way down the digester wall. It is usually 200 mm in diameter. The place connecting the pipe to the digester tank should be strengthened with concrete or cement plaster.

Displacement tank can be made of the same materials as the digester. Its volume is about half the volume of the gas produced per day. A lid is fitted for safety to prevent evaporation or ruin water getting in.

The digester bottom floor is usually curved to avoid sharp corners and minimize stress concentration. A central pole is usually erected at the very center of the digester tank to control its curvature with a string gauge as radius.

The pipes are thus connected to the gas stoves or lamps, which ever is applied.

Cost of Installation of Biogas Plants

The total cost or investment of a biogas plant depends on the types of the plant owners have not maintained any records of the biogas establishment cost. The particulars covering the establishment cost are the gasholder, construction materials, labor accessories, appliances, construction charge and transportation charge and guarantee charge. The plant stiller didn’t provide the exact cost of the plant construction but the guarantee provides the subsidy to the construction. The subsidy provided is according the following decision of area:

District Name	Sudsidy	
All districts of Tarai (20 Districts)	4 & 6 ghameter	8 &10 ghameter
Banke, Bara, Bardia, Chitwan, Danusa, Jhapa, Kailalli, Kanchanpur, Kapilbastu, Mohattari, Morong, Nawalparasi, Parsa, Rauthat, Rupandai, Saptari, Sarlai and Sunsari.	Rs. 6500	Rs. 6000
Hilly Region (Total 40 Districts)		
Acham,Dailekh,Magdi,Okhaldhunga,Remachap, Rukum,terathum,Argakhachi,Baglung,Baithadi,Bhaktapur,Daduldhura,Dhading,Dhunkuta,Dolkha,Dothi,Gorkha,Gulmi,Ilam,Kaski,Kathnandu,Kabrepalanchowk,Lalitpur,Lamjung,Makwanpur,Newakot,Patchthar,Parbat,Pyuthan,Rasuwa,Rolpa,Salyan,Sindhuli,Sindhuplachowk,Surkhet,Sayanja,Tanahu,Teplajunj and Udhayapur.	Rs. 9500	Rs.9000
c)Remote Himalaya region (Total 15 Districts)		
Bhojpur, Darchula, Jajarkot, Khotang, Sankhuwasava, Bajhang, Dolpa, Humla, Kalikot, Manag, Mugu, Mustang and, Solokhambu.	Rs. 12500	Rs.12000

Note:- The district allocated as less plant, total 18 district (District, Acham,Dailekh,khaldhunga,Rukum,Baglung,Baitadi,Daduldudha, Doti,Pacthar,Rolpa,Salyan,Teplajung,Dhunusa,Mohattria, Parsa, Rauthart, Saptari, Siraha) has been given extra Rs 500 as a subsidy.

Analysis

11. The target and achievement of the installation of biogas plant of Birendranager Municipality of surkhet district, which contain 12 wards and 50 VDCS is given below.

2051/052	105	28
2052/053	150	69
2053/054	150	85
2054/055	200	47
2055/056	100	62
2056/057	100	82
2057/058	120	137
2058/059	141	112
2059/060	150	95
2060/061	165	130
2061/062	125	98
2062/063	125	95
2063/064	125	98
2064/065	125	96

Source: Biogas office of Surkhet district

This above table show that the target of installation of biogas plant is increasing per year and achievement has also gained in satisfactory manner. From this result we conclude that the people are conscious above their health and want to decrease their workload to search/credit firewood day by day. So there is positive relation between biogas plants.

2.2.8 Application of Biogas Plants

These plants serve a multiple purpose. The gas produced has its own importance with the effluent (slurry) holds its own eminence.

The common uses of the produced gas are for cooking and lighting whereas the effluent serves as an "A" grade fertilizer.

The principle use of biogas is cooking. It is clean in the sense that it does not dirty cooking vessels, clothes or even kitchen. It consumes less time to cook and it is healthier since it is smokeless. Biogas can be used like any other gas- natural or LPG.

For an efficient use of this methane gas certain rules in constructing the gas stove must be followed:

1. Air must be thoroughly mixed with the gas before it reaches the flame ports, if not, there will be a slight smell from the burning gas.
2. The total area of the flame ports should be between 80 to 200 times the area of the gas jet.
3. The distance from the flame ports to the surface of the cooking pot should be 25-30 mm.
4. Supports for cooking pots must not prevent air form getting at the flame.
5. The distance between the flame ports should not be more than 20 mm.
6. The thickness of materials at the flame ports should be about 10 mm.
7. For corrosion resistance properties cast iron is better than mild steel.

There are many different designs of biogas stoves available. Several manufacturers in India are supplying stoves to the KVIC and to other biogas programs. The Chinese government has issued a set of standards for stoves made in China to ensure that better quality stoves are available. a biogas stove was designed by DCS which is now manufactured and sold by GGC for the Nepal biogas program. It works well and is about 55 percent efficient; similar to the best of the Indian designs.

Next important use of the gas is for the lighting purposes. There is a big demand for biogas lamps in unelectrified rural areas. While biogas lights are inefficient, expensive and need more regular servicing, they give as good as a light as kerosene pressure lamp and are easier to handle. A gas lamp gives the same illuminations a 40 to 60 W electric light bulb. Electricity, where available is cheaper, simpler and better.

These gas lamps may have a single mantle or a duo mantle. Few table lamps have also been invented in Pakistan, whereas in Nepal, mostly hanging, ceiling lamps can be noticed. The Indian designs are usually made mainly of metal, such as cast iron, brass aluminum and enameled steel and are fairly expensive.

The Chinese designs are often made of ceramic and are much cheaper but are les reliable and difficult to use. One mantel requires 0.11-0.15 m3 (4-5.5 cu.ft./hr.). in summary, one m3 of biogas produces mantle lamp equivalent to 60 w for about seven hours; run two horse power engine for one hour; run 300 liter refrigerator for 3 hours; generate 1.25 KW of electricity and can cook 3 meals for a family of 4.

Biogas is a high-grade fuel because it burns at a fairly high temperature. Hence, it can e used for purposes other than just cooking and lighting, such as fuel for running internal combustion engines for small-scale cottage industries.

Biogas offers a decentralized power supply. The energy need of the villages, where the animals are kept and crops grown and harvested; biogas can be used to supply energy for cottage industries as well, so catalyzing development away from the towns. Village people can begin to consider a slightly more advanced standard of living, as they become able to earn money in the place where they are already settled. This technology offers the rural areas of developing countries the possibility of increasing self-sufficiency by reducing the dependence upon supplies from the towns.

Biogas has industrial uses as well. One of the earliest uses of anaerobic digestion was on the reduction of the pollution load of municipal wastes such as the sewerage.

2.2.9 Benefits from the Plant

Besides cooking, lighting and other energy uses, biogas has other indirect benefits as well.

It saves a lot of time, previously engaged for cooking, cleaning pots and fuel management, thus providing extra time to use in income generating activities, hence covering up their existing opportunity costs. Since it is a smokeless technique it looks after the health and hygiene of the family, which in turn saves the preciously prevailing medical expenses and laundry expenses.

Other alternative sources such as the very scarce fuel wood and imported expensive kerosene consumption can be curtailed from the use of biogas. First, it saves the forest, further saving soil erosions and landslides; second, it checks the balance of payment to a certain extent via curtailment of kerosene consumption. Moreover, the tedious hours of collecting firewood and kerosene are saved.

The output product or the effluent (output slurry) is a very high grade fertilizer. But the extent of the use of slurry in increasing the yield is difficult to calculate in isolation since the level of production depends on the total effect of many factors such as the increases in crease ion cropping intensity, improved practices, better irrigation facilities and better managements. Nevertheless, a recent survey of ADB/N has provided an increment record from the use of slurry of 13% in paddy, 4% in wheat, 10% in maize in the plain area of Nepal. Whereas these main crops have increased by 41% in paddy, 7% in wheat and 13% in maize in the hilly area of Nepal. This brief description proves the benefits attained form effluent as well. Therefore, the use of slurry helps in getting more production, which means more income and a higher consumption level, thus increasing the standard of living of these rural farmers.

All in all, biogas is very beneficiary from every aspect that it holds for.

2.2.10 Operating of a Biogas Plant

After the completer construction the operation part becomes important. Filling the digester and fitting of the gasholder must be done.

The operations of different types of plants differ. For the operation of the drum type plant the following steps must be followed.

Initially, the pre-treatment of the digester must be done. But no pre-treatment is required where a cement mortar or a lime-mortar painted with cement has been used. Either a weak solution of HCl can be brushed ion or the digester may be filled with plain water for 2 to 3 weeks.

For these type of plants other inputs than dung is not used. Dung and water mixture, slurry, is prepared. A concentration of 7 to 9 percent dry matter in water is generally found to work best. The moisture content of dung depends on the type of animal, its health and the existing climatic conditions. It is usually ¾ to 11/2 liters of water per kg. of fresh dung to make the slurry. No earth or sand, straw of grass, sawdust, oil, soap or detergent should get into the digester along with the slurry.

The consistency of the slurry can be checked with the help of hydrometer. After making the slurry a number of times it is quite easy to see by eye, if the slurry consistency is correct or not. If too thin slurry is used, it tends to separate out into three layers inside the plant: heavy solids at the bottom, water in the middle and floating matters on top. It too thick, the gas finds it difficult to pass. Both ways gas production is noticeably reduced.

The filling of the digester must be done as quickly as possible. Dung can be collected for up to about 10 days prior to the start of the first filling. It must not be allowed to dry and become hard. The inlet pipe should be blocked with a piece of wood and the prepared slurry poured then unplugs the inlet pipe. Care must be taken that both the compartments on both sides of the center wall must be equally filled providing no uneven pressure.

When the plant is full of slurry there will be no leaks of water into digester. Slurry is put in until it starts to overflow through the outlet.

After the digester is full, gasholder is to be fixed.

The daily dung feeding of the correct amount of slurry into the gas plant should only commence after 15 days from the time when the gasholder is put on.

For fixed dome type plants, the important steps are as follows:

Initially, the digester tank must be checked for the right level of water. For this, the valve of the gas outlet pipe should be opened and the water digester tank filled with water to about half of the inlet and outlet compartment. Then left for three to five hours until the tank walls have become saturated with water, then the water level should be marked. Of there is a drop in the water level after a day, it proves the existence of a leakage. The location of these leaks must be attempted and plastered if found. When plaster is dry, the digester is ready.

Dome plants can digest vegetable matters as well therefore, at first these weeds, stalks and leaves must be crushed or chopped then fed or pile composing could be done before feeding.

For feeding, first we place the composted plant wastes then human or animal waste through both inlet and outlet compartments. But the dung must be mixed with water and then poured in through the inlet compartment. The gas pie should be disconnected or the safety valves, if any opened during filling so as to avoid a build up of pressure in the gasholder. The digester tank should not be filled more than 80 percent of its volume, thus allowing volume for the storage of gas.

During the first few days, gas stored will be impure and incombustible hence it should be allowed to escape a few times.

New materials may be added after two weeks of the initial filling of the digester tank.

2.3 Biogas Development in Nepal

Biogas technology is of a recent origin in Nepal. The first historical plant was built in St. Xavier's School, Godavari (Kathmandu) in 1995. The pioneer of this technology in Nepal was B.R. Saubolle S.J., a Belgian teacher at the school.

In 1968 KVIC built a plant for an exhibition in Kathmandu. However, even successful running of biogas in a private premises in 1972, it was not accepted by the people owing to lack of technical know-how available within the country.

Keeping the energy crisis in view, for the first time an Energy Research and Development Forum was set-up in 1975, at the Tribhuvan University. Along with other alternative sources of energy this group gave attention to energy available from organic wastes, by forming a biogas committee to initiate study and research aimed at exploiting this source of energy to its maximum

As directed by Gvernment of Nepal, Nepal celebrated the year 1975-76 as the "Agriculture Year", with special emphasis to the biogas programmed amongst, other programmed of agriculture. The main objective behind the launching of this programmed was to check both deforestation and the practice of burning cattle dung for cooking, which otherwise could be used as manure. In fact, the number of biogas plant establishment in Nepal was at an insignificant level around 1975/76. But the programmed during the agricultural year aimed to install 250 family – sized gas plants through out the country. Farmers willing to install were given interest free loans from Agriculture Development Bank, Nepal. Thus, as a result of the combined effort of ADB/N and the department of Agriculture, people responded well, and consequently 196 plants were built within that year.

Prior to this 1974, the Development and Consulting Services (DCS) (i.e. part of UMN) built four biogas plants to the KVIC design. The Butwal Engineering Works (BEW), then part of Butwal Technical Institute (BTI), was shown at an exhibition held at the corporation of King Birendra in 1974.

Compared to the 196 plant installation in the agricultural year, 1975/76, the following year proved disappointing. DCS managed to build only half as many plants, while the rest of the national programmed seemed to evaporate. Two groups still involved in biogas extension – DCS and ADB/N – decided to pool resources by setting up a commercial concern to sell biogas plants, hence Gobar Gas Company (GGC) was formed in 1978. the capital financiers to GGC were the UMN, ADB/N and the Fuel Corporation of Nepal, based on the DCS biogas extension organization. The company set up branch offices in about nine strategic places within the country. By the mid – 1987 the company had built over 2,300 biogas plants in Nepal, including those built under DCS, of which, with the timely follow up, 95 percent of these plants continue to work. Even after eight years of trading, however, the company has not gained any profit. But since the inception of the programmed, the ADB/N has advanced a loan of about 23.4 million rupees to construct about 2000 plants of various size and design in the country. Of the total, about 75% are in the Terai area. The programmed has so far covered 48 districts out of the total 75 districts of the country.

In the development course, the main devotion has been directed to the development and installation of biogas plants, in every plan of the Nepalese Economy. Though the idea of biogas plant propagated a long time before the planned development of the economy, it was the fifth plan, which included the biogas development prospects. The sixth plan (2037/042 B.S.) states that alternate energy sources be encouraged and targeted for an installation of more than 1600 plants within the plan period. Further, the seventh five-year plan (2042/47 B.S.) targeted for an installation of about 4000 in number, during the plan period, with an allocation of Rs. 5,00, 00,000.00 for the development of all alternative sources of energy. In the Budget Speech of 1992/93 it is stated that the credit facilities for the establishment of biogas plant will be expanded to meet the rural energy demand and to control the deforestation, therefore, the capital subsidy of the previous year will be maintained. For this purpose an amount of 32.1 million rupees have been allocated for the current fiscal year.

With the active involvement of ADB/N, the number of biogas plants installed was 1,400 against its annual target of 1,719 plants, during the fiscal year 1989/90 and in the prior year the achievement was a 108 plants more than the annual target of 1,000 plants. Whereas, in the fiscal year 1990/91 the target fell down to a 100 plants due to lack of subsidy.

Analyzing the performance of Gobar Gas Company, the leading agency for construction and dissemination of biogas plants in Nepal, has so far constructed about 9000 plants. For the years to come, GGC has taken the challenge of construction more than 25,000 plants with special emphasis on family size plants of 4 – 10 m3 in size.

The installation trend of these plants in Nepal since the year 2031 B.S. is as follows:

Fiscal Year	No. of Plants Installed.
2031-32	199
2032-33	143
2033-34	122
2034-35	114
2035-36	127

2036-37	87
2037-38	134
2038-39	232
2039-40	281
2040-41	177
2041-42	270
2042-43	277
2043-44	401
2044-45	676
2045-46	1108
2046-47	1400

We can observe an increasing trend of the biogas installation. Though the rate of increase was at a decreasing rate at the initial stage of the programmed. With an exception of the fiscal year 2040/41, we can observe the rate of increase is at an increasing rate in the latter years. This shows, the confidence people have started to gain in this technology.

Analyzing the trend of plant establishment in Nepal; at the initial periods only drum type plants were installed. Since the climatic and socio-economic conditions of Nepal and India are very similar, the KVIC drum design was installed and investigated at the initial stage of biogas development. Till the fiscal year 1978/79, we can observe no existence of dome type plants. From 1979/80 onwards dome type has been installed, we can observe its popularity overshadowing the drum type as drum type installation has dried up. Since the dome type plant was found convenient, needed less repair and maintenance and had an advantage of using locally available materials for construction and moreover reported less gas leakage with higher efficiency as compared to drum type, it soon caught it popularity. As can be noticed in the table, the drum type really seems to have lost its grounds. From the year 1986/87 onwards we can see that no drum type plants have been installed. This indicates the high popularity of the Chinese fixed dome type under the Nepalese context.

2.3.1 Funding of plants in Nepal

Besides from the internal resources, biogas program also received support from foreign donor agencies. From the inception of the programmed to the full-fledged development stage, these foreign donors have been assisting Nepal.

i. United Mission to Nepal (UMN) : This is the pioneer donor agency for the inspection of biogas programmed in Nepal. This agency contributed through the Development and Consulting Services (DCS) in the field of introducing the technology and conducted a series of experiments and research for biogas designs and various feedstock's, Utilization in the plant operation. Further it contributed in the maintenance and operation of more than 200 drum design plants for free replacement of drums of 100 and 200 cu.ft. plant built before the establishment of Gobar Gas Company. Later GGC took over the responsibilities, but yet GGC received extension and promotion support of Rs. 30,00,000 in the F.Y. 2041/42 and 2041/43.

ii. Asian Development Bank : This agency supported the strengthening of the capabilities of the GGC and in the Research and Development fields, in training programmed, in holding workshops and providing subsidies for community plant installations.

iii. UNICEF : This agency significantly encouraged the community plants establishments, especially in the Small Farmers Development Project Area of ADB/N. about 50% capital subsidies were received community plant owners; which were mainly used for commercial operations.

iv. USAID : This donor, too, was more interested in the community biogas plants aiming at the utilization of human excreta in order to advocate hygiene and improve health in the slummy areas.

v. FAO : assisted in holding up workshops and funded training programmed concerning biogas technology.

vi. UNCDF : This project under the UN funding was initiated in 1986, but it was implemented only in 1988. Their support was extended to the following fields:

Capital 'subsidies for installation of biogas plants of 6 cu.m. and 10 cu.m., and additional support and subsidies given to GGC for promoting biogas in remote districts of Nepal

Financial aid provision for the establishment of one workshop in the Eastern Region and storage facilities for the company.

Various logistics support to the company.

vii. SNV-NEPAL : Initially SNV-N showed their interest by providing the services of two DA's (volunteers) in the workshop and Research Unit of Gobar Gas Company. Later a joint venture between SNV and GGC was under taken for the support of 20,000 biogas plants installation in the next five years which was designed accordingly to receive capital subsidies as a grant for each plant established by the company. This project will be implemented by the year 1991/92.

CHAPTER III

Research Methodology

Research design

For this study, a descriptive research design is followed. The descriptive as well as analytical research is utilized for the quantitative and qualitative data obtained derived during the study. The data that are not quantifiable explained literally. Generating the tables of averages and percentages makes analysis of data.

Selection of the study site.

Birendranagar municipality-3, Surkhet is chosen for the study. It lies in the mid west part of the Nepal. It is 600 km far from Kathmandu valley. Surkhet district is situated in Bheri Zone of mid western development region. This municipality has some scattered and some clustered settlement. Almost 60 households are situated in ward no.3. Out of these households some are belongs to Brahmin, some are Chhetri, some are Newar, some are Gurung, some are Dalit. Amongst these households distribution, Brahmin and Chhetri households has installed plant. But rarely other caste of peoples has installed the plant. So Brahmin and Chhetri who installed the Biogas plant are selected in certain quantities. i.e. 5 households are selected from amongst these.

3.2.1 Birendranagar: At Glance

Geographical

Longitudional - 28 ˚22'to 28˚ 58' and
Lattitude - 80˚ 59' to 82 ˚2'
600Km west from Ktm.
665 m high from sea level

Area

Birendra nagar Palika : 36 Square km
Forest : 23 Square km
Residential : 13 Square km

Surkhet Valley : 88 Square km

Climate:

Maximum 33˚c & minimum 10˚c Temperature
Average Rainfall 150˚mm (per year)

Occupation:

» Agriculture : 58.8% »Labour : 18.6%
»Service : 11.2% »Business : 11.2%
»Others : 0.2%
»Literacy Rate: 76.8% (Birendranagar Municipality Office 2058)

3.3 The sample size and sampling techniques

Out of the total biogas owner 20 households are sampled for the study. Simple random sampling techniques are followed for the selection of the sample.

3.4 Technique of Data Collection

(i) Primary data

The techniques used in order to collect the primary data are as follows:

(a) Interview Schedule:

Keeping in view of the objectives, interview was conducted through detailed structured questionnaire. Various kind of questions such as socio-economic characteristic of the biogas users, impacts of biogas on the users after its installation etc. were made and collected the answer from the questionnaire. The questionnaire was finalized after consulting concerned experts. The approved questionnaire served as basic tools of primary data collection.

(b) Unstructured interviews

To collect further information and data, open-ended questions -were made for the concerned people including

- Interviews with governmental and non governmental authorities.
- Group discussions also conducted in the study site.
- Interview with the Staffs of Biogas companies and the
- Owners of Biogas plants.

But this method of collecting primary data is not used in my project work.

(C) Observation

Some of the biogas plants were observed directly to have better idea about the biogas plant. Observation included the following

-Biogas plant under construction
-Working of biogas plants
-Working of cooking gas stoves and lights
-Site of slurry output and its utilization in garden and field.

The direction observation provided information about how the biogas plant was constructed, how it was operated in the kitchen, how the slurry was composted and used in the field. In this way above sources serves as the chief source of primary data.

(ii) Secondary data

Secondary data were taken from the concerned institutions, books, reports, thesis etc.

3.5 Method of Data Analysis

The primary data supplied by each questionnaire was coded and categorized as according to the required variables. The coded data were converted into averages and percentages in tables.

Certain conversion tables are used wherever needed. No complex statistical tools were used as these averages and percentages were considered to be adequate for an impact analysis of the plant installation.

CHAPTER IV

An analysis of the socio-economic Impact of Biogas plants

The search for alternative sources of energy has been a priority in every plan of development through the help of national expertise or internal aids. The establishment of biogas plants increased day by day

Along with this high degree of installation, the working of such plants must be analyzed in order to develop further and expand the technology within the country. To make an analysis of the impact that the plant installation has provided to the installers, it is very necessary to find certain general information about the plant owners. This has been done in the following chapter. All the information has been expressed here as were answered by the respondents themselves.

4.1 General information about the plant owners:

Demography

The average size of family of plant owners of study area (Birendranagar municipality 3), the maximum family size is 8 and the minimum is 2. This result was obtained through the field survey.

Occupation

The plant installers, usually the head of the households is seen to have taken the decision to install a plant as according to his need and capability and both these variables, directly or indirectly is influenced by the occupation the installer holds.

Table: 1
Household and Occupation

Occupation	% of the head of household holding the main occupation
Agriculture	53%
Business	5%
Services	25%
Teachers Labors	8%
Labors	0%
Others	10%

Source: Field Survey 2007

The majority of the plant owners 53% have agriculture as their main occupation. Similarly, 5 percent of the people are involved in business activities. Twenty five percent services holders and 8% teachers have installed the plant. No labors people have installed the plant due to the deficiency of capital, so the people have more income generation occupation then they are interested to install plant. So plant installation rate is depended on their occupation in Surkhet district.

Literacy

The respondent biogas plant holders of people of Birendranagar municipality are hundred percent literate. They know how to read and write.

Landholding

As we know that the majority of the plant owners are involved in agriculture as the main occupation. In the study area the average land holding is 10 Kattha of the plant owners. Maximum size of land holding of the plant owners is 15 Begha and minimum is 1 Kattha.

From the above result we come to know that most large and medium sized farmers have attempted to adopt this technology. Most of the landowners are medium or large farmers. There are a few small farmers who are investigating the biogas technology in order to curtail the other expenses in agriculture.

Livestock Situation

In order to analyze the operation of biogas plants, it is important to analyze the most eminent input dung and for this a look into the livestock situation of the plant owners becomes essential.

Table: 2 Livestock Holding

No. of respondents	% of plant owners having			Average animal per house hold
	Cattle	Buffalo	Chicken	
20	70	10	20	4

● Cattle include only cows and oxen.
Source: Field Survey, 2008.

It is obvious that without certain livestock holding no one would dare to install a plant, since the animal dung is the most important raw material in the process of plant operation. As cent percent of plant owners in Surkhet district have own cattle. The popular livestock include cattle, buffaloes and poultry.

4.2 Cast of the plant owners

It was thought, initially that the plant installation was very much influenced by the caste of the people, as this was a breakthrough to the traditional ways of energy consumption and would be difficult to convince the general public. Going through the field, it was found that most of the plant owners belonged to the Brahmin/Chhetri community. A very small percent represented Newar community and even smaller percent represented the Gurung, Magar community.

Table: 3
The % of plant owners belonging to,

Brahmin/Chhetri	Newar	Gurung/Magar	Others
74	12	8	6

Source : Field Survey,2008.

As we can observe that among the total plant owners the highest percent of installers belong to Brahmin/Chhetri community (74%). This indicates that this technology has gained a lot of understanding and popularity in the Brahmin/Chhetri community.

4.3 Caste wise connection of toilet facility to the plants.

In spite of a high degree of ad vocation on the advantages of connecting toilets to biogas plants and on a higher degree of gas production from human fasces; it was found that many of the installers were reluctant to join toilets to the plants. Many of the respondents were of the opinion that it would feel very filthy to use the human waste in order to cook food. Further, some pointed to the sin that they would be committing in combining cow dung, considered to be sacred and human waste in one place. Further more some also expressed the difficulty in fusing the slurry in the fields when toilet was connected. In spite of the toilets being constructed under the bank loan, it was observed that only a very few were willing to accept the connecting toilets, through these respondents found it odd to respond to this particular query.

The government provided the same amount of subsidy for the construction of toilet facility, the people do not seem to have digested the idea of connecting toilets to the biogas plants. Most of the respondents blamed the female section, who works in the kitchen for not allowing the connection of the toilets to the plants. Moreover, the religious belief of treating the cow dung as sacred has made it difficult. It was further found that the picking up of the slurry to use as fertilizer posed problems when toilets were connected to the plants. One of the non farmer respondent reported that it was difficult to sell the slurry, be it in any form, composted or liquid, when the toilet was joined. Moreover as long as the gas from cow dung was sufficient, people were found to have ignored the idea of connective toilets. The thought that more gas is produced with joining up of the toilet has not crossed the minds of the mass and more over, the ones who have the knowledge have not been able to accept it completely.

4.4 Source of Information

The table below describes the source of communication to the plant owners on the information about the plants. As reported by the plant owners Agricultural Development Bank (ADB/N) has been the main source of communication with respect to establishment of these plants.

Table: 4

% of plant owners reporting the source of communication

ADB/N	GGC	Radio	Neighbor	Friend/Relatives	Others
8	20	30	25	10	7

Source : Field Survey, 2008.

From above table 8 % of the total owner reported ADB/N to be the first source to have informed them about the plants, 25% reported the neighbor was their source of information for plant installation. The performance of Radio in advocating the technology seems to be of a higher than others [30%]. Because radio is one of the easier medium of communication. During the course of the survey, only 10% were informed by friend/relatives.

4.5 Dung availability and Dung feeding

Animal dung is the main input required to keep the plant working. The availability of dung hence influences the gas production and hence the plant operation in a high degree.

The dung feeding differs according to the plant size. According to the various sizes the Gobar Gas Company, Nepal has established certain norms. According to these norms the optimum dung required for plant sizes 6m3, 10 m3 , 15m3, 20m3 is 36 kg, 60 kg., 90 kg and 120 kg respectively.

But it was found that the dung fed rate is less than Gobar Gas Company's norms. The dung was fed about 20% less than the average required amount. In spite of the decency in dung feeding as compared to the GGC norms, there were very few households complaining of insufficient gas. Some respondents felt that existing dung feeding rate did not hamper the gas production, instead temperature was a strong constraint. But some respondents felt that with the greater amount of dung feeding the production of gas is also greater. But in winter this process is decreased.

4.6 Plant and Family Size

During the research large family size of plant owners have install large plant size. The large family obviously consumes more energy. They have use the energy basically for cooking purpose. Similarly less energy is required for small family size. So their plant sizes were also small. About the size of plant GGC has make some norms but during the study, it is seen that these norms had been violated because of the lack of information. In some household extra energy was produced which was wastes and unproductive, but in some cases there was insufficient energy. There is observed Positive relationship between the plant size and family size.

4.7 Plant installation and cost

Total installation cost of biogas Plant is increase now a day. But the plant owners have not mentioned the records of the biogas establishment cost. But all households gave stressed that cost of installation becomes high due to increase in construction material and labour wages. In Surkhet, transportation cost is also high than terai. ADB prepared the tentative cost of installation for terai and hilly region in the context of Nepal. But cost is increasing gradually due to increase the price of the construction materials and labour charges. But it is cheaper than the other resources Obviously.

4.8 Plant installation and agriculture sector

During the study, it was clearly seen that agriculture sector has also improve from the biogas plant. The use of by-Product slurry is seen to have increased per unit of land yield of the cultivated crops. According to the respondents, By product slurry has play vital role to increase the productive capacity of the land as compared to the previously used dund manure. Basically, farmers are benefited from the plants.

4.9 Uses of the gas produced

The gas produced has many uses besides cooking. i.e. heating, lighting, running engines, operating refrigerators and using for incubators. However the main use if the gas produced, in an under developed context of the chosen study sites was for cooking purposes. Due to the facility of electricity no one of plant owners use the gas for the lighting purpose of the study site. The volume of gas produced daily from the plants of different sizes could not be determined because the plant owners did not have any idea of measurement. However, all the plant owners are using the methane gas only for cooking purposes and hence they could at least communicate the number of biogas stoves used and their burning hours per day.

Table: 5
% of plant owners using the biogas are as follows:

% of plant owners using biogas			
Stoves as cooking	Lamps for lighting	Both	Others
100%	0%	0%	0%

Source: Field Survey, 2008

As can be observed, 100% of the plant owners use biogas stoves for cooking. No respondents were using the gas for lighting purpose.

4.10 Saving of time due to installation of biogas plant

All the plant owners of Surkhet district is fed very much convenient after installation of biogas plant. They take effective benefit from it. The gas produced from the plants is used for cooking and hence burning hours of fuel wood is saved. It is quicker to cook in gas than in firewood. The collection time taken in collecting the needed, fuel wood and money used for kerosene for cooking is saved. Hence a lot of time is saved, in which people gain ample time to do other works or even rest. Similarly enrollment of girl children in school is increased. They lost their more time in collecting firewood even in cooking and washing pots. This biogas is blue burning gas so it does not make the pots black and dirty. So pot-washing time is also saved and it cooked foods faster than fire, so cooking time is also saved.

Most of the women and girl children of the study area were engaged in kitchen work. Before the installation of plant and girl children were lost their time in work but after installation of plant they gain sufficient time to read and write. By this way their study time was increased.

Indoor pollution is also decreased. This gas does not produce the smoke so the health problem such as eye problem, respiration, headache, and burn related problems were decreased. According to the respondent, after installation of plant they felt relief from their health problems.

Table: 6

% of people are suffering form the following health problems

Health Problems	Before plant Installations	After Plant Installations
Eye Problem	80%	10%
Respiration	40%	5%
Headache	70%	20%
Burn related problem	15%	5%

Source: Field Survey, 2008.

Most of the plant owners were affected from the eye problem. Before installation of plant, 10% were affected which was previous affect of smoke produced by firewood, similarly, other health related problem were decreased after installation of plant. So we conclude that it affect positively in health.

4.11 Source of energy use before installation of plant

Majority of the plant owners used firewood but some used kerosene, agricultural residue etc.

Source of energy, time needed to collect per day and money needed to buy per month in average is shown in the table before plant installation.

Table: 7

Item	Time needed to collect per day	Money needed to buy per month
Firewood	2 hours	-
Kerosene	-	Rs.565
Agricultural residue	1 hour	Rs 280
Electricity	-	-
Others	-	-

Source : Field Survey, 2008

The source of energy of plant owners before installation of plant was kerosene, firewood, agricultural residue and electricity also. From table above, time needed to collect firewood per person per day were 2-3 hours but now plant owners in cooking and cleaning pots and collecting firewood save a day the time. That saved time was used in productive work for creative works. Similarly, money was also saved to buy kerosene per month. Electricity consumption rate is also decreased.

4.12 Problems faced by the plant owners

While going through the study, the most common problem faced by every plant owners was the temperature. The plant owners found it very unfortunate that the gas production decreased substantially during winters, forcing them back to the consumption of traditional source of energy. This problem was more critical during winter months.

Problems concerning the operation of the plant were almost nil, since the owners found this technology very simple. The availability of dung was no problem to the owners since they had already calculated their capacity of owing adequate livestock before indulging themselves in the risk of loans, collection and availability of water was also not a problem in study site since almost all households had prominent water sources.

Repaying of loans and the land mortgage has been problematic to the plant owners, especially with the increasing rate of interest.

Some households, especially the Newar households brew alcohol and celebrate many festivals complained of insufficient gas production, as the fuel consumption level of these households are seen to be above the average level. Few other holding business concerning milk products also faced such problems.

4.13 Repair and maintenance

All the plant surveyed was established in the fiscal year 2063/064. As these installations are not a decade old, all respondents reported not to have faced any problems concerning repair. Few households reported slight gas leaks and jamming of the gas pipes but this did not demand the care from Gobar Gas Company, the owners themselves could take care of these, as those were considered very minor problems. No such major problems requiring care from the company was reported.

4.14 Users Suggestion

About the effectiveness of the biogas plant, users suggested that mainly go bar gas companies should educate about the benefits from the biogas plant to the households properly. Subsidy process should also be simplified according to the respondents. Necessities and norms should also be properly analyzed by the plant users to decide about the plant size middle level households have not been educated about the positive impact of biogas plant yet. They also are facing difficulties from traditional energy sources. So communication for all households is also necessary, positive impact of biogas such as health improvement, sanitation, economic impact and agriculture sector should be properly communicated.

CHAPTER V

Summary, Conclusion & Recommendation

1. Summary

Many studies have been made concerning the energy situation in Nepal. Almost all studies have concluded to one result -and, almost all the crisis is due to high demand and less supply of the energy sources.

Nepal is no exception to this crisis. Energy consumption gradually increases along with the economic development and population growth. Hence the rate of energy consumption is also viewed as an index of development. Per capita energy consumption is very low in Nepal. The annual per capita energy consumption for the country as a whole is estimated to be 505kg [CE][eco survey 1991/92]. Though, the country has a hydro power generation potential of 83000 megawatts, only 0.287 percent of the total potential has come under utilization.

Fuel wood remains the major source of energy, accounting for about 75 percent of the traditional energy consumed in Nepal. There is an over dependence on the forest resource for the fuel needs. Thus, one hand less then one percent of the hydropower of the country is being used at present which is a great under utilization of the vast source of the country has come under interest pressure in order to meet energy requirements. The slow replacement energy source will not be able to meet the high-energy demand of the country. The use of imported and non renewal source of energy, kerosene is bound to drawn the country in debts and a high use of source for primary purposes in a high taxing to the balance of payment of the countries economies.

Keeping all these problems in view, the government has taken steps to improve the alternative energy source for daily uses. In order to reduce the high consumption of expensive source of energy, a search for an alternative energy has become a must.

As previous studies reports more than 85% of the total population of Nepal, mainly depend on agriculture. Our economy is an agriculture-oriented economy, thus implying that the rural people who consume the highest fuel wood, are bound to own cattle for their daily purposes.

Moreover, the industrial sectors of Nepalese economy contributes negligible amount to the total gross domestic product as compared to the agriculture sector. Therefore, more concern must be bestowed upon the development of the agriculture sector.

Agriculture can be developed either by increasing the total cultivable land holding [the cropping intensity] or by increasing yield per unit of land.

The availability of dung was no problem to the owner since they had already calculated their capacity of owing adulates livestock before indulging themselves in the risk of loans. Collection and availability of water was also not a problem in this study bite since almost all households had permanent water sources.

2. Conclusion

After making an in-depth study of the concerned variables taken into account, under the study, certain conclusions have been derived. These conclusions derived entirely depend on the responses of the respondents, many of which are out of their memories and not based on recorded data.

More plant owners are seen to be literate. Most of the plant owners are involved in agriculture. It is natural that people involved in agriculture understand more of the demand of the output slurry. And, since more than 85% of the total population is involved in agriculture. Moreover, people involved in this occupation tend to hold livestock due to its various uses and hence, the plant installations are popular amongst this group.

Every plant owners have their own livestock. Cattle seem to be popular amongst the livestock holding whereas, buffalo seem to be popular in study site. It was observed that the livestock size and plant size have a positive relation. Higher the livestock holding bigger plant were installed.

A high number of the plant installers, belong to the Brahmin/Chhetri community. The participation by the Newari community is low due to their closed traditional society.

Out of the total plant installers the highest number of toilet-attached plants was found in the Brahmin/Chhetri households. This again proved the backward traditionally of the other community.

Only a few of the plant owners have reported ADB/N and GGC as the main source of their information about the plant proving the inadequate performance of these agencies.

There is an observed positive relationship between the family size and the plant size. A higher percentage of big are seen to be owned by large families. But, the plant installation does not tally with norms established by the GGC under capacity and over capacity plants are seen to be in use. This is due to lack of knowledge on the part of the plant owners.

As compared to the plant cost, percent cost of the plant installation is increased this is due to the increase in the price of construction materials, high transportation and labor charges.

Relative cost of other consumed fuels seems to have an influence on the plant installation decisions. Higher oil and fuel wood prices and more scarce forests would imply higher rate of plant installation. The difficulties and time-consuming factors in collecting other fuel sources would encourage plant installation.

The dung production is seen to be higher in study site. But the dung feeding by almost all the plants is less than required. Through with high dung production, the feeding process covers only a small amount. The main cause for this low dung feeding is the still, existing use of cakes in times of need. These reasons do not allow the complete produced dung to be fed. Moreover some amount of dung is lost while collecting.

The gas is used for cooking purposes; this is the major step since a lot of firewood is used in the process of cooking, which is almost entirely saved. The saving from fuel wood due to plant installation seems significant and same is the case with kerosene consumption. Likewise, the saving volume use of kerosene due to plant installation.

There is a massive change in the energy consumption pattern before and after the installations of plant. But the consumers of kerosene at an average are seen to have increased. This is due to the fact that those owners using fuel wood before installation are now using kerosene in winters. Thus, at an average the kerosene consumers are high in number after the installation. Likewise, the consumer of agricultural residue during winter has also increased. The electricity consumers are the same as biogas lamps are not in use.

The average time saved per day per person per household is three hours. This would imply 90 hours a month or 360 hours a year. This received time has been used in income generating and knowledge earning activities and the opportunity cost lost previously has been acquired after the plant installation. But a high percent of the women are seen to have been using this time in leisure and sleeps. Very few go for jobs or work in field.

The time saved from fuel wood collection amounts to 528 hours per person and 264 hours per person annually. This is a massive time saving which if utilized to improve the economic standard if the plant users.

Plant installation has effects in the agriculture sector as well. The use of the by-product slurry is seen to have increased per unit of land yield of the cultivated crops. This is due to high nutrient content in slurry as compared to the previously used dung manure.

As analyzed there are a lot of indirect benefits from the plant installation. Improve in health would imply a cut down in the medical expenses further implying a savings. The clean clothes due to smokeless character of the plant stove implies a curtail in laundry expenses further implying savings. Improvement in sanitation, environment pollution is the unaccountable benefits attained from plant installation.

Though not much, few of the households were seen to have devoted their attained free time in income generating activities such as getting employed, helping in business works and small cottage industries set a home. Further, few households devoted their free time in watching television and even sleeping for rest.

Many of the plant installers were found to have complained about the less gas production during winter and some time wood consumption in three-winter season.

3. Recommendations

As according to the derived conclusion certain recommendations are prescribes within the limited scope of the study.

Higher percentage of the literate installing plants proves the low level of influence from the agencies and neighbors. Only the educated people are seen to have installed these plants. Hence, the concerned authorities and agencies should promote the techniques in a more grass root level, hence the mass populations mostly uneducated, can also have an opportunity to understand this technology.

The main reason for not installing a biogas plant by the households belonging to other professions than agriculture as there was found to be the output slurry replacement. Hence, Proper replacement of slurry was the main problem. There fore the slurry selling policies and standard price must be standard by the concerned authorities. This was people involved in other occupations can encouraged to use the gas produces from the plant and side by side earn income from selling the slurry. Slurry market establishment is highly recommended.

As the installation of the plant is seen popular amongst the rich group, steps must be taken to make the technology popular amongst the poor section as well. Then only the actual impact will be seen in a poor country like ours. For the promotion of the technology to the poorer section, community plant can be advocated and encouraged. For this fair distribution policies must be set by the authorities since the distributional aspects trouble the gas uses later after the installation of the plant.

The concerned agencies should promote and advocated these techniques reaching every corner and community of the country. Trained an confident personnel must be sent in order to win the confidence of the people in expanding this new technology to the difficult, but poor and suffering people.

It is observed that the participation of GGC is negligible in these areas. Further studies, actions and activities are recommended.

As observed, the plant size and family size as per the norms established by the GGC, is not met. Under capacity and over capacity plants are seen to be under use. This is due to the lack of Knowledge. This requires and expensive training programmer which must be provided in time.

Farther, most of the plant installers were educated indicating only the Knowledge groups had taken the initiation of applying a new technology. Moreover, the illiterates seem to have confusion on loan systems and the technology itself. Once again demanding for training on plant installation and the interest rate systems.

Relative cost of other supplementary fuels consumed has highly influenced on plant installation. Hence to promote installation of plants, all the people should be exposed to the existing prices fuel sources such as fuel wood and kerosene.

As gas and slurry produced on the dung feeding and this in turn depends on dung availability of the production of dung, care should be taken in the animal feeding pattern on order to attain the optimum required. Therefore people must be education on this aspect, prior to the plant installations decisions.

Though, amongst the installers under the survey, most had more than required dung produced, the dung-feeding rate is seen to be minimal. The main reason being the use of dung cakes in winter, the installers should be made aware of the slurry use and hence prohibit the use of manure. But a peculiar thing was noticed during study. Even though with less than the required during feeding the plant installers were found to have owners were not using the produced gas for lighting purpose. They had a demand for a separate norms established for cooking and lighting purposes. Therefore the GGC norms in establishing the optimum dung-feeding rate be revised and kept separate for different uses of the produced gas.

There is a lot of time saved from the plant installation, as can be observed. But, the use of the achieved times has not be to optimum utilized many woman are seen to have spent their time in leisure hence not realizing their own opportunity cots. Very few are seen to have utilized their time, fruitfully.

Therefore, encouragement in vocational training other income generating works such as small-scale cottage industries the adult education and such programs is a must. Once the illiterate woman of the plant installing households is trained, they would be involved in income generating activities and hence increase the economic standards of theses rural people.

While interviewing the one owner of biogas plants, the main cause for not installing a biogas plant, was found to be the high installation cost. Though the Bank financed the plant installations and the GGC took all the tedious difficulties in hand, many people were found to be very scared of the loan system and could not bear the high rate of interest. Thus, the loan system if kept to its minimal the rural poor, who actually represent the large proportion of total fuel wood consumption, who actually represent encouraged to install such plants and accrue the possible benefits. As could be observed the maximum voted interest rate as the appropriate one, by the installers was 7.5% (i.e. the level with 50% subsidy interest rate).

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