CHAPTER –I

INTRODUCTION

1.1 Background

Nepal is primarily an agricultural country with about 26.6 million human populations out of which 83 percent population resides in rural area and 73.9 percent people are highly dependent on agriculture (CBS 2011 Praramvik Natija). Fuelwood has been and still is the major source of fuel daily used by rural mass in Nepal. This total dependence on fuelwood as the source of energy for cooking has resulted in deterioration of the quality and quantity of forests and has posed a serious threat in maintaining ecological balance, thereby manifesting various problems like deforestation, flood, Global warming, soil erosion , landslides, climate change etc. The pressure on forest resource for energy fulfillment is considerably increasing due to high population growth in rural areas causing scarcity of fuelwood for cooking. As a consequence, many people in the rural areas are burning livestock dung and other agricultural residues. This has been one of the factors in deterioration of environment and soil fertility in the country.

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

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

1.1.1 Energy and Renewable Energy Situation in Nepal

Nepal has one of the lowest energy demands in the world: around 885 MW during peak demand. (In 2008/09 the demand for energy was met from the following sources: agricultural residue 3.7%, animal dung 5.7%, fuelwood 77.7%, petroleum 8.2%, coal 1.9%, electricity 2.0%, biogas 0.6%, micro hydropower 0.0% and solar 0.0%) (WECS,2010). Nevertheless, energy supply does not meet demand in Nepal. Furthermore, an important part of the energy utilized comes from non-sustainable sources such as fuelwood, petroleum products, natural gas and imported coal. These forms of energy have high economic and ecological costs.

1.1.2 Introduction of Biogas

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

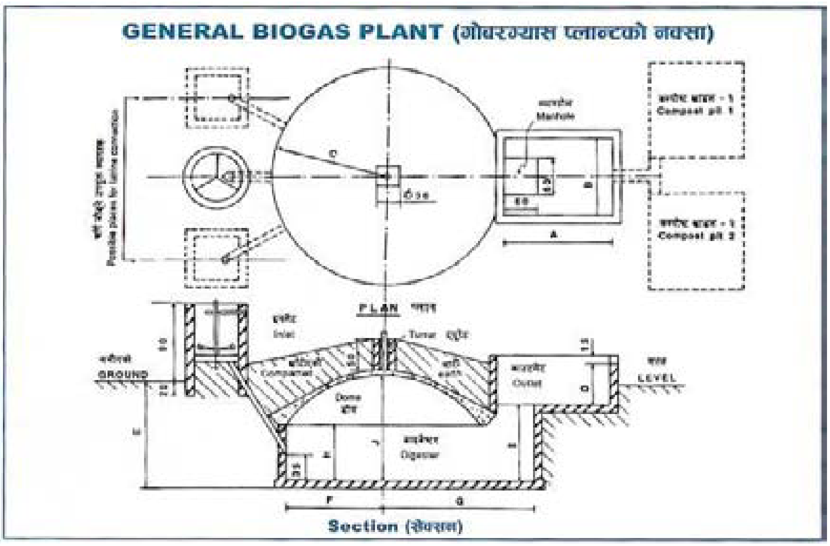
1.1.3 History of Biogas in Nepal

Although, Biogas was first introduced to Nepal on an experimental basis in 1955.Mainly it has Started Nepal in the 1980s as a technological research project with a limited number of test models, it was expanded during the 1990s by the Biogas Support Program into a very successful market development program with the active involvement of the business community.

1.1.4 Technology Design Approach of Biogas

The SNV/BSP was instrumental in helping identify, design and develop an appropriate, cost-effective and reliable biogas system for Nepal. To achieve this objective, the SNV/BSP initially worked in association with GGC to conduct its research and development. In the process, strict standards for quality and design were established that all biogas producers were required to follow, since its inception in 1992, the SNV/BSP has strategically developed and promoted a uniform technology - the fixed dome biogas digester (Figure-1). This design is suited for both the Terai and Hill regions and has received wide acceptance. The uniform design approach has made it more practical for increasing production and quality control.

Figure No.4.1: Biogas Map –GGC 2047 Model Fixed Dome Biogas System



Source: GGC 2047

1.1.5 Institutional Development and Strengthening of Biogas

AEPC co-ordinates all alternative energy development programs in Nepal and hosts the Biogas Co-ordination Committee. Working in close partnership with APEC and key financial institutions, qualified private sector firms, responsible government agencies and active NGOs, the BSP has successfully commercialized biogas systems in Nepal.

1.1.6 Potential of Biogas Plant in Nepal

For Nepal, being an agricultural country, livestock plays an important role in the Nepalese farming system. The total households with cattle and buffalo in Nepal was estimated to be 2.7 million in 2001 Based upon the study of technical biogas potential of Nepal, it is estimated that a total of 1.9 million plants can be installed in Nepal out of which 57% in plains, 37% in hills and rest 6% in remote hills or in mountain region.

1.1.7 Social Benefits

1.1.7.1 Health Benefits

Indoor air pollution and smoke exposure, from the use of fuelwood, dung cakes and agricultural residues for cooking and heating, in rural Nepal is amongst the worst in the world. It is one of the major causes for acute respiratory infections among women, infants and children (Pandey, 2003). This, in turn, is one of the most important causes of child mortality in the country. The use of biogas significantly improves the indoor air quality. Since women and female children are the ones predominantly involved in cooking, they are the first beneficiaries in terms of improved health. Moreover, since the combustion of biogas is relatively clean, it reduces eye ailments associated with smoke from ordinary fuelwood stoves. In addition, dung management and sanitary toilets attached to biogas digesters lead to better hygienic conditions, It helps keep the areas surrounding households clean and reduces the chances for the spread of infectious and other diseases,

1.1.7.2 Education

The time saved from the use of biogas has enabled female children to attend school, which previously was not possible as they were involved with household chores as well as collection of fuelwood and water.

1.1.7.3 Impacts on Poverty

The primary impact of biogas systems on poverty alleviation has been to reduce the financial costs expended on fuel for cooking and light-ting. Although most of the adopters of biogas technology have been among the larger and medium-scale farmers, smaller scale farmers have been increasingly attracted to the use of biogas. The policy of a flat rate subsidy favors smaller system sizes and smaller-scale farmers more than larger-scale farmers. In addition, the increasingly active involvement of local NGOs in the promotion, organization, financing and construction of biogas systems on the basis of self-help has the added benefit of bringing biogas systems within the reach of smaller farmers with fewer cattle. However, biogas does not benefit those formers without cattle who generally represent the poorest strata of society. Cattle-less, landless and marginal farmers may benefit only indirectly, from increased employment opportunities and greater availability of fuelwood.

1.1.8 Economic Benefits

On the cost side, biogas systems require some time for the collection of water and mixing of dung and water to keep the system operational. Time required for collection of dung, herding, collection of fodder and application of dung to the fields is not affected by the operation of a biogas system, An estimate of the average positive and negative time impacts of a biogas system show an average time saving of approximately three hours per HH per day when a biogas system is installed, (Est. consult 2004).So This time can be invested in income generating activities.

1.1.9 Environmental Benefits

The introduction of biogas technologies in Nepal has significantly contributed to the improvement of the local, national and global environment.

1.1.9.1 Local Environmental Benefits

From a local perspective, the use of biogas has helped significantly improve the indoor air quality of homes employing- biogas stoves in place of wood stoves. In addition, installation of biogas systems has resulted in better management and disposal of animal dung and night soil. This fact alone has helped improve the sanitary conditions.

1.1.9.2 National Environmental Benefits

From a national perspective, biogas systems have helped reduce deforestation. This in turn has important implications for watershed management and soil erosion. In addition, biogas systems, where the slurry is collected and returned to fields, have helped reduce the depletion of soil nutrients. This in turn reduces the pressure to expand the area of land cleared for agriculture, the principal cause of deforestation in Nepal.

1.1.9.3 Global Environmental Benefits

Biogas fuel helps reducing greenhouse gas emissions by displacing the consumption of fuelwood and kerosene. The biogas used in a sustainable basis assures the CO_2, associated with biogas combustion will be reabsorbed in the process of the growth of the fodder and food for the animals. All the CH_4 and CO_2 emissions that are associated with the combustion of fuelwood can be accounted as being displaced when replaced by a biogas system.

1.1.10 BSP and Clean Development Mechanism

BSP has been the first CDM Project in Nepal with registration of two CDM Projects in December 2005 of 19,396 plants constructed under BSP Phase-IV, have been registered with and approved by the CDM Executive Board. An Emission Reduction Purchase Agreement (ERPA) for the projects has been signed with the World Bank for trading of the Emission Reductions from the two Projects for first seven years starting 2004/05 as the first crediting year at the rate of US $ 7 per ton-CO2 equivalent of Greenhouse Gases (GHGs). Annual reporting and field verification for the two Projects for crediting years 2004/05 and 2005/06 were completed by the end of 2006 and payment of US $ 887,784 was made too. From these two Projects, the annual carbon revenue (net of verification expenses) is around US$ 600,000.

1.1.11 Study Area

1.1.11.1 Geographic Location and Climate

Chillindin VDC ward no-1 is one of the villages of Hilly regions of Nepal and lies to the south-western part of Phidim. It is located in Panchthar District the latitude 27° 02.376' N and longitude 87° 45.445' E within an elevation range 1332 m from the sea level.

4.1.11.2 Population

The Chilindin VDC ward no-1 has a total population of 562 with 274 male and 288 female. The total number of household is 98 with an average household size of 5.73 members (Distrc profile 2008).

4.1.11.3 Education

The area is facilitated with secondary school. The educational achievement is good among younger group of population. Most of the elder populations are illiterate among the ethnic groups.

4.1.11.4 Economic activities

Economic activities in the surveyed VDC are quite diverse. Agriculture in the VDC is subsistence oriented and majority of the households are involved in at least one activity such as Government Service, chili farming, etc. A significant percentage is dependent upon Pension from Government services, Ex-British Army, Ex-Indian Army. Likewise, the trend of foreign employment in Gulf Countries, Qatar and Saudi Arab is also considerable. The main crops in the VDC are paddy and maize. In addition to these crops potato, millet, vegetables and cash crops such as mustard, cardamom, amliso and chili are cultivated for self.

1.2 Statement of the Problem

According to MOF (2007), 85.5 percent of the Nepalese populations still burn traditional fuels (fuelwood, agricultural residues and dung cake) inside their homes. Fuelwood being the principal energy source among these biomass fuels, its demand far exceeds the sustainable supply (Rijal 1998). In addition, there are other socio-economic and health related adverse impacts, many of which are disproportionately suffered by the women and the poorest of the poor. On the other hand, Nepal is dependent on the imported fossil fuel; the rising price of fossil fuel in the international market is a burden on its foreign exchange. Due to these manifold adverse impacts associated with traditional biomass fuels, there have been efforts from all sides to substitute these traditional energy sources with alternative energy sources, which are cleaner and greener. So bio gas is the one of the best, reliable, easily available and economically feasible source of alternative energy which can be managed by locally available sources and simple technology for the rural villages. Therefore in the context of present situation of Nepal this study seems to need.

1.3 Objectives of the Study

The general objective of the study is to find out the prospects of biogas in the socio-economic and environmental benefits to the rural community of Nepal. The study is about socio-economic structure and environmental structure in ward no-1 of Chilindin VDC Panchthar District.
The specific objectives of the study are:

- To find out average income saving due to non-burning of fuel wood and average saving from kerosene.
- To study the health, economic and environmental benefits of biogas plants.
- To analyze the GHG emission reduction and potentiality of biogas as Clean Development Mechanism.

1. 4 Significance of the Study

The main challenge of present world is to harness the energy source which is environment friendly and ecologically balanced. This need has forced to search for other alternate source of energy. But unfortunately the new alternative energy sources like the solar, hydro, wind etc. require huge economical value and technical power to operate, which seem to be very difficult for the developing countries like Nepal. In the present moment biogas energy can be one and only reliable, easily available and economically feasible source of alternative and renewable source which can be managed by locally available sources and simple technology for these rural villages. So this study will find out the importance and prospects of bio gas in terms of socio-economic and environmental aspects for the rural community of

Nepal. After that this study will be useful for the student of the similar field to start another study and to the all biogas sector persons as well.

1.5 Limitations of the Study

1. The study was mainly confined to Chilindin VDC ward no-1 of Panchthar District.

2. Interview was made with the family head as for as possible, if such was not possible interview was taken from the next knowledgeable member of the house.

3. The study on CDM was limited within the potential Carbon Abatement Revenue from the reduction of fuelwood due to biogas installation in the VDC.

4. GO/NGO working in the field of health, environment, public awareness, poverty alleviation, women empowerment and youth mobilization has not been considered about the benefits of biogas installation so this study was focused only on the benefits of biogas installation.

1.6 Organization of the Study

This study is organized into six chapters. The first chapter is about introduction to this study, second chapter is literature review which consists of literatures about biogas published by different organization and scholars. Similarly chapter three consist methodology of this study. And chapter four is about physical, socio-economic and environmental situation. Then chapter five includes presentation and discussion. The final or chapter six is about summary, conclusions and recommendations of the study.

CHAPTER-II

LITERATURE REVIEW

The first biogas plant, first constructed in Nepal on an experimental basis by the Reverend B.R. Saubolle, a Belgian teacher at Godavary St. Xavier's School, in 1955, demonstrated its capability to utilize organic waste such as animal dung to produce gas that can be used as fuel for household use. It was only in 1974 that His Majesty's Government of Nepal realized the potential of this technology in Nepal and the biogas program was officially launched. With an increasing popularity of biogas plants, various studies have been carried out to examine the different aspects of biogas plants. Some of the literature relevant on Nepal's biogas plants is reviewed in this chapter.

2.1 Review of Previous Studies

New ERA (1985) conducted a study on "Biogas Plants in Nepal" to investigate the major factors responsible to installation of biogas plants in Nepal. The study identified capital cost of installation, dung requirement, temperature requirement, slurry as fertilizer requirement, and subsidies and incentives provided from different sources as the main factors determining the installation of biogas plants.

The Water and Energy Commission (1985) sponsored a "Five Energy Workshop" in September-November 1985 to explore the issues surrounding five sources of energy, namely small hydro, micro hydro, biogas, improved cooking stoves, and firewood and fodder. The workshop recommended, among others, that a complete appraisal of biogas be carried out to launch it on a massive scale. The workshop participants reached to the conclusion that capital was not the only constraint for its development, the number of animals needed and the problem of maintaining temperature were also thought to be decisive.

Pokharel (1990) examined the impact of biogas technology on environmental stability. The findings of the study concluded that biogas technology reduces the level of dependency on firewood by 80 percent and on kerosene by 60 percent. The study has also emphasized on the improvement of household sanitation through the eradication of flies and cleaner cooking utensils. The study also tried to estimate the substitution effect on the level of chemical fertilizer used. The study suggested that a coordinated effort by the departments of Health. Forest and Agriculture to formulate a comprehensive plan to promote biogas technology in order check environmental damage.

DevPart Consult-Nepal (1998) carried out another study whose main objective was to evaluate the biogas on the users of plants constructed by eleven smaller biogas plant construction companies. A total of 100 households were selected from among plants constructed by branch, sub-branch, or depot office of any of the selected biogas plant construction companies. The sample households cover five districts, namely Nawalparasi. Nuwakot Chitwan,Morang, and Jhapa. The major findings of the study are: (a) present subsidy scheme has encouraged the farmers to install smaller sized plants - from 9 cubic meters to 8.6 cubic meters, (b) biogas has the potential for increasing the attractiveness of life m rural areas, (c) biogas technology has a penetration among small and marginal farmers because majority of the plant owners are now marginal and small farmers, (d) time savings chae to biogas plants is 2.38 hours/day/family, (e) subsidy is one of the major attractions for biogas installations, (f) lack of collateral is a problem for getting loans, and (g) installation of biogas has helped in environmental protection, such as conservation of forest.

Similarly, with a general objective to examine the socio-economic variables that influence the potential demand for biogas plants and an effective promotional and marketing strategy with a view to develop its market, CEDA (1998) conducted a study on the effective demand for biogas in Nepal. The study was conducted in three districts (Gulmi, Kavre and Saptari) of the country. Four wards from each of the ten VDCs from these three districts (four from Gulmi and three each from the other two) were taken as the sample wards. Households from these wards were randomly selected for interview. The number of households per VDC ranged from 21 (Rimuwa of Gulmi) to 146 (Kanchanpur of Saptari). The total number of sample households was 800. The major conclusions drawn from this study arc: (a) awareness program, especially among low caste/ethnic groups and Tharu community, should be enhanced; (b) a separate program to motivate low caste/ethnic groups and Tharu community,should be implemented; and (c) informal channels of information dissemination are found to be more effective than the formal ones. Therefore, local people with some training should be hired as motivators.

2.2 Adverse Impacts Associated with Traditional Biomass Fuels

According to Pandey (1989) in rural communities of the hill region of Nepal, domestic smoke pollution is a risk factor of ARI among infants and children less than 2 years spent near the fireplace. The health problems like, Conjunctivitis, Upper Respiratory Irritation, Inflammation, Acute Respiratory Infection (ARI), Acute poisoning (from carbon monoxide), Burns, Cataracts, Arthritis, Lung Cancer, Chronic Bronchitis are the adverse effects of biomass combustion on human health (WHO 1991).

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

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

2.3 Benefits of Biogas

2.3.1 Benefits from Replacement of Fuelwood

With the installation of biogas systems, the annual reduction of fuelwood was two tones per household and this provided an equivalent protection of 6,790 hectares of forest per year through 11,395 operational biogas plants (Winrock and Eco Securities 2004).

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

2.3.2 Benefits of Biogas on Health and Sanitation

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

In Bhaktapur District, 67 percent of the households reported reduction in smoke related diseases (NGO Promotion Center 2003). The primary benefits of improved health among biogas households are due to reduced indoor smoke indirectly reducing health- related expenses (East Consult 2004). Indoor climate dramatically improved as a result of using clean biogas stoves instead of burning fuelwood, straw and dung cakes would mean that a lot of the problems with hazardous smoke particles would be avoided (Li et al. 2005). Biogas installation (BSP 2007).Only 58 percent of households had toilet before biogas installation which have increased to 97 percent after biogas installation (CMS 2007).

2.3.3 Time Saving and Workload Reduction

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

2.3.4 Economic Benefits

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

2.3.5 GHG Reduction

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

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

2.3.6 CDM Approach

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

2.4 National Policies and Action Plan

Renewable Energy Technologies have increasingly received due attention in periodic plans since the Seventh Plan (1985 -1990) where, for the first time, a targeted approach amongst other policy measures was established for its development. The Eight Plan (1992 - 1997) envisaged the need for a coordinating body for large- scale promotion of alternative energy technologies in Nepal and the Alternative Energy Promotion Centre (AEPC) was thus established as an executing body. The Ninth Plan (1997 - 2002) formulated long term vision in the science and technology sector which has the fundamental goal of rural energy systems developed as to increase employment. The Tenth Five Year Plan (2002-2007), therefore, puts emphasis on increasing energy consumption in rural households by developing and extending alternative energy sources as energy could be a powerful tool in poverty alleviation. The other consideration has been driving the concept of commercialization in rural areas by developing and promoting alternative energy technology based on local resources and tools, not to mention the aim of reducing consumption of imported commercial fuels and increasing their access to indigenous alternative sources.

CHAPTER-III

RESEARCH MATHODOLOGY

3.1 Research Design

The study is specially designed to explore prospects of biogas in socio-economic benefit to the rural community of Nepal. This study is based on descriptive exploratory research design. It would be helpful for researcher assesses the knowledge about Nepal's prospect of biogas and identify promoting and hindering factors of motivation with some facts and figures of socioeconomic characteristics of the respondents.

3.2 Selection of the Study Area

Chilindin VDC Ward no-1 is purposely selected as a sample case study area keeping in mind that the selected area 73 households use biogas plants out of 98 HHs (field survey 2011) are one of the well managed. The study area consists of various caste/ethnic groups who are divided in different socio-economic strata.

3.3 Sampling Procedure and Sample Size

Out of 73 bio gas users household 15 HHs were sampled with The Random Sampling method. Sample was taken covering only one ward of Chillindin VDC from the villages namely Jyamire, Tumbung and Tumpati etc.

3.4 Source of Data

This study is based on primary as well as secondary data. Primary was collected through various techniques and tools. Secondary data used as supportive information they obtained mainly from journal, article, books and VDC bulletin and internet.

3.5 Data Collection Tools and Techniques

In order to meet the objectives of the study, the researcher used Field visit and Primary data collection with household structured questionnaire survey, focus group discussion and field observations.

3.6 Techniques of Data Presentation and Analysis

The information obtained from the study has been presented using simple mathematical tools such as ratio, percentage and average. The software MS-Excel as well as used for data processing and appropriate tables and graphs has been created from quantitative data.

CHAPTER-IV

DATA ANALYSIS AND PTESENTATION

4.1 Demographic Analysis of Respondents

Of 30 respondents questioned during this study, 15 were from Biogas Households and 15 from Non-Biogas Households. In the study, 60 percent respondents from Biogas Households were male and 40 percent female. Among Non-Biogas Household respondents, 60 percent were male and 40 percent female. The educational statuses of the respondents in Biogas Households were gradually illiterate 26.66 percent, bellow class five 40 percent, above class five 13.33 percent and above SLC 20 percent similarly in Non-Biogas Households were illiterate 33.33 percent, bellow class five 33.33 percent, above class five 20 percent and above SLC 13.33 percent. The major ethnical groups in the surveyed VDC were limbu, Newars, and others include Siwa, Bagdas and Biswa Karma.

TABLE 4.1: Demographic analysis of the respondents

Particulars	Biogas Households	Non-Biogas

				Households	
		No. of Respondents	%	No. of Respondents	%
Sex	Male	9	60	9	60
	Female	6	40	6	40
Literacy	Illiterate	4	26.66	5	33.33
	Below Class 5	6	40	5	33.33
	Above Class 5	2	13.33	3	20
	Above SLC	3	20	2	13.33
Ethnical Groups	Limbu	11	73.33	13	86.66
	Newar	1	6.66	1	6.66
	Others (Siwa, Bagdas and Biswa Karma)	3	20	3	6.66
Average Family Size		6.2		4.4	

Source: Field Survey, 2012

Figure No.4. 2: Literacy Status of Respondents

Figure No.4.3: Ethnical Composition of Respondents

4.2 Analysis of Occupation of Respondents

The percentage having agriculture only as the main source of income was comparatively high (46.66 % Bio-Gas Household and 66.66 Non-Biogas Household) among both the respondent Households. Other occupation activities were service such as Teaching, government service, Indian army, British army, employment in Gulf countries, Qatar, Dubai, Saudi Arab. Similarly, respondent households also had business as source of income.

TABLE 4.2: Occupation of Respondents

Occupation of Respondents	Biogas Households		Non-Biogas Households	
	No. of Respondents	%	No. of Respondents	%
Agriculture only	7	46.66	10	66.66
Agriculture & Foreign Employment	5	3.33	2	13.33
Agriculture and Service	2	13.33	3	20
Agriculture and Business	1	6.66		
Total	15	100	15	100

Source: Field Survey, 2012

Figure No.4.4: Occupation of Respondents

4.3 Comparison of Total Land Holdings

The average landholding size per family was 27.43 ropanies (1.371 ha.) for Biogas Households and 11.66 ropanies (0.583 ha.) for Non-Biogas Households.

TABLE 4.3: Analysis of Total Land Holdings

Total Land Holdings in Ropani	Biogas Households		Non-Biogas Households	
	No. of Respondents	%	No. of Respondents	%
<5	2	13.33	5	33.33
5-16	4	26.66	7	46.66
16-30	5	33.33	2	13.33
>30	4	26.66	1	6.66

Total	15		15	
Average Total Land Holdings	27.43ropanies =1.371 ha		11.66 ropanies =0.583ha	

Source: Field Survey, 2012

4.4 Comparison of Annual Major Crop Yield

Agriculture in the VDC was subsistence type with insignificant market involvement. The average annual paddy yield for Biogas Households was 432 kg/HH/yr and that for Non-Biogas Households was 301.33 kg/HH/yr. The paddy yield for Biogas Households was 17.82 percent higher than Non- Biogas Households. The average annual maize yield for Biogas Households was 361.33 kg/HH/yr and that for Non-Biogas Households was 234.66 kg/HH/yr. The maize yield for Biogas Households was 21.25 percent higher than for Non-Biogas Households.

TABLE 4.4: Comparison of Annual Yield of Major Crops

Major Crops	Annual Yield in kg	Biogas Households		Non-Biogas Households	
		No. of Respondents	%	No. of Respondents	%
Paddy	No Paddy	1	6.66	5	33.33
	< 1500	7	46.66	7	46.66
	1500-3000	7	46.66	2	13.33
	> 3000			1	6.66
Total		15	100	15	100
Average Annual Paddy		**432 kg**		**301.33 kg**	

Yield/HH					
Maize	No Maize				
	< 500	10	66.66		
	500-1000	5	33.33	15	100
	> 1000				
Total		15	100	15	100
Average Annual Maize Yield/HH		**361.33kg**		**234.66**	

Source: Field Survey, 2012

4.5 Comparison Through Cultivation Practice of Secondary Crops

Secondary crops cultivated in the VDC were potato, millet, cash crops (Chili, Cardamom, Amliso) with 20 percent Biogas Households and 26.66 percent Non-Biogas Households cultivating potato. Millet cultivation was related to ethnicity. This may be the reason for lesser millet cultivators of 4 percent among Biogas Households 4 percent than for Non-Biogas Households. 53.33percent Biogas households and 46.66 percent Non-Biogas Households cultivated at least one of the cash crops mentioned in the Table 4.5.

TABLE 4.5: Comparisons through Cultivation Practice of Secondary Crops

Crop Type	Biogas Households		Non-Biogas Households	
	No. of Respondents With Cultivation	%	No. of Respondents With Cultivation	%
Potato	3	20	4	26.66
Millet	4	26.66	4	26.66
Cash Crops Chili, Amliso, Cardamom	8	53.33	7	46.66
Total No. of Respondents	15	100	15	100

Source: Field Survey, 2012

4.6 Analysis of Fertilizer Types Used by Respondents

In the VDC, 26.66 percent Biogas Households used bio-slurry as fertilizers in combination with Farm Yard Manure and chemical fertilizer while 20 percent Non-Biogas Households used combination of Farm Yard Manure and chemical fertilizers. Urea was the chemical fertilizer preferred in the VDC. Average annual amount of Urea used annually by Biogas Households was 5.33 kg/HH/yr and that used by Non-Biogas Households was 3.73 kg/HH/yr.

TABLE 4.6: Comparison through Fertilizer Types used by Respondents

Respondent Type	Fertilizer Used	No. of Respondents	%
Biogas Households	Farm Yard Manure,Bio-slurry	11	73.33
	Farm Yard Manure and Chemical fertilizer	4	26.66
Non-Biogas Households	Farm Yard Manure	12	80
	Farm Yard Manure and Chemical fertilizer	3	20
Average urea used /HH/yr kg	Biogas Households	Non-Biogas Households	Difference %
	5.33	**3.73**	**1.60**

Figure No.4. 5: Average Urea Used per Household per year

4.7 Bio-slurry Use and Storage Practice

The respondent Biogas Households applied bio-slurry in crop field and kitchen garden. It was used either in composted form with use of agricultural residues for mulching or in non-composted dried form but not in liquid form. Field observation showed only one compost pit was more common rather than two and bio-slurry was stored in heaps but was not covered. Respondents informed during use, bio-slurry was spreader but incorporating into soil was not immediate.

4.8 Buffalo and Cattle Holding Households

All surveyed Biogas Households possessed at least one head of buffalo or cattle with more preference to buffaloes due to more dung. 66.66 percent of Non-Biogas Households possessed at least one head of buffalo or cattle.

TABLE 4.7: Buffalo and Cattle Holdings Households

Households	Biogas Households		Non-Biogas Households	
	No. of Respondents	%	No. of Respondents	%
With Buffalo and/or Cattle	15	100	10	66.66
Without Buffalo and/or Cattle	0	0	5	33.33
Total No. of Respondents	15	100	15	100

Source: Field Survey, 2012

4.9 Analysis of Total Number of Livestock Among Respondents

The entire Biogas Households surveyed owned 19 heads of buffaloes and 45 cattle and these for Non- Biogas Households was 8 heads of buffaloes and 20 heads of cattle. The Biogas Households surveyed owned a total of 51 goats and Non-Biogas Households had a total of 28 goats. The average livestock-holding size was 8.66 heads for Biogas Households and 4.73 heads for Non-Biogas Households. Besides, buffalo and cattle goats, pigs and poultry were also owned by both the respondents.

TABLE4.8: Livestock Types and Number among Respondents

Livestock	Biogas Households			Non-Biogas Households		
	Number of Livestock			Number of Livestock		
	Big	Small	Total	Big	Small	Total
Buffalo	15	4	19	5	3	8
Cattle	30	15	45	16	4	20
Goat			51			28
Pig			18			15
Hen			101			61
Total 19+45+51+18			133	8+20+28+15		71
Average Livestock Holdings per HH		8.66				

Source: Field Survey, 2012

4.10 Probability of Biogas Based on the Availability of Cattle

According to the study, 53.3 percent of Non-Biogas Households had at least one head of buffalo or cattle. Based on, number of buffalo and cattle, the installation of 13 biogas plants of 6 cu.m were technically potential.

TABLE 4.9: Probability of Biogas based on the availability of cattle

Livestock	Total No. in Non-Biogas Households	Dung per animal per day	Total Dung per day	Potential No. of plants of 6 cu.m
Buffalo	8	5	40	13.32
Cattle	20	3	60	
Total	28		100	

Source: Field Survey, 2012

4.11 Estimation of Weight of a Bhari

When ten Bharis of dry fuelwood in the Chilindin VDC were analyzed, it was found that a *bhari* contains about 40 kg by dry weight.

4.12 Sources of Fuelwood

The entire land of village is situated in the elevation between 1215 m and 1865 m from the mean sea level. The people were totally dependent on private forests for fuelwood collection. Basically Fuelwood was collected from community during months of January- February (Magh and Falgun) every year.

TABLE 4.10: Sources of Fuelwood

Sources of Fuelwood	No. of Biogas Households	Percentage	No. of Non-Biogas Households	Percentage
Private Forest	15	100	15	100

Source: Field Survey, 2012

Figure No.4. 6: Sources of Fuelwood

4.13 Trees Species Used for Fuelwood

The main tree species used for fuelwood purpose were *Schima wallichi* (Chilaune), *Castanopsis indica* (Katus) and Utish. These were commonly found tree species in the private forests.

4.14 Fuelwood Consumption Pattern

The average fuelwood consumption was 375.33 kg per month i.e. about nine "*Bhari*" of fuelwood for Non-Biogas Households and the average fuelwood consumption for Biogas Households was 213.55 kg per month i.e. about five "*Bhari*" of fuelwood. There was a considerable saving of 1945.78 kg (43.45%) of fuelwood per year per household among Biogas Households.This contributed to an average saving of NRs. 7783.12 per household per year at the rate of NRs. 160 per "*Bhari*" in the study site.

TABLE 4.11: Fuelwood consumption among Respondents

Average Fuelwood consumption in kg/HH	Biogas Households	Non - Biogas Households	Fuelwood Saving in kg/HH	% Fuelwood Saving
Per Day	7.02	12.35	5.33	43.15
Per Year	2562.66	4508.44	1945.78	
Annual Expense in Fuelwood/HH @ NRs. 160 per Bhari (1 Bhari = 40 kg)	10250.64	18033.76	7783.12	43.15
1 US$ = NRs. 88.269 (September, 2012)				

Source: Field Survey, 2012

4.15 Fuelwood Consumption Pattern Before and After Biogas Plant Installation

Comparing Biogas Households before and after biogas use, 37.73 percent of fuelwood was saved. The reduction was coherent with the reduction of fuelwood consumption by 43.15 percent per household per year among the Biogas Households and Non-Biogas Households. This was equivalent to an average annual saving from fuelwood of NRs. 6213.36 per household per year.

TBLE 4.12: Fuelwood Consumption among Respondent Biogas Households Before and After Biogas Plant Installation

Average Fuelwood consumption in kg/HH	Biogas Households (Before	Biogas Households (After	Fuelwood Saving in kg/HH	Percentage of Fuelwood Saving
Per Day	11.27	7.02	4.25	37.73
Per Year	4116	2562	1553	
Annual Expense in Fuelwood/HH @	16464	10250.64	6213.36	37.73

NRs. 160 per Bhari (1 Bhari = 40 kg)				
1 US$ = NRs. 88.269 (September, 2012)				

Source: Field Survey, 2012

Figure No. 4.7: Annual Income Saving due to Reduction in Fuelwood Consumption

4.16 Calculation of Per Capita Fuelwood Consumption

The per capita fuelwood consumption for Biogas Households before installation of biogas was 10289.92 MJ/yr which reduced to 6413.28 MJ/yr after biogas installation. Similarly, there was significant reduction in per capita fuelwood consumption among Biogas Households on comparing with Non-Biogas Households with per capita energy consumption of 11286.79MJ/yr.

TABLE4.13: Annual per Capita Fuelwood Consumption in MJ

Respondent Type	Annual Per Capita Fuelwood Consumption	
	in kg	in MJ
Biogas Households (Before)	663.87	10289.985
Biogas Households (After)	413.33	6413.28
Non - Biogas Households	728.18	11286.79

Source: Field Survey, 2012

Figure No.4.8: Annual per Capita Fuelwood Consumption

4.17 Estimation of the Equivalent Forest Area Protected from Reduction in Fuelwood Consumption

With the installation of biogas plants the annual reduction of fuelwood was over 1.95 tonnes and each biogas plant installed in the VDC protected over 0.058 ha forest per year.

TABLE 4.14: Estimation of the Equivalent Forest Area Protected (ha)

Particulars	Comparing Biogas Households and Non-Biogas Households	Comparing Biogas Households (Before and After Biogas Plant Installation)
Annual Fuelwood Savings (tonnes per HH per Year)	1.954	1.534
Equivalent Forest Area Protected (ha)	0.058	0.0459

Source: Field Survey, 2012

4.18 Estimation of the Number of Trees Saved from Potential Biogas Plants

From the technically potential 13 biogas plants among buffalo and/or cattle holding respondent Non-Biogas Households (53.3%), a total of 151 trees could be saved annually.

TABLE 4.15: Estimation of the Number of Trees Saved from Potential Biogas Plants

Potential No. of Biogas Plants of 6 cu.m	Trees saved per biogas plant of 6 cu.m per year	Total No. of Trees saved per year
13	11.6	151

Source: Field Survey, 2012

4.19 Fuelwood Consumption and Greenhouse Gas Emission

The average annual GHG emission for Non-Biogas Households was 6843.7267kgCO2e/HH/yr and after biogas use, it was 3889.033 kgCO2e/HH/yr per

Biogas Households. Before biogas installation, annual GHG emission was 6248.0646 kgCO2e/HH/yr.

TABLE 4.16: Greenhouse Gas Emission from Fuelwood per Household

Respondent	Average Fuelwood consumption in kg/HH/	GHG	Emission in kg/month / HH	Emission in kg /yr/HH	Emission in kg CO2e/HH/ yr.	Total Emission in kg CO2e/HH/ yr
Biogas Households (Before)	343	CO2	482.258	482.258	5784.096	6248.0646
		CH4	1.372	16.464	345.744	
		N2O	0.031213	0.374556	115.2246	
Non-Biogas Households	375.70	CO2	528.2342	528.2342	6338.8104	6843.7267
		CH4	1.5028	18.0336	378.7056	
		NO	0.034189	0.410268	126.2107	
Biogas Households (After	213.5	CO2	300.181	3602.172	3602.172	3889.033
		CH4	0.854	10.248	215.208	
		N2O	0.019429	0.233148	71.7233	

Source: Field Survey, 2012

4.20 Kerosene Consumption in the VDC

In the VDC, use of kerosene was limited within lighting purpose. Both Biogas Households and Non-Biogas Households were using kerosene despite having access to electricity power supply. This was due to irregular electricity supply in the VDC. The average kerosene consumption in the VDC was 1.338 liters per month for Biogas Households and 1.34 liters per month for Non- Biogas Households.

TABLE 4.17: Kerosene Consumption among the Respondents

Average Kerosene Consumption in liters/HH	Biogas Households	Non - Biogas Households	Kerosene Saving per HH
Per Month	1.338	1.34	0.002
Per Year	16.6	16.08	0.02

Source: Field Survey, 2012

4.21 Kerosene Consumption and Greenhouse Gas Emission

Kerosene consumption was found to produce approximately 39.9 kg CO2e per year GHG per household in case of both the Biogas Households and Non-Biogas Households.

TABLE4.18: GHG Emission from Kerosene per Household

Respondent	Average Kerosene consumption in litres/ HH/month	GHG	Emission in kg/month/ HH	Emission in kg/ HH/yr	Emission in CO2e kg/ HH/yr	Total Emission in CO2e kg/ HH/yr
Biogas Households	1.338	CO2	3.2883	39.4594	39.45942	39.89304
		CH4	0.000468	0.005621	0.11242	
		N2O	0.0000843	0.00101178	0.3212	
Non-Biogas Households	1.34	CO2	3.2925	39.50856	39.50856	39.94272

		CH4	0.00047	0.005628	0.11256	
		N2O	0.0000842	0.00101304	0.3216	

Source: Field Survey, 2012

4.22 Estimation of Methane Leakage from Slurry Tank

The total methane leakage per annum from the surveyed Biogas Households was calculated to be 270.81175 kg/yr and the average methane leakage in the VDC was 448.91kg CO2e/yr/plant.

TABLE 4.19: Estimation of Methane Leakage

Plant size (cu.m)	No. of Plants	Average Methane Leakage per Plant cu.m per day	Total Methane Leakage cu.m per day	Total Methane Leakage cu.m per year	Total Methane Leakage kg per year
2	4	0.11	0.44	160.6	114.026
4	11	0.055	0.605	220.825	156.78575
Total				381.425	270.81175
Average Plant Size =2.53 cu.m					
Average Methane Leakage = 0.0825cu.m/day/plant = 21.376865 kg/yr/plant					
Average Methane Leakage in CO2e per Plant per year =21.376865 ×21= 448.914165 kg CO2e					

Source: Field Survey, 2012

4.23 Total Annual GHG Emission

The total annual GHG emission was 4101.46004 kg CO2e /yr/HH for Biogas Households and 6397.19672 kg CO2e/yr/HH for Non-Biogas Households.

TABLE 4.20: Total Annual GHG Emission

Fuel Type	Annual GHG Emission in kg CO2e/yr/HH

	Biogas Households	Non-Biogas Households
Fuelwood	3612.653	6357.254
Kerosene	39.69304	39.94272
Average Methane Leakage	448.914	-
Total	4101.46004	6397.19672

Source: Field Survey, 2012

Figure No.4.9: Annual GHG Emission from a Household

4.24 Total Resultant Annual GHG Reduction Per Plant

The biogas use had not contributed in reducing kerosene consumption and the total resultant annual GHG reduction was only through reduction in fuelwood combustion. Comparing Biogas Households and Non-Biogas Households, it was 2,368.836 kg CO2e/plant/yr and that comparing Biogas Households Before and After Biogas Plant Installation amounted 2,493.0702 kg CO2e/ plant/yr.

TABLE 4.21: Total Resultant Annual GHG Reduction per Plant

Total Annual GHG Emission in kg CO2e by consuming Fuelwood	Total Resultant GHG Reduction per plant in kg CO2e per

				Plant
Non-Biogas Households	per yearBiogas Households	Difference	Average Methane Leakage in kg CO2e per Plant per year	
6357.254	3612.653	2744.601		
Biogas Households (Before)	Biogas Households (After)	Decrease	448.914	2295.687
6248.0646	3669.033	2359.0316		1910.1176

Source: Field Survey, 2012

4.25 Estimation for Carbon Abatement Revenue

Each biogas system in the study area would reduce approximately 2.1 tons of GHGs per year per system. Based on the study, each biogas plant was likely to bring Nepal an annual Carbon Abatement Revenue of around US $39.90 per year if claimed under CDM.

TABLE 4.22: Carbon Abatement Revenue per plant per year

Comparing Annual GHG Emission from Fuelwood Combustion	Total Resultant GHG Reduction per plant per year	Total Resultant GHG Reduction per plant per year in tons CO2e	Certified Emission Reduction Rate per t CO2	Carbon Abatement Revenue per plant per year

for	in kg CO_2e			
Biogas Households and Non-Biogas Households	2295.687	2.29	US$ 19	US$ 43.51
Biogas Households (Before - After)	1910.1176	1.91.1	US$19	US$36.2919
1 US$ = NRs. 88.269 (September, 2012)				

Source: Field Survey, 2012

4.26 Analysis on the Health Benefits

The study showed 100 percent of the surveyed Biogas Households and 66.66 percent of Non-Biogas Households had toilet. Besides better management of dung, introduction of biogas plants had also benefited in health and sanitation through toilet construction.

TABLE 4.23 Possessions of Toilet

Possession of Toilet	No. of Biogas Households	Percentage	No. of Non-Biogas Households	Percentage
Yes	15	100	10	66.66
No			5	33.33
Total	15	100	15	100

Source: Field Survey, 2012

Figure No.4.10: Toilet Possession among Respondents

4.27 Impact of Biogas on Health and Sanitation

The direct, effects of biogas plant on health and sanitation were found to be more visible than indirect ones, its impact on public health can be expected to be tremendous in future as, its effect on cleanliness and sanitation was quite visible in the study area. The change in sanitation and cleanliness had been a matter of great satisfaction brought about by biogas and biogas induced wave of toilet construction.

4.27.1 Impact of Biogas on Diseases Occurrence

The study revealed that smokeless biogas had greatly benefited the plant owners by contributing to a significant reduction in eye related problems, respiratory diseases etc.

TABLE 4.24: Analysis on the Health Benefits

Health Problem	Biogas Households		Non-Biogas Households	
	No. of Respondents With	%	No. of Respondents With	%
Eye Problems	1	6.66	3	20
Respiratory Diseases	4	26.66	6	40
Diarrheal Diseases	5	33.33	3	20
Cough and Cold	4	26.66	2	13.33
Headache	1	6.66	1	6.66
Total Respondents	15	100	100	100

Source: Field Survey, 2012

Figure No.4.11: Health Problems among Respondents

4.28 Average Time for Daily Works

Biogas Households spent less time in managing household energy system and were able to give more time in terms of collection of fodder for livestock, maintenance of better cleanliness around home, more time for family care etc. Biogas Households needed to do more water fetching and dung collecting works which seemed quite true.

TABLE 4.25: Analysis on Average time for Daily Works

Daily Works	Average Time in minutes per day		Average Time saved per day (minutes/HH)
Fuelwood collection	40	70	+30
Cooking	130	170	+40
Fetching Water	50	40	-10
Cleaning Utensils	40	60	+20
Livestock Caring	50	40	-10
Dung Collection	15	-	-20
Slurry Mixing	15	-	-15
Total	340	380	40
+ shows saved time due to Biogas Plants			

Source: Field Survey, 2012

Figure No.4.12: Benefits of Biogas in terms of Time Saving

4.29 Construction, Operation and Maintenance of Bio-digester

The success of biogas programme is highly influenced by the flawless construction and prolonged operation of biogas plants with satisfactory results to the users.

4.29.1 Analysis on Plant Size and Approximate Time Period of Plant Construction

In the VDC, majorities (26.66 %) of the biogas plants were found to be installed before two to five years, 73.33 percent plants were installed less than one year or an year ago of the biogas plants surveyed were of 2 cu.m. followed by 73.33 percent plants and 26.66 percent plants were 4 cu.m.

TABLE 4.26: Analysis on Plant Size and Approximate Time Period of Plant Construction

Time of Construction(Years)	No. of plants		Total	Percentage of plants
	2cu.m	4 cu.m		
<1Year and 1Year	11		11	73.33
2-5 Years		4	4	26.66
Total			15	100
Percentage	73.33	26.66	100	

Source: Field Survey, 2012

Figure No.4.13: Variation in Plant Size

4.29.2 Analysis on Reasons for Biogas Installation

There seemed to be more or less uniformity in the diversified reasons for the installation of biogas plant installation. A notable point was none of the respondent mentioned about the availability of bio-slurry as fertilizer as reason for installing biogas plants. There seemed the lack of knowledge among the Biogas Households in use and storage of Bio-slurry as fertilizer.

TABLE 4.27: Analysis on Reasons for Biogas Installation

S. No	Reasons for Biogas Installation	No. of Respondents	Percentage
1	Less fuelwood collection	12	80
2	Easy to cook	15	100
3	Smokeless kitchen	15	100
4	Time saving	9	60
5	Better sanitation	13	86.66
6	Money saving	10	66.66
7	Subsidy	11	73.33
	Total	15	100

Source: Field Survey, 2012

4.29.3 Feeding Materials and Frequency

In the study area, Biogas Households used buffalo and cattle dung as the feeding materials followed by use of night soil among the Biogas Households with toilet attachment. As regards to feeding frequency, all the surveyed Biogas Households fed their plants once a day. The average plant size of the study was 2.53 cu.m. and the average amount of dung fed per plant per day was 23.66 kg. Comparing to the theoretical amount, (34.92 kg of dung and 34.92 liters of water) the feeding amount of dung was adequate to maintain a plant average 2.53 cu.m as obtained from the study.

TABLE 4.28: Feeding of Plants

Dung (kg per day) and Water (litres per day)	No. of Biogas Households	Percentage
<20	11	73.33
20-25	4	26.66
Total	15	100

Source: Field Survey, 2012

4.29.4 Toilet Attached Biogas Plants

Biogas induced wave of toilet construction in the VDC. The survey showed 100 percent of the Biogas Households had toilet attached Biogas plants. The main reason was to reduce the amount of dung needed for biogas. The construction of toilet significantly benefited to improved health and sanitation of community and community members.

TABLE 4.29: Toilet Attached Biogas Plants

No. of Toilet Attached Biogas Plants	Percentage	No. of Toilet Not-Attached Biogas Plants	Percentage
15	100	0	0

Source: Field Survey, 2012

4.30 Analysis for Approximate Installation Cost per Plant

The cost of installation was observed through three parameters: total cost of installation; subsidy provided by institution and self-investment from the Biogas Households. As per the company rules besides subsidy, the Biogas Households had to bear certain installation cost by themselves.

4.30.1 Subsidy Rates

Based on Subsidy policy, a subsidy of NRs 18,700 per plant was provided for plants of 2 cu.m and 4 cu.m. As the subsidy was provided in terms of construction materials, wage for mason, supervisor etc, the respondents seemed not to be satisfied regarding subsidy delivery.

4.30.2 Installation Cost as Self-Investment from Biogas Households

Majorities (73.33%) of Biogas Households had investment between NRs. 12,000 and NRs. 14,000 for a biogas plant construction. The minimum self-investment cost from Biogas Households per plant was approximately NRs. 15,000 while the maximum was approximately NRs. 20,000.

TABLE 4.30: Number of Plants and Self-Investment from Biogas Households

Installation Cost /Plant in NRs.	No. of Plants	Percentage
<14000	11	73.33
1500-20000	4	26.66
Total	15	
Average Installation Cost (Self-Investment From Biogas Households)		15,120
1 US$ = NRs. 88.269 (September, 2012)		

Source: Field Survey, 2012

4.30.3 Total Investment Cost

The average total investment cost for the installation of a biogas plant was NRs. 34,800 per plant

TABLE 4.31: Analysis on Plant Size and Total Investment per Plant Construction

Plant Size (cu.m)	No. of Plants	%	Approximate Expense from Biogas Households per Plant (NRs.)	Subsidy (NRs.)	Total Investment Cost (Self Investment from Biogas Households + Subsidy) (NRs.)
2	11	73.33	14,000	18,700	32,700
4	4	26.66	18,200	18,700	36,900
Total	15	100			
Average Plant Size=2.53 cu.m.					
Average Total Investment Cost Per Plant= NRs. 34,800					
1 US$ = NRs. 88.269 (September, 2012)					

Source: Field Survey, 2012

Figure No.4.14: Approximate Construction Cost per Plant

4.31 Operation and Maintenance Status and User's Satisfaction

All the surveyed biogas plants were operational and the responses obtained were quite satisfactory. Appreciably, 86.66 percent of the sample households reported the plant to be in smooth operation and had not incurred any expenditure since the installation of the plants. The average cash amount incurred for the maintenance was within the range of NRs. 300 per year.

TABLE 4.32: Maintenance Status of Biogas plants

Maintenance Status	No. of Biogas Households with expense incurred for maintenance	%	No. of Biogas Households with no expense incurred for maintenance	%	Total
	2	13.33	13	86.66	15

Source: Field Survey, 2012

4.32 Calculation of Payback Period

At an average total investment of NRs. 34,800 per plant, the payback period of the initial investment of a biogas plant installation was calculated to be 4.6 years.

TABLE 4.33: Calculation of Payback Period

S. No	Particulars	Amount
1	Annual Saving per plant	7783.12
2	Average Total Investment Cost per plant	34,800
3	Labor cost -15minutes a day @ NRs. 75/day	900
4	Maintenance Cost/Yr	300
5	Miscellaneous Cost	100
6	Annual Expenditure per plant	1,200
7	Subsidy per plant	18,700

Payback Period	4.6 years
1 US$ = NRs. 88.269 (September, 2012)	

Source: Field Survey, 2012

4.33 Perception of Biogas Households on Biogas

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

TABLE 4.34 Perceptions of Biogas Households on Biogas

Remarks	No. of Biogas Households	Percentage
Fully Satisfied	7	46.66
Moderately Satisfied	8	53.33
Not Satisfied	0	0
Total	15	100

Source: Field Survey, 2012

4.34 Reasons for Not Installation of Biogas plants among Non-Biogas Households

Despite interest, 66.66 percent of Non-Biogas Households could not afford the high initial investment cost and were expecting higher subsidy, 6.66 percent were not interested of biogas installation and 26.66 percent reported lack of sufficient information about biogas technology, its multiple benefits and about the subsidy delivery process.

TABLE 4.35: Reasons for Not Installation of Biogas plants

Remarks	No. of Non-Biogas Households	Percentage
Not interested	1	6.66
Unaffordable Initial Investment	10	66.66
Lack Information	4	26.66
Total	15	100

Source: Field Survey, 2012

CHAPTER-FIVE

DISCUSSION

5.1 Demography

The average family size was 6.2 members per household for Biogas Households and 4.4 for Non-Biogas Households. This was quite similar to the average family size 4.7 as given by CBS (20011). In the VDC, the average family size, ethnicity, landholdings, production and consumption pattern, livestock ownership, literacy pattern etc. appeared quite comparable among Biogas Households and Non-Biogas Households.

5.2 Benefits of Biogas

5.2.1 Benefits from Replacement of Fuelwood

The study showed, in the surveyed area (Chilindin VDC), each Non-Biogas Households consumed on average 4508.44 kg of fuelwood annually. Biogas Households used fuelwood for preparing animal feed locally called "*Kudo*" and for making alcohol for household use and the average annual fuelwood consumption for Biogas Households amounted 2562.66 kg per household. There was a considerable saving of 1945.78 kg (43.15 %) of fuelwood per year per household. Comparing Biogas Households before (4116 kg/HH/yr) and after biogas use, 37.73 % of fuelwood was saved on average.

In the VDC, the average size of biogas plant was 2.53 cu.m and each biogas plant saved over 1.95 tonnes of fuelwood annually which was comparable to an annual saving of two tonnes of fuelwood per household due to installation of biogas plant as studied by Winrock and Eco Securities et al. (2004) and CMS (2007). This was also comparable to the displacement of three tonnes of fuelwood by a biogas plant of 6 cu.m as studied by Devkota (2007).

In the surveyed VDC, each biogas plants saved over 1.95 tonnes fuelwood annually and protected over 0.058 ha forest per year which was comparable to a saving of 0.061 ha of forest per biogas plant as studied by Winrock and Eco Securities et al. (2004) and also with an annual saving of 0.058 ha of forest by one 6 cu.m biogas plant as estimated by Devkota (2007).The study also showed if the technically potential biogas plants could be installed in the VDC, an annual saving of 151 trees could be achieved. The saving of trees from the saved fuelwood could directly be attributed to Biogas installation.

5.2.2 Kerosene Consumption in the VDC

According to BSP (2006), of total 168,613 biogas plants, the operational biogas plants (97 %) replace 5.2 million litres of kerosene. Each biogas plant of 6 cu.m displaces 38 litres of kerosene annually (Devkota 2007). The study showed, in Chilindin VDC, use of kerosene was limited within lighting purpose and both Biogas Households and Non-Biogas Households used kerosene despite having access to electricity power supply due to irregular electricity supply. The average kerosene consumption in the VDC was 1.338 litres per month for Biogas Households and 1.34 litres per month for Non- Biogas Households. This showed in the study are, biogas has not yet been able to contribute in reducing kerosene consumption.

Bajgain and Shakya (2005) stated biogas can also be used for lighting however in the study area use of biogas is limited only as a cooking fuel. Kerosene is imported in Nepal and the use of kerosene in rural areas is limited to relatively well-to-do families. Under such context, if use of biogas plants could be extended for lighting purpose, the benefits of biogas could be considerably increased promoting interest towards biogas plants. This would also result economic benefits to Biogas

Households along with environmental benefits from replacement of imported fuel kerosene.

5.2.3 Benefits of Biogas on Health and Sanitation

The study in the Chilindin VDC showed increased toilet construction among Biogas Households which was comparable to IEIA (2002) study carried out by SNV/BSP and also to the study made by CMS (2007). In the study area, most of the Non-Biogas Households have traditional stoves with poor ventilation in kitchen room as found by Panday (1989). The study showed significant percentage of reduction in the incidences of eye problems, respiratory diseases, diarrheal diseases and headache after biogas installation as that revealed by the study of RUDESA (2002) in Kaski and Tanahun district. The findings of the study were also compatible to the result of Biogas Users Survey done by BSP (2007). 46

Improved sanitation and reduction in smoke in kitchen are two basic reasons that imply for better health status. The indoor climate among Biogas Households had improved as a result of using biogas stoves instead of fuelwood. This could have contributed to significant improvement in health among Biogas Households.

5.2.4 Time Saving and Workload Reduction

In the surveyed VDC, biogas installation provided each Biogas Household an average saving of 40 minutes per day. The saved time was relatively lower compared to a saving of 93.2 minutes per day as studied by CMS (2008) but the reduction in the physical stress in terms of fuelwood collection, cooking and cleaning utensils was remarkable.

In the study area, Biogas Households used the time saved in better care of family, maintaining household cleanliness; collection of fodder for livestock, social gathering but alternative income generating activities was not noticed. The lack of motivational organizational efforts, trend of younger generation migrating to cities or abroad and lack of market for the production could be the major constraints in encouraging the people in the surveyed VDC towards alternative income generating activities.

5.2.5 Benefits of Bio-slurry

The review of previous studies entailed compared to farmyard manure, bio-slurry has more nutrients because in farm yard manure, the nutrients are lost by volatilization. According to BSP (2006), operational biogas plants replace chemical fertilizers with 280 thousand tones of bio-fertilizer.

Unexpectedly, in the surveyed VDC, Biogas Households used 5.53 percent more urea than Non-Biogas Households. This created ambiguity in associating higher paddy and maize yield among Biogas Households with the effectiveness of bio-slurry. In the VDC, farmers seem not to realize the importance of the digested slurry and had misconception that slurry coming out of biogas might have lost its fertilizer value as gas is generated during the anaerobic digestion process which also significantly affected payback period of biogas installation.

Chemical fertilizers are imported in Nepal and are expensive and at times, are not available. If the use of bio-slurry could be effectively promoted, Biogas Households would be economically benefited through replacement of chemical fertilizer and sustainable agricultural production from organic fertilizer. This could further encourage the installation of new biogas plants.

5.2.6 Economic Benefits

In surveyed VDC, the installation of biogas plants reduced the annual fuel wood consumption by approximately 1.9 tones per household and provided each Biogas Household an equivalent saving of NRS. 7783.12 per year at the local rate of NRs. 160 per bhari.

The variation in the rate of fuel wood in different areas can cause the variation in saving from fuel wood from biogas operation. In the study area, fuel wood was collected mainly through household labor which was not given monetary significance causing minimal expense for fuel wood. However more significant is there is unanimous result of saving of unsustainable energy source fuel wood which in future is likely to be very crucial both economically and environmentally.

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

5.2.7 GHG Reduction and CDM Approach

The total annual GHG emission by consuming fuel wood and kerosene was 6357 kgCO2e/yr/HH for Non-Biogas Households and that including methane leakage from slurry tank was 448.91 kgCO2e/yr/HH for Biogas Households.

According to Shrestha et al. (2003) the biogas plants of sizes 4, 6 and 8 cu.m mitigates about 3, 4 and 5 tonnes of carbon dioxide per plant per year in the hills and study by Winrock and Eco Securities et al. (2004) shows the available carbon reduction per plant is 4.6 tones of CO2 equivalent. Devkota (2007) calculated each biogas plant of 6 cu.m reduces 4.9 tons of carbon dioxide equivalents per year. Similarly AEPC (2008) capped the GHG reduction rate at 4.99 tonnes per year per plant.

Based on the study, in Chilindin VDC, the total resultant annual GHG reduction comparing the Biogas Households and Non-Biogas Households was 2.37 tons of CO2 equivalent and that comparing Biogas Households before and after biogas plant installation amounted 2.496 tones of CO2 equivalent. In the study site, each biogas system reduced approximately 2.4 tones of GHGs per system per year. In the surveyed VDC the reduction in GHG emission was limited within the replacement of fuelwood from biogas use with no share of displacement of agricultural residues, animal dung and kerosene causing relatively lower reduction in GHG emission.

The biogas programme has been the first CDM Project in Nepal and based on the study, if claimed under CDM, each biogas plant in the VDC was likely to bring Nepal an Annual Carbon Revenue of around US $39.90 per year. This can play a significant role in financing biogas projects in rural communities.

5.2.8 Investments Aspects and Payback Period of Biogas Plants

The study in entailed as in the national context, in Chilindin VDC, majority of plants (73.33 %) were of 2 cu.m and with the average plant size 2.53 cu.m in the VDC, the average total investment cost for installation of biogas plant was NRs. 34,800 per plant. The total installation cost was compatible to NRs. 35,156 per plant of 4 cu.m in the hills as quoted by BSP for the fiscal year 2007/08. The reason for the apparent variation in installation cost among respondents under survey could be due to the personal contribution made by the respondents during the construction work in the form of labor, variation in the year of construction, size of plants and the access for the delivery of construction materials.

Majority (26.66 %) of the biogas plant under survey were installed in the past two to five years which shows as stated by WECS (2006), the contribution of biogas in the residential energy sector is increasing. All the surveyed biogas plants were operational and 86.66 percent surveyed Biogas Households not incurred any repair and maintenance expenditure since the installation. The average annual maintenance cost per plant was below NRs. 300. The simple technology and high operational efficiency gives biogas its reliability.

According to calculation made by Devkota (2001), the pay back period is 6.1 years without subsidy and 4.1 years with subsidy and as calculated by Woods et al. (2006) without any subsidies the payback period biogas plant would be around 3.6 to 5.8 years. In Chilindin VDC, all biogas plants were installed under subsidy and the pay back period was very similar (4.6 years) with this data. According to Devkota (2001), the economic value of the bio-slurry shows that the investment can be gained back in three to four years. Thus, generating awareness about bio-slurry could thereby further reduce the payback period of biogas plant installation. Furthermore, if the use of biogas could be extended for lighting purpose, biogas could significantly reduce the expense in kerosene.

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

CHAPTER-SIX

SUMMARY CONCLUSION AND RECOMMENDATIONS

6.1 Summary

The study area is situated in the elevation between 125 to 1865 m from the mean sea level at the south-western part of the Phidim(Headquarter of the Panchthar District).There was not any community forest. So the people were totally depended on privet forests for fuel wood collection, therefore demand and use of Biogas was very high in that area.

The average fuel wood consumption was 375.33 kg per month for Non-Biogas Households where the Biogas Households consumption was 213.55 kg per month. Similarly the installation of Biogas plants the reduction of fuel wood was over 1.95 tones and each Biogas plant installed in the VDC protected over 0.058 ha forest per year. It shows that a considerable saving of fuel wood per year per Household among biogas Households.

In the study area 100 percent of surveyed Biogas Households had toilet. It shows that effect on cleanness and sanitation was quit visible in the study area. The change sanitation cleanness had been a matter of great satisfaction brought about by Biogas. Similarly the study revealed that the smokeless Biogas had greatly benefited the plant owners by contributing to significant reduction in eye related problems and respiratory diseases etc.

By the cause of the similar trends of kerosene consumption among both Non-Biogas Households and Biogas Households the Biogas use had not contributed in reducing kerosene consumption and total resultant annual GHG reduction. So GHG reduction was only through reduction in fuel wood consumption. Comparing Biogas Households and Non-Biogas Households it was 2368.936 kgCO2e/plant/yr/ and that comparing Biogas Households before and after Biogas installation amounted 2493.0702 kgCO2e/plant / yr. Each Biogas system in the study area would reduce 2.1 tones of GHGs per year per system. Based on the study each Biogas plant was likely to bring Nepal and annual carbon Abatement Revenue of around US$ 39.90 per year if claimed under CDM.

From the findings, it can be conducted that the shortage of fuel wood seems to be the main reason for installing Biogas. Users of Biogas satisfied with the plant operation.

The reasons for the justification are smokeless kitchen, efficiency cooking, and washing utensils, saving fuelwood and testy food.

6.1 Conclusion

The study with field survey conducted during May2012, explored the beneficial aspects of biogas plant installation in Chilindin VDC. According to the overall study we can conclude the research in the following paragraphs:

The study found that in the VDC, the people were fully dependent on private forests for fuelwood because there was not any community forest so the use of biogas was limited for cooking daily human food with no use in lighting purpose. Despite significant reduction in fuelwood consumption with biogas installation, with collection of fuelwood through self-wage, the equivalent income saving was comparatively low.

In the VDC, use of kerosene was limited within lighting purpose and kerosene consumption trend was similar among both Biogas Households and Non-Biogas Households thus, biogas has not yet been able to contribute in reducing kerosene consumption.

Installation of biogas and replacement of fuelwood reduced the annual GHG emission from total of 6397.19 kgCO2e/yr GHG for a Non- Biogas Household to 4101.46 kgCO2e/yr GHG (including 448.91 kg CO2e/yr/plant from slurry tank) for a Biogas Household.

The improved indoor environment, reduced incidences of disease occurrence, better sanitation around house premises and ease in daily household activities showed better livelihood condition among Biogas Households compared to Non-Biogas Households in the VDC. However, lack of motivational organization and increasing trend of out-migration of younger generation to cities and more recently to foreign countries could not stimulate to use saved time in alternative income generating activities.

The reduction in fuelwood consumption after biogas operation provided an annual protection of over 0.058 ha of forest area per household. Further, if the technically potential biogas plants in the VDC be installed, could annually save a total of 151 trees. Thus, biogas installation has significant environmental benefits.

Each biogas system in the study area would reduce approximately 2.1 tones of GHGs per year per system. Based on the study, if claimed under CDM, each biogas plant in the VDC was likely to bring Nepal an Annual Revenue of around US $ 39.90 per year. The Carbon Revenue generated from avoided GHG emissions is an important mean to establish biogas as a self-sustainable technology.

In the VDC, the promotion of bio-slurry as potential fertilizer seemed to be highly essential to enhance the beneficial prospects of biogas and to reduce the payback period of biogas installation. The study concluded the high initial investment is one of the main constraints that hinder the rapid diffusion of biogas in rural communities. In case of slight increase in subsidy and increased biogas promotional activities, the VDC has appreciable biogas possibilities.

In overall, the study concluded direct and indirect benefits, simple technology and high operational efficiency makes biogas viable and feasible technology in rural setting.

6.2 Recommendations

Based on the study and findings the following recommendation has been purposed:

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

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

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

• Lack of financial capabilities to invest in biogas plants among poor farmers in rural areas is one of the biggest challenges. Possible solutions to this should be explored.

• The Clean Development Mechanism (CDM) can help finance further biogas growth in developing countries. More research should be made in biogas and related aspects of CDM to obtain supportive data and information.

• According to findings, the policy of promotion of biogas in context of rural part of Nepal is appropriate.