ROLE OF BIOGAS FOR EMISSION REDUCTION OF GREENHOUSE GASES, A STUDY FROM DAMAK MUNICIPALITY OF JHAPA DISTRICT

Master of Science Thesis

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LETTER OF RECOMMENDATION

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This thesis bears the candidate's own effort and is in the format as required by the Central Department of Environmental Science, Tribhuvan University. We therefore recommend her work for the approval.

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LETTER OF APPROVAL

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ABSTRACT

Burning of fossil fuel and extensive use of fuel wood are the major sources of green house gas emission in Nepal. It can be reduced by the use of biogas. The field work was conducted on January and February of 2010. This thesis work tends to calculate the emission reduction of greenhouse gases by the use of biogas at Damak municipality of Jhapa district. The study estimates the benefits of using biogas over the traditional use of fuel wood. Both primary and secondary data collection and analysis were done. Primary data were collected through questionnaire survey, focus group discussion; key informants interview and field visit whereas the secondary data were gathered from the review of related literature, publication from various organizations and related websites.

There was a considerable reduction in the consumption of fuelwood at the surveyed households after the installation of the biogas plant. Reduction in fuelwood consumption consequently reduces the emission of greenhouse gases. There was a reduction of 7.99 tons of carbondioxide equivalent per households per year due to reduction in consumption of fuelwood. There was reduction in 0.0022 tons of Carbondioxide equivalent per households per year due to less consumption of LPG. But there was no reduction in the consumption of the kerosene at the study area after the installation of the biogas plant. There was an annual saving of NRs.21210.55 due to reduction in consumption of fuelwood and LPG at the study area. The payback period for the biogas plant that gets subsidy and economic incentives from community forest and those which do not get any subsidy are 1.58 years and 2.16 years respectively.

Key words*: Biogas Plant, Emission reduction, Greenhouse Gases, Payback Period*

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Bimala Adhikari

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LIST OF ACRONYMS AND ABBREVIATIONS

AEPC	Alternative Energy Promotion Centre
ARI	Acute Respiratory Infection
BGP	Biogas Plant
BSP	Biogas Support Programme
BSP/N	Biogas Sector Partnership Nepal
CBS	Central Bureau of Statistics
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CFCs	Chlorofluoro Carbon
CH_4	Methane
CO_2	Carbon Dioxide
CO_2eq	Carbon Dioxide equivalent
CO_2eq/yr	Carbon Dioxide equivalent per year
CO_2eq/yr/HH	Carbon Dioxide equivalent per year per households
CRT/N	Center for Renewable Technology Nepal
DGIS	Directorate General for International Cooperation of the Netherlands
DMO	Damak Municipality Office
ESAP	Energy Sector Assistance Program
g-C	Gram Carbon
GGC	Gobar Gas and Agricultural Equipment Development Company
GHG	Greenhouse Gas
GJ	Giga Joule
GoN	Government of Nepal
Ha	Hectare
HDCFOP	Humse Dumse Communiy Forest Operational Plan
HHs	Household
IAP	Indoor Air Pollution
ICS	Improved Cooking Stoves
IET	International Emission Trading
INGO	International Non Governmental Organization
IPCC	Intergovernmental Panel on Climate Change

	Krediltanstalt fuer Wiederaufbau of Germany,
Kfw	A German Bank Financing for Development Projects
Kg	Kilogram
$kgCO_2eq/HH/yr$	Kilogram of carbon dioxide equivalent emitted per HH annually
LPG	Liquefied Petroleum Gas
m^3	Meter Cube
MT	Metric tons
NBPG	Nepal Biogas Promotion Group
No.	Number
NRs	Nepalese Rupees
PV	Photo Voltaic
SLC	School Leaving Certificate
TCS	Traditional Cooking Stoves
TU	Tribhuvan University
UNFCCC	United Nation Framework Convention on Climate Change
US$	United States Dollar
VDC	Village Development Committee
VER	Verified Emission Reduction
WECS	Water and Energy Commission Secretariat
WHO	World Health Organization
Yr	Year

CHAPTER I

1. INTRODUCTION

1.1. Background

Energy is a means for performing activities (Rathore, 1994). In Nepal, overall energy resources can be categorized into three types these are traditional, commercial and alternative (Nepal, 2009). Traditional energy resources include fuel wood from tree and forest resources, agricultural residues coming from agricultural crops and animal dung in the dry form. Traditional energy resources are biomass energy resources. Energy resources coming under the commercial or business practices are grouped into commercial energy resources that particularly include the coal, grid electricity and petroleum products. Biogas, solar power, wind and micro level hydropower are categorized into the alternative energy resources in Nepal (WECS, 2010).

Renewable sources can be replenished through natural process in nature and can contribute towards reduction in dependency of fossil fuels (Rathore, 1994). Nepal has great potential of renewable sources of energy like biogas, solar and micro hydro but due to the lack of skilled manpower, people continued to relies on traditional way of energy utilization like fire wood, agricultural waste and animal dung (APCTT-UNESCAP, 2009).

Nepal is the highest traditional fuel consuming country in Asia because of its high dependency on traditional biomass fuel and limited extend to charcoal and imported fuel (WECS, 2010). These biomasses are used in preparing food, animal feed, processing of livestock products etc (Bhattarai, 2004).

According to Ely, (2005), the major portion of energy consumption is occupied by the renewable sources of energy in Nepal but the use is not in sustainable way. Total energy consumption in the year 2008/09 was about 9.3 million tons of oil equivalents in the country out of which 87% were derived from traditional resources, 12% from commercial sources and less than 1% from the alternative sources (WECS, 2010).

The heavy dependency on firewood for energy is leading to the deforestations in Nepal (Morris, 2008). According to Devkota, (2003), biogas helps in reducing deforestation because majority of the biogas owner use the gas for cooking purpose.

1.1.1. Energy consumption scenario of Nepal

The overall energy consumption of Nepal is largely dominated by the use of traditional non commercial forms of energy such as fuelwood, agricultural residues and animal waste (WECS, 2010). About 95% of the total energy is consumed in the domestic sector of which 90% is used for cooking only (CRT/N, 1999). Fuelwood was the largest energy resources in Nepal providing about 77% of the total energy demand in the year 2008/09. Other biomass based fuels are agricultural residues and animal dung which contribute about 4% and 6% respectively. Share of petroleum fuels in the total energy system is about 8%. Other sources of commercial energy are coal and electricity both of which contributes about 4% in the total energy supply (WECS, 2010).

Nepal does not have proven and significant deposits of fossil fuel due to which people rely heavily on the traditional energy sources such as fuelwood, agricultural residues and animal waste. In Nepal less than 2% total energy demand is being met by electricity and 9.8% by petroleum products. Due to lack of much industry, Nepal has a very low per capita energy consumption which is only 15 GJ and is one of the least energy consuming countries in the world (APCTT-UNESCAP, 2009).

1.1.2. Fuelwood and indoor air pollution

Combustion is the complex sequences of chemical reactions of fuel and oxidant accompanied by the production of heat or both heat and light. Smoke is the result of incomplete combustion of the fuel wood. The emission of smoke depends on fuel type, types of stoves and temperature of the fuel wood and the wind condition of the burning site (WINROCK, 2004).

The burning of fuelwood, dung cakes, straw and agricultural residue creates many hazardous particles, since cooking is usually done indoors this can lead to severe health problems (Smith, 2006). The particles in smoke can go deep into the lungs and these particles alone or combination with other air pollutants can cause acute respiratory diseases such as lung cancer, asthma, chronic bronchitis and irreversible damage to air sacs to those who are in contact with the smoke (Miller, 2004). In Nepalese society there is a gender specific problem in cooking; always female have to cook for their family members, so female are more vulnerable to air pollution (Tamrakar, 1998).

Indoor air pollution, especially smoke generated from burning solid biomass fuel in kitchens, is a major environmental health issue in Nepal (CBS, 2004). According to Pradhan, (2009), biomass fuels such as animal dung, crop residues and wood, which are considered the most polluting fuels, lie at the bottom of the energy ladder, and are used mostly by the poor people in Nepal (Pradhan, 2009). In Nepal these fuels are typically burnt in open fires or poorly functioning stoves with poorly or non ventilated kitchen due to which of hundreds of women and children are exposed on a daily basis (Panta, 2007).

1.1.3. Greenhouse gases (GHG) and climate change

Greenhouse gases are those gases that absorb infrared radiation and trap the heat in the atmosphere causing an increase in the average surface temperature of the Earth over time (UNFPA, 2009). The greenhouse gases (GHGs) cause the global warming by absorbing some of the infrared radiation radiated by the earth surface which ultimately increases the average temperature of the earth surface (Critchfield, 2007). According to Miller, (2004), global warming is the warming of the earth's atmosphere due to increase in the concentrations of one or more GHGs primarily as a result of human activities. According to Kafley, (2007), three gases have more potential for the direct greenhouse effects which are Carbondioxide (CO_2), Methane (CH_4) and Nitrous oxide (N_2O).

Climate refers physical properties of the troposphere of an area based on analysis of its weather records over a long period of time (at least 30 years) (Miller, 2004). Due to natural variability or as a result of human interventions, there is gradual increase in the emission of the greenhouse gases (Gautam, 2007). The effect of heat trapping due to the increase in GHG enhanced greenhouse effect which causes global warming and subsequent result of warming leads to climate change (Melkania, 2007). UNFCCC defines climate change as "a change of climate is attributed directly or indirectly to human activity that alters the composition of the global atmosphere" (UNFCCC, 2006).

The main gases that play significant role for the warming of the earth surface and consequently leads to climate change are CO_2, CH_4, N_2O, Chlorofluorocarbons (CFCs) etc (Pradhananga, 2010). The main sources of these gases are anthropogenic in nature, fossil fuel burning especially coal, deforestation and plants burning. As well as landfills, coal production and natural gases leakage from oil and gas production are sources of CH_4 (APCAEM, 2008).

Most of the green house gas emissions, responsible for world's current climate change, can be traced to human activities over the last 200 years (Khatiwoda, 2011). The biogenic and non biogenic energy production and consumption patterns of humans particularly in industrialized countries resulted in high concentration of some of these gases specially CO_2, CH_4 and N_2O. Also some other solely manmade gases like Chlorofluoro carbons, Hydro-chlorofluoro carbons, Bromo-fluorocarbons and Sulphur hexa fluoride also causes the global warming (Sarkar, 1998).

Although Nepal's total GHG emission share is negligible compared to global community, Nepal has already encountered some of the negative effects of global climate change (Agrawala, 2003). According to Department of Hydrology and Meteorology (DHM) average annual temperature of Nepal is increasing at an approximately $0.06^{O}C$ per year (DHM, 2011).

1.1.4. Main sources of alternative energy in Nepal

According to WECS (2010), residential sector consumed almost 89% of the total energy consumption of Nepal in 2008/09. Biomass resources are the major fuels used in this sector, namely fuel-wood, agricultural residue and the animal waste. Now a day's renewable sources like biogas and electricity from micro-hydro and solar home systems are substituting conventional fuels used mainly for cooking and lighting.

According to the AEPC (2009), cited in WECS (2010) the main sources of alternative energy in Nepal are:

1.1.4.1. Hydropower and micro-hydro power

Nepal is a country with enormous water resources. The theoretical hydropower potential has been estimated to be 83,000 Mega Watt (MW) of which 42,000 MW is technically feasible. Hydropower utilization is currently about 1.5% of the proven potential (Chaulagain, 2006). The total installed electricity generation is about 613.5 MW, out of total generation, 603 MW are hooked to the national grid and the remaining are in isolated system comprising of 40 small/mini hydro plants, about 2000 micro hydro and about 1200 peltric sets serving the remote areas of the country (APCTT-UNESCAP, 2009).

Micro-hydro power can be used to power TV, radios, and various household electric appliances. Hydro electricity is also a clean and renewable form of energy. Government of Nepal (GoN) with the assistance from the Kingdom of Denmark has jointly initiated Energy Sector Assistance Programme (ESAP) that provides a comprehensive subsidy program for micro-hydro power. Micro hydro has no any contribution in the residential sector energy consumption in Nepal till 2008/09 (WECS, 2010).

1.1.4.2. Biomass energy

Biomass resources are the major fuels used in residential sector, namely fuelwood, agricultural residue and the animal waste. According to WECS (2010), the residential sector consumed almost 89%, agriculture residue contributes 3.7%, animal dung contributes 5.7% and biogas contributes only 0.6% of the total energy consumption in Nepal at the end of 2008/09.

1.1.4.3. Solar energy

Two types of solar energy technologies, namely solar thermal and solar photovoltaic (PV) systems, are available in Nepal. Solar thermal systems include solar water heaters, solar dryers and solar cookers. Solar PV systems include solar communication systems, solar electrification systems, and solar pumping systems.

Using solar energy for lighting purpose has become popular in Nepal since 1993. More than 2600 units of solar home system with a total generation capacity of about

100 KW have been installed in Nepal (WECS, 2010). Solar home system constitutes above 5000kWp with 185017 numbers until 2008/09 (AEPC, 2010).

1.1.4.4. Wind energy

Although wind energy is one of the cheapest and cleanest renewable energy sources, wind is still unharnessed energy resource in Nepal (WECS, 2010). Due to its diverse topography and the consequent variation in the meteorological conditions, it is difficult to generalize wind conditions in the country thus wind energy is not in practice for commercial and residential sector till now (CRT, 2005).

1.1.4.5. Biogas

Biogas is produced when organic material is digested in an anaerobic environment (Wargert, 2009). The organic materials which are being used in the production of biogas are typically consists of animal dung, human excreta, cattle manure, waste water, kitchen waste etc (Lunkhimba, 2010). The most common biogas plants used in developing countries are small household based fixed dome models. Household biogas plants commonly use kitchen wastes, toilet wastes and cattle manure (BSP/SNV, 1998).

Biogas is the mixture of gas produced by methanogenic bacteria while acting upon biodegradable materials in an anaerobic condition (Edem, 2010). This gas is principally composed of CH_4 and CO_2. Methane is virtually odorless and colorless and burns with a smokeless clear blue flame and is non toxic in nature (Wargert, 2009). The technology of the plant itself is quite simple: cow dung goes in, gas comes out. Some systems are also connected with toilet which helps in improving sanitation and boosting gas production. The Nepali biogas plant design uses an airtight underground digester, where dung is put in and then stirred with some water. In Nepal, a fixed dome design, the GGC 2047 model (Fig 1.1) is popular (BSP, 2006).

The estimated total technical potential of biogas plants is about 1.9 million plants of which 1000000 plants are thought to be economically viable (APCTT-UNESCAP, 2009). At the end of December 2008/09, more than 200000 biogas plants of varying capacities (4, 6, 8, 10, 15 and 20 m^3) have been installed (BSP, 2010).

1.1.5. Characteristics of biogas

Biogas is a combustible gas produced by anaerobic fermentation of organic materials by the action of methanogenic bacteria (BSP/SNV, 1998). The approximate composition of biogas, which could vary according to the experimental condition, is given in Table 1.1.

Table1.1: Average Composition of biogas

S.N.	Constituents	Percentage (%)
1	Methane	50-70
2	Carbon Dioxide	30-40
3	Hydrogen	5-10
4	Nitrogen	1-2
5	Water vapor	0.3
6	Hydrogen sulphide	Traces

(Source: BSP, 2009)

1.1.6. History of biogas

Biogas for the first time was discovered by Alessandro Volta in 1776, but the presence of combustible gas CH_4 in the farmyard manure was pronounced by the Humphery Davy in the early 1800s (Bajgain, 2005).

1.1.7. History of biogas in Nepal

In 1955 biogas plant was introduced for the first time in Nepal by the effort of school teacher, late father B.R. Saubolle at St. Xavier School, GodaBhari in Kathmandu (Karki, 2007).

On the year of 1975/76 Department of Agriculture planned a programme to install 250 biogas plants during agriculture year and in 1977 Biogas and Agricultural Equipment Development Company was established (GGC) in collaboration with Asian Development Bank (ADB) and Nepal Fuel Corporation and involved in developing and testing of biogas designs, appliances, fabrication and installation (Devkota, 1998).

The Biogas Support Program (BSP) started in July 1992 with funding from the Directorate General for International Cooperation (DGIS) of the Netherlands government through the Netherlands Development Organization (SNV/N) in Nepal to develop and promote the use of biogas in Nepal (Devkota, Undated). Government of Nepal (GoN) and the Kreditanstalt fuer Wiederaufbau of Germany (KfW) also started funding the BSP from Phase–III. In 1994 in Nepal there was introduce the Nepal Biogas Promotion Group (NBPG) for the promotion of the biogas. Likewise Alternative Energy Promotion Center (AEPC) was introduced on the year of 1996 (Karki, 2007).

1.1.8. Present status of biogas programme in Nepal

From July 2003 to June 2009 4th phase of biogas programme has been started. Biogas Sector Partnership Nepal (BSP/N) was introduced for further development and dissemination of biogas technology in rural areas of Nepal targeting to install 200,000 biogas plants. At present 72 biogas companies working in 65 districts with more than 180 branches and 16 appliances manufacturers are actively involving in the manufacture of the biogas appliances. Agricultural Development Bank Nepal (ADB/N), Rastriya Baninjya Bank (RBB), Nepal Bank Limited (NBL) and 173 micro finance companies are providing loan for the installation of biogas (Devkota, 1998). Table 1.2 gives the details about the number of biogas plant constructed at different phase under BSP.

Table 1.2: Number of BGP at different phase

	Phase I	Phase II	Phase III	Phase IV	Total
Year	(92-94)	(94-97)	(97-03)	(03-07)	
No of plant constructed	6824	13375	91196	61110	172505

(Source: Nepal, 2008)

1.1.8. Description of GGC 2047 Model

The Chinese fixed dome model biogas system (also called drum less digester) was built in China as early as 1936 (CMS, 1996). The fixed dome model was introduced in Nepal in 1980. After several modifications, the fixed dome design (GGC model Fig 1.1) was approved in 1992. BSP-Nepal made further modifications and recommend the "Modified GGC 2047" model .The GGC 2047 systems are available in 4, 6, 8, 10, 15 and 20 m^3 volume. However, fixed dome biogas plants of 5, 7, 9 and 12 and larger sized fixed dome biogas plants of 75 m^3 and 100 m^3 especially for running engines had also been designed (BSP 2008).

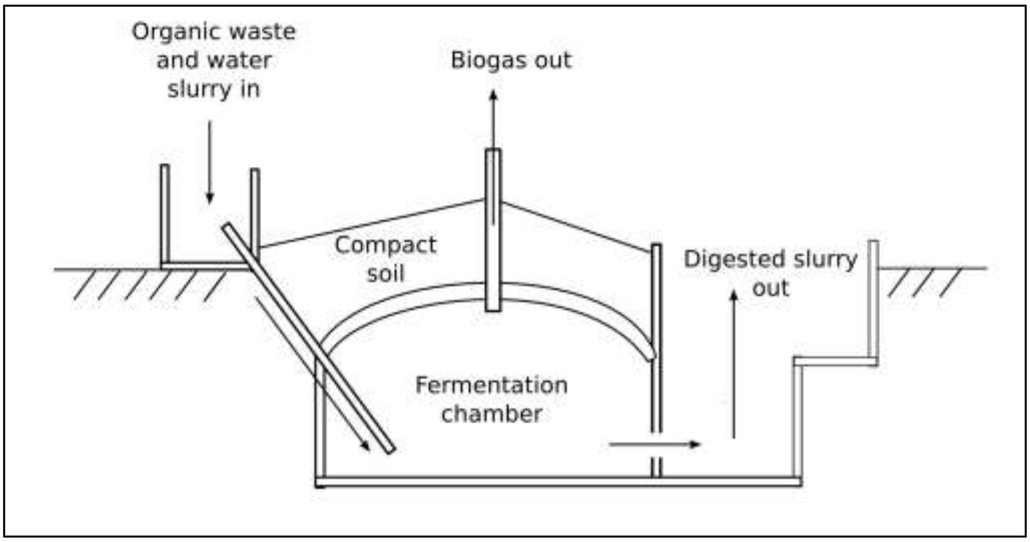

Figure 1.1: Biogas Map –GGC 2047 Model Fixed Dome Biogas System (Source: Bajgain, 2005).

1.2. Statement of the problem

About 85.8% of the total population live in rural areas of Nepal and meet their energy demand from biomass combustion, particularly firewood, while about 15% of the total population living in urban areas depends on non-renewable form like Liquid Petroleum Gases (LPG) (CBS, 2004).

Nepal's total greenhouse gas emission share is negligible compared to global community; Nepal has already encountered some of the negative impacts of climate change (Gautam and Kedar, 2007). Water vapor, CO_2, CH_4, Nitrous Oxide (N_2O) and Chlorofluoro Carbons (CFCs) are the major gases that play important role in the greenhouse effect. Among the GHGs CO_2, CH_4 and N_2O are the 3 major gases which contribute about 88% roles in global warming. Over the last 3 decade, GHGs have been increased by an average of 1.6% per year (Malla, 2008).

About 85% of the people at Damak are dependent on the agriculture (DMO, 2010). Nepal's agricultural system is mainly based on human labor and is of traditional type which needs supports of animals as well. The dung obtained by the animals if used to produce the methane gas via adoption of biogas the local people may be benefited in two ways. The first and the foremost benefit is to solve the fuelwood problem and the next is to get clean indoor environment and better management of dung and human excreta.

According to BSP, (2009), there are 1,310 biogas plant at Damak municipality that cover only 12% of the total HHs. Rest of 88% HHs still depends on traditional fuelwood and LPG to fulfill their energy demand. Biogas thus plays an important role in less consumption of fuelwood for cooking which ultimately conserve the forest and substitute the imported fertilizer. This makes rural people self sufficient in energy and fertilizer. Thus the role of biogas must be quantified in terms of local, environmental and health benefits. This will also helpful for the local to understand the benefits of biogas and for the encouragement for the installation too.

1.3. Research questions

- Is there significant reduction in emission of GHGs by the use of biogas in the study area?
- In how many years the total investment cost of the BGP is refund; i.e. payback period of the BGP.

1.4. Objectives of the study

The main objective of the present research is to study the role of biogas plant in reducing the emission of green house gases in Damak municipality of Jhapa district. Whereas the specific objectives are:

- To quantify the reduction in emission of GHGs after the installation of biogas plant.
- To calculate the average save in expenditure due to non-burning of the fuelwood and saving from the Liquid Petroleum Gases (LPGs).
- To calculate the payback period for biogas plant.
- To find out the health, environmental and economic benefits of biogas plant.

1.5. Scope of the study

This research was mainly focused on the effectiveness of biogas plant for the emission reduction of GHGs at the Damak municipality of Jhapa. For the completion of the research, primary data were collected with the help of structured questionnaire for which a total of 80 HHs were selected out of 1310 BGP containing HHs by following the linear systematic sampling method. The 4 wards (Ward No. 10, 11, 12 and 13) of the Damak were excluded from the sampling frame because they are located at the core market area. The scope of the research includes the collection of secondary data from different websites, and collection of literature from different institutions relevant to the study. Questionnaire was developed in such a way to get the every information on past and present fuelwood, LPG and kerosene consumption pattern and role of BGP on human health and sanitation condition. Then the collected data were analyzed to find out the real role of biogas for the emission reduction of GHGs.

1.6. Limitations of study

Following were some limitation of the present study

- The 4 wards of Damak municipality (Ward No. 10, 11, 12, 13) were excluded because these wards of the study area lies in the core market (Bazar) area, where biogas alone cannot fulfill the energy demand due to lack of sufficient cattle dung. At two wards 11 and 12 there was no any biogas plant till the date of questionnaire survey.
- Methane leakage calculation in the study includes the leakage only from the slurry tank but not from the compost tank, inlet, pipes, valve and burner.
- Total emission of the GHGs was calculated during the cooking purpose only. The GHGs emission from the running of the vehicle was omitted during the research.

1.7. Overview of the contents

Chapter I covers the introductory parts including background of the study, objectives of the research, statement of the problems, scope and limitation of the study. Chapter II includes literature review regarding the study. Chapter III includes the research design, methodology for the collection of data, and results interpretation techniques. Chapter IV provides the brief glimpse of study area. Chapter V includes data analysis and major findings of the research. And chapter VI explains discussion of the result and findings on the socioeconomic, energy status, energy consumption patterns, fuelwood consumption pattern and impacts of BGP on local. Chapter VII includes conclusion and recommendations of the research.

CHAPTER II

2. LITERATURE REVIEW

2.1. Rural energy scenario in Nepal

In Nepal the energy available in the rural sector are: fuelwood, agricultural residue, animal waste, and in few quantity coal, petroleum and electrical power. Among these sources, the dependence is heavy on fuelwood and biomasses due to their local availability and affordability (WECS, 2010). The high demands on fuelwood increase the pressure on the forest resources. The existing energy consumption pattern in Nepal is not in sustainable this may lead to rapid degradation of the natural environment and threaten the livelihood of the people if sustainable and timely interventions are not introduced. The environmental consequences arises from the imbalance of resources are loss of soil fertility, loss of agricultural production, desertification and ultimately climate change (Gautam and Kedar, 2007).

2.2. Kyoto Protocol and Clean Development Mechanism (CDM) in Nepal

The Kyoto Protocol was formed in 1997 by the United Nations Framework Convention on Climate Change (UNFCCC) to combat global warming. Signed by 175 countries, it aims to reduce the green house gas emissions by 5.2% below the 1990 levels by 2012. Developed countries are categorized under Annex 1 countries and are legally bound by the protocol while the developing nations, categorized as Non Annex 1 countries, which ratify the protocol, are not legally bound by it. The Kyoto Protocol has three mechanisms: Joint Implementation (JI), CDM and International Emission Trading (IET). The CDM mechanism allows Annex 1 countries to meet their reduction targets by implementing emission reduction projects in Non Annex-1 developing nations. A certified emission reduction (CER) is a certificate given by the CDM board to the projects in developing countries to certify that they have reduced GHGs emissions by one metric ton of carbondioxide equivalent (CO_2eq) per year. These CERs are bought by the Annex 1 countries to meet their emission reduction targets (UNFCC, 2010).

2.3. Nepal and carbon trading opportunities

After ratifying the Kyoto protocol earlier in 2005, as a non Annex 1 country, Nepal can sell its carbon credits to Annex 1 countries and earn foreign exchange by purchasing Clean Development Mechanism (CDM) (HANDS, 2006).

Nepal has a large potential to develop CDM projects any sector where use of unsustainable firewood or fossil fuels can be replaced with clean energy will qualify. Nepal's biogas is considered to be the most advanced CDM project of the country . Each BGP prevents 5 tons of CO_2eq from being released to the air in one year. The market price of CO_2 costs nearly US $ 7 per kg of CO_2 (UNFCCC, 2010).

Other potential CDM projects in Nepal includes ICS, electric vehicles, micro hydro, solar system, wind energy, methane captured from the landfill sites, low emission brick kilns, hydropower for replacement of the fossil fuels and for the protection of the forest (Aryal, 2006).

2.4. Biogas plant and Clean Development Mechanism

Biogas is the first CDM project in Nepal (BSP, 2009). In December 2005; 19, 396 plants under BSP phase IV, has been registered and approved by the CDM approved Board. An emission reduction purchase agreement (ERPA) for the two projects for first seven years starting 2004/05 as the first crediting year at the rate of US $ 7 per tons of CO_2eq of GHGs was done. 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. From these two projects, the annual carbon revenue is around US $ 600,000 (CDM Executive Board, 2005). The table 2.1 given below gives the details of existing CDM project under BSP.

Table 2.1: Existing CDM project under BSP

Particulars	No. of Plants	Construction Date	Start Date of crediting year
BSP-Nepal Activity 1	9,708	1-Nov-2003 to 15-jun-2004	1-Aug-04
BSP- Nepal Activity 2	9,688	16-Jun-2004 to 6-Apr 2005	1-Aug-05

(Source: BSP, 2009)

2.5. Fuelwood used and greenhouse gases emission in Nepal

The adverse effects of unsustainable uses of biomass fuel especially fuelwood is immensely contributing to global warming resulting in increased concentration of the greenhouses gases (Smith, 2006). This accounts to damage on the earth system including increases in average temperature accompanied by the change in rainfall pattern, vegetation pattern and extremes on the weather condition collectively known as climate change (ICIMOD, 2009). Burning of fossil fuel and extensive uses of biomass are the major sources of GHG emission in Nepal (Ely, 2005).

2.6. Potential of biogas in Nepal from cattle dung

According to BSP (2009) in Nepal 1.02 million plants in Nepal can be constructed. Out of which 57% can be installed in plains, 37% in hills and rest of 6% are in remote hills or in mountain region (BSP, 2009).

2.7. Health impact on local people due to uses of solid biofuel

According to the World Health Organization (WHO), indoor air pollution from solid fuel burning was responsible for the deaths of 7,500 people and 2.7% of the national burden of air pollution related diseases in 2002. In Nepal, acute respiratory infections (ARI), Chronic Obstructive Pulmonary Disease (COPD) and Tuberculosis are among the top 10 causes of death (WHO, 2007). According to Smith (2005), biogas can play a strong role for the control of indoor air pollution and for the reduction of respiratory illness too.

2.8. Benefits of biogas

Some of the benefits of using biogas plant are as follows:

2.8.1. Social benefits

2.8.1.1. Health

The use of biogas significantly improves the indoor air quality because it burns without smoke. Since women and female children are predominantly involved in cooking, they are the first beneficiaries in terms of improved health. Moreover, since the combustion of biogas is relatively clean and it reduces eye ailments. In addition, dung management and sanitary toilets attached to biogas digesters lead to better hygienic conditions, helps to keep the areas surrounding areas clean and reduces the chances for the spread of infectious and other diseases (BSP, 2008).

According to the biogas user's survey, (2000), conducted in India, biogas can have positive impacts on the health of its user. Out of 42 respondents who had respiratory problems in the past, it was reported that the problem has improved for 34 of them. Similarly those who had problems like asthma, eye infections and lung problems found that their problems had decreased due to the not consuming of the solid biofuels.

2.8.1.2. Education

The saved time from due to the use of biogas has enabled female children to attend school, which previously was not possible as they were involved with HHs works as remove as well as add including collection of fuelwood and water. According to BSP, (2009), 20% of the HHs use biogas lamps for lighting purpose; this has provided convenient means for reading or study even in the evenings (BSP, 2008).

2.8.1.3. Save Time

Biogas is effective to create the smokeless indoor environment. This is also helpful to keep the cooking utensil cleaner. Cleaner utensil requires less effort to clean. And less attention required at the fireplace for continuous burning of the stoves. This saves the time during the cooking period. Time available can be utilized for other household activities. Biogas makes easy in cooking for the rural women who are using the biogas as the main fuel for cooking (BSP, 2008).

According to BSP Nepal, (2009), there are 200,000 HHs in Nepal with clean energy and saving an average of 3 hours per day in each HHs.

Vliet, (1993), studied on the effects of biogas on the workload of women in the village of Madan Pokhara in Palpa district of Nepal. According to him the resultant time saved due to the biogas plant was 1 to 2.5 hours/day/HHs. Biogas was helpful to reduce household work which used to take long time for completion like collection of fuelwood.

Shrestha, (2010), studied on the prospects of biogas plant in terms of socioeconomic and environmental benefits to rural community of Nepal. She found that some more works were added for the feeding of the BGP but finally there was decrease in the total working hours per days. In her study she found that for the smooth running of biogas more time is consuming for fetching water, livestock caring, dung collection and slurry mixing but there is decreases the consumption of time for fuelwood collection, cooking and cleaning utensil resulting an average saving of fifty minutes per day.

According to ICAR, (2000), the households having the BGP there was saving for firewood collection and cooking averages to almost saving of 1000 hours per year.

2.8.2. Environmental benefits of biogas plant

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

2.8.2.1. Local environmental benefits

The uses of biogas help significantly to improve the indoor air quality. In addition, installation of biogas systems has resulted in better management and proper uses of animal dung to feed the digester tank (BSP, 2008).

2.8.2.2. National environmental benefits

From the national perspective, biogas systems can help to check the deforestation. This in turn has important implications for watershed management and soil erosion. In addition the slurry obtained from the biogas that can restore the fertility of the soil and, helps to reduce the depletion of soil nutrients and reduces in the consumption of the imported fertilizer (BSP, 2008).

2.8.2.3. Global environmental benefits

Chand studied on mitigation and adaptation of climate change by using biogas of Kanchanpur district. The demand of the fuelwood among community forest user group was found to be 1038.81 kg/capita/yr where as among the biogas user the demand of the fuelwood was found to be 449.71 kg/capita/yr. The amount of the greenhouse gas emission reduction due to reduction in the fuelwood consumption was

8.02 tons per plant per year of CO_2eq. There was an annual saving of 10.15 trees per biogas plant per year. According to him, there was an average time saving of 2 hours and 24 minutes/HHs/day and most of the respondents were positive in fertilizer quality from the slurry obtained from the biogas plant (Chand, 2011).

According to energy synopsis report the most important socio-economic benefits of biogas plants are reduction of the workload of mainly women and girls. Three hours can be saved due to the biogas plant. Annual fuelwood savings of 2 tons/plant/yr, agricultural residue saving of 0.35 tons/plant/yr and dung cake saving of 0.35 tons/plant/yr. According to which there is as annual saving on kerosene of 25 liters per plant and annual reduction of GHG emissions at the rate of 7 tons per plant CO_2eq (WECS, 2010).

WWF, (2010), studied on Terai Arc Landscape area for the contribution of biogas for the reduction in emission of GHGs by decreasing the use of solid fuelwood. They calculate the volume of GHGs stepwise yearly emission and finally add them all to estimate the total volume of GHGs. They found that the emission reduction for 2007 was found to be 3034.56 tons of CO_2eq and for year 2008 the emission reduction was found to be 9090.49 tons of CO_2eq. They found that the total emission reduction was 12,125.05 tons of CO_2eq for crediting period 1^{st} July 2007 to 31^{st} December 2008.

There are 140,000 HHs which fully depends on biogas for cooking purpose. The biogas plants of Nepal have been helping to save 400,000 tones of firewood and 800,000 liters of kerosene, as well as preventing 700,000 tones of GHG from escaping into the atmosphere (BSP, 2010).

Shrestha, (2010), studied on the socioeconomic and environmental benefits of BGP in Gaikhur Village Development Committee (VDC) of Gorkha district. The non-burning of fuelwood provided an annual saving of NRs. 2653.2/HH. The total annual GHG emission was 3,656.65 kgCO_2eq/HH/yr and 6,025.54 kgCO_2eq/HH/yr for biogas and non-biogas households respectively. There was an annual savings of 2.4 tons/HH per year of GHGs and could bring a carbon abatement revenue of around US $17 under CDM. Accordingly biogas contributed in improved sanitation, reduction in smoke and significant reduction in respiratory and eye related disease.

According to BSP, (2009), 7.4 tons of GHG reduction/year/HHs, 250,000 trees protect per year and 6.4 liters kerosene saved per HHs per year.

According to BSP, (2009), there are a total of 111,395 biogas system installed until 2009 under SNV/BSP I, II and III. Out of these 97% are in operational stage with the production of 55 million m^3 biogas annually. From the installed biogas 222 thousand tons of fuelwood, 3.6 million liters of kerosene and replaces chemical fertilizers with 189 thousand tons of bio-fertilizer annually.

Yiwen, (2008), studied on patterns of energy consumption and farming activity in Miao Villages of Danzhai district of China. She found that before using biogas, local used to consume an average of 47.16 kg of biomass for cooking which turns 22.97 kg of dry biomass. After implementation of the biogas tank, the equivalent dry firewood extraction from trees used for cooking was estimated 13.03 kg per day per household. The savings of dry firewood due to the biogas tank were then assessed of 9.94 kg of equivalent dry firewood extracted from trees per day per household.

Shrestha, (2007), studied on domestic biogas plants in Nepal specially its contribution in greenification of semi arid land and avoidance of GHGs emission. The calculation was based on 140,000 BGP installed as of mid July 2005. They found that the total annual GHG reduction potential from the BSP installation till mid July 2005 was 1,857,636 tons CO_2eq.

Sigdel, (2006), studied on the development of biogas energy and its impact on users in Raipur VDC of Nepal. Accordingly the biogas was used for cooking purpose only and there was saving of only 10 minutes each day but there was a remarkable reduction in the fuelwood consumption after the installation of the biogas plant which was 1860 kg of fuelwood per year per HHs.

According to Bajgain, (2005), the available carbon reduction per year per system from the displacement of fuelwood, agricultural wastes, dung and kerosene is nearly 4.6 tons of carbon equivalents (CO_2eq). The net CO_2 emission savings from the use of biogas as against the use of fuelwood and kerosene is presented in table 2.2 given below.

Table 2.2: Net GHG savings per biogas system

Size of the biogas system	Terai	Hills	Mountain
4 m^3	2.56	2.68	2.77
6 m^3	5.83	3.92	4
8 m^3	7.56	4.59	4.7
10 m^3	5.98	3.67	3.37

Tons of CO_2 equivalent/biogas system/year

Source: Winrock & Eco Securities *et al*. 2004 cited in Bajgain, 2005.

According to BSP, (2005), the different sizes of biogas plants at different locations have different emission reduction capacity. The table 2.3 gives the details about the size of BGP, and emission reduction at different location per households.

Table 2.3: Emission reduction per households

	tCO₂eq/BGP/yr		
Size of biogas (m^3)	Terai	Hills	Mountain
4	2.94	5.43	5.43
6	6.83	7.6	7.6
8	8.45	9.42	9.42
10	6.61	7.03	7.03

(Source: BSP, 2005)

Khanal & Bajracharya, (2005), a research team of IUCN works on the Tinjure Milke Jaljale area to quantify the reduced volume of GHGs after the installation of ICS. The study demonstrated that, there was a significant reduction in the emission of the CO_2 due to the use of the ICS. Before adopting ICS, the total amount of CO_2 emission was 14.9 MT/HHs/yr which was reduced to 8.42 MT/HHs/yr after the installation of ICS in 71 sampled households in the project site which is equivalent to 6.66 MT per households per year1. The research also revealed that after using ICS technology, each household from the sampled households contributed about 1.52 MT Carbon to be sinked in the community or natural forest in the project area.

According to Bajgain, (2005), with the installation of biogas systems, the annual reduction of fuelwood per HH was 2 tons. There were 111,000 systems in operation which helps annual savings of 222,790 tons of fuelwood, which consequently protect the 6,790 ha of forest per year.

According to ICAR, (2000), with the installation of a single BGP there was an annual saving of more than four tons of firewood and 32 liters of kerosene. A single biogas system with the volume of 2.8 m^3 can save as much as 0.3 acres (0.12 ha) of forest each year. And each biogas plant can mitigate about five tons of CO_2eq/yr.

Pokherel, (1990), one single 6 m^3 biogas plant can replace the use of 3 tons of fuelwood and 38 liters of kerosene annually. It was also calculated that it produces 27 tons digested slurry and reduces 4.2 tons of CO_2eq/yr and there was an annual saving of 11.6 trees and 0.055 ha of forest. It was also estimated that, the single operational biogas plants can reduced on dependency on fuelwood by 80% and on kerosene by 60%.

2.9. Payback period of the BGP

Lungkhimba, (2010), conducted a research on biogas production from anaerobic digestion of biodegradable HH wastes. He created a biogas digester by using 1000 Liter water tank of Appropriate Rural Technology Institute (ARTI) model with 1m^3 bio-digester and 0.75 m^3 gasholders. The financial analysis of the biogas plant showed the simple payback period of 4.81 for kerosene substitution, 7.57 for firewood substitution and 7.20 years for LPG substitutions.

Shrestha, (2010), studied on the payback period of the HHs level BGP on Gaikur VDC of Gorkha district. According to her the payback period was 15.6 years. She consider the initial installation cost of NRs.32,184.44, on her study there was no any saving of kerosene consumption due to the BGP installation but there was considerable saving of money for purchasing fuelwood which was NRs. 2,653.2. She consider a 15 minutes labor cost for the smooth running of BGP, for this annually NRs.800 was consider and annual expenditure per plant was NRs. 1200.

Dhital, (2004), studied on possibility of the large scale biogas plant in Nepal. He took a sample from the sugarcane industry of the Nawalparasi district for the feasibility in terms of cost benefit estimation for calculation of the payback period of the BGP. The initial investment cost of the plant according to the factory was 1.25 Corer. The saving from the rice husk was 766,500 per year and the payback period of the BGP (Dhital, 2004).

According to Devkota, (2001), the payback period of the GGC 2047 model biogas plant the pay back priod is 6.1 years without subsidy and 4.1 years with subsidy provided by the BSP Nepal. On his research he assumed the initial investment cost of NRs. 27,204. He assumed that there was saving of 6 kg of firewood per households per day. The market price of the fuelwood was considered to be NRs.1.5 per kg of fuelwood. He found that there was an annual saving of 510 from the less consumption of the kerosene. And there was an annual saving of NRs.2,000 from the chemical fertilizer, for the smooth running of the biogas he consider NRs 800 for the daily feeding and NRs 400 for the maintenance cost for miscellaneous he consider NRs.100.

CHAPTER III

3. MATERIAL AND METHOD

3.1. Study area

3.1.1.1. Location

Nepal is a landlocked country with a total land area of 147,181 km^2. Roughly rectangular in shape, the land extends approximately 885 km east-west and 145 km at its narrowest to 241 km at its broadest, north -south. The country is bordered by China in the north and by India in the south, west and east (CBS, 2004).

Administratively, Nepal is divided into five development regions and 75 districts. The districts are further divided into a large number of Village Development Committees (VDCs) and municipalities as local units. Currently there are 3,915 VDCs and 58 municipalities including one metropolitan and four sub metropolitan cities (District profile of Nepal, 2003).

Jhapa is divided into 46 VDCs and three municipalities, namely Bhadrapur in the south, Mechi Nagar in the east and Damak in the west. Though Birtamode was recommended for municipality by GoN, people opposed and is back to VDC again i.e., Anarmani VDC (wikipedia.org retrieved on April 2012).

Damak municipality lies in Jhapa district and is surrounded by Lakhanpur V.D.C.in the east, Urlabari, Madhumalla, and Rajghat V.D.C. in the west, Chulachui V.D.C.in the north and Kohobhara V.D.C.in the south. But the east west barrier are made by two major rivers of Damak known as Ratuwa and Mawa locating east and west margin respectively which can be seen in detail in the map below (Fig 3.1). The total area of the municipality is 75.13 km^2 (DMO, 2066).

Damak municipality lie between $26^{o}20^{'}$ to $26^{o}50^{'}$ N latitude and $89^{o}39^{'}$ to $89^{0}50^{'}$ E longitude at an elevation of 132 m from mean sea level (DMO, 2066). The detailed location of the study area is presented in annex 3.

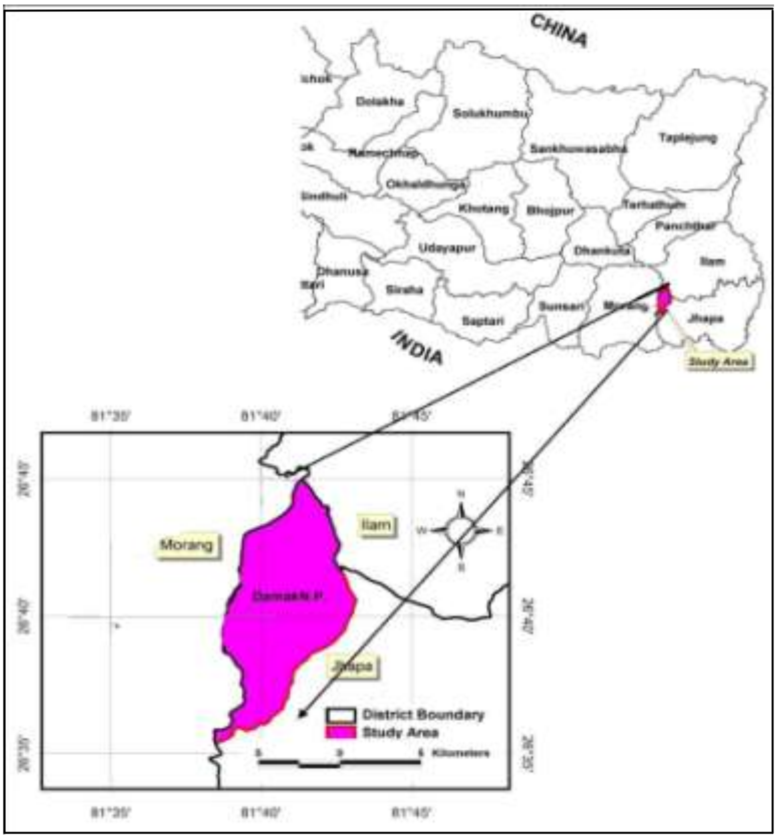

Figure 3.1: Location map of the study area

3.1.1.2. Temperature pattern and types of tree species

Jhapa receives 2500-3000 cm of rainfall a year, and mostly during the monsoon season and its hilly northern area receives more rainfall than the south. It's major river are like Mechi, Kankai, Ratuwa etc. that provides water for irrigation. Due to its alluvial soil best suited for agriculture, Jhapa has been the largest producer of rice and is therefore known as the Grain Grocery of Nepal. Besides cereal crops like rice and wheat, it is also one of the largest producers of jute, tea, betel nut, rubber and other cash crops (wikipedia.org retrieved on April 2012).

Jhapa has vast areas of forests such as Charali, Charkose Jhaadi, Hadiya, Sukhani, Jalthal, and others. Its name itself is derived from the Rajbanshi word "jhapa" meaning "canopy", which suggests that the area was a dense forest in the past. It was once such a dense and dangerous forest that it was called Kaalapaani and prisoners were sent here to die of malaria and other diseases in the jungle (wikipedia.org retrieved on April 2012).

The average annual rainfall recorded at Damak municipality is 1900 mm. The minimum temperature and maximum temperature recorded at the area is 10^0C and 35^0C respectively. The major forest types found there is tropical and sub tropical forest. The forest is mainly dominated by sisso (*Dalbergia sisoo),* bakino *(Melia azidarach),* khayar (*Acacia catechu),* bamboo *(Bambosa tulda)* simal (*Bambox ceiba) species*. The total population of the municipality is 75,164 (DMO, 2066 BS).

3.1.1.3. Population

According to population census 2010 conducted by the municipality the total population of the Damak municipality was 75,164 with 10,964 numbers of families. Among them 37,201 were female and rest of 37,963 were male.

3.1.1.4. Education status

Jhapa has a good literacy rate of 66.9% which is highest in Nepal after the capital city Kathmandu (www.maplandia.com retrieved on April 2012). The literacy rate of Damak municipality is 88% which is quite high as compared to that of national average literacy rate. The national average of literacy rate of Nepal is only 54% (District Profile of Nepal, 2003).

3.1.1.5. Land distribution

Total area of the whole municipality is 7,513 Hector (ha) of which residential area covers 2,140 ha, agriculture area covers 4030 hectors, urban area covers 550 ha forest area covers 674 ha and rest 119 is other (DMO, 2066). The following figure (3.2) shows the details about the land distribution at Damak municipality.

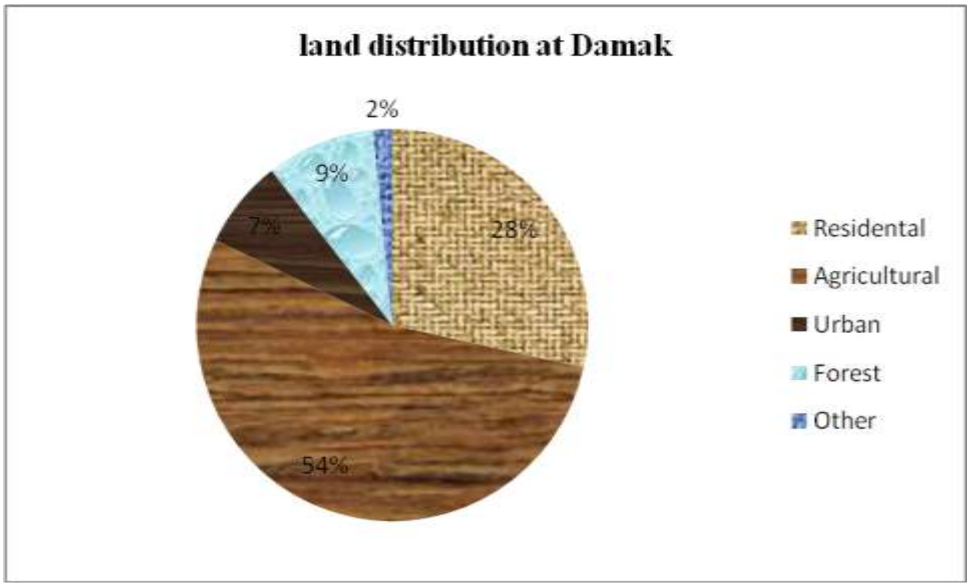

Figure 3.2: Land distributions at Damak municipality

3.2. Methodology

The methodology used in this research included two stages; field data collection and analysis of the collected data. The details of the procedure followed in each step of the field and data analysis works are enumerated in the following sections.

3.2.1. Research design

The following research frame work was adopted for the necessary data collection.

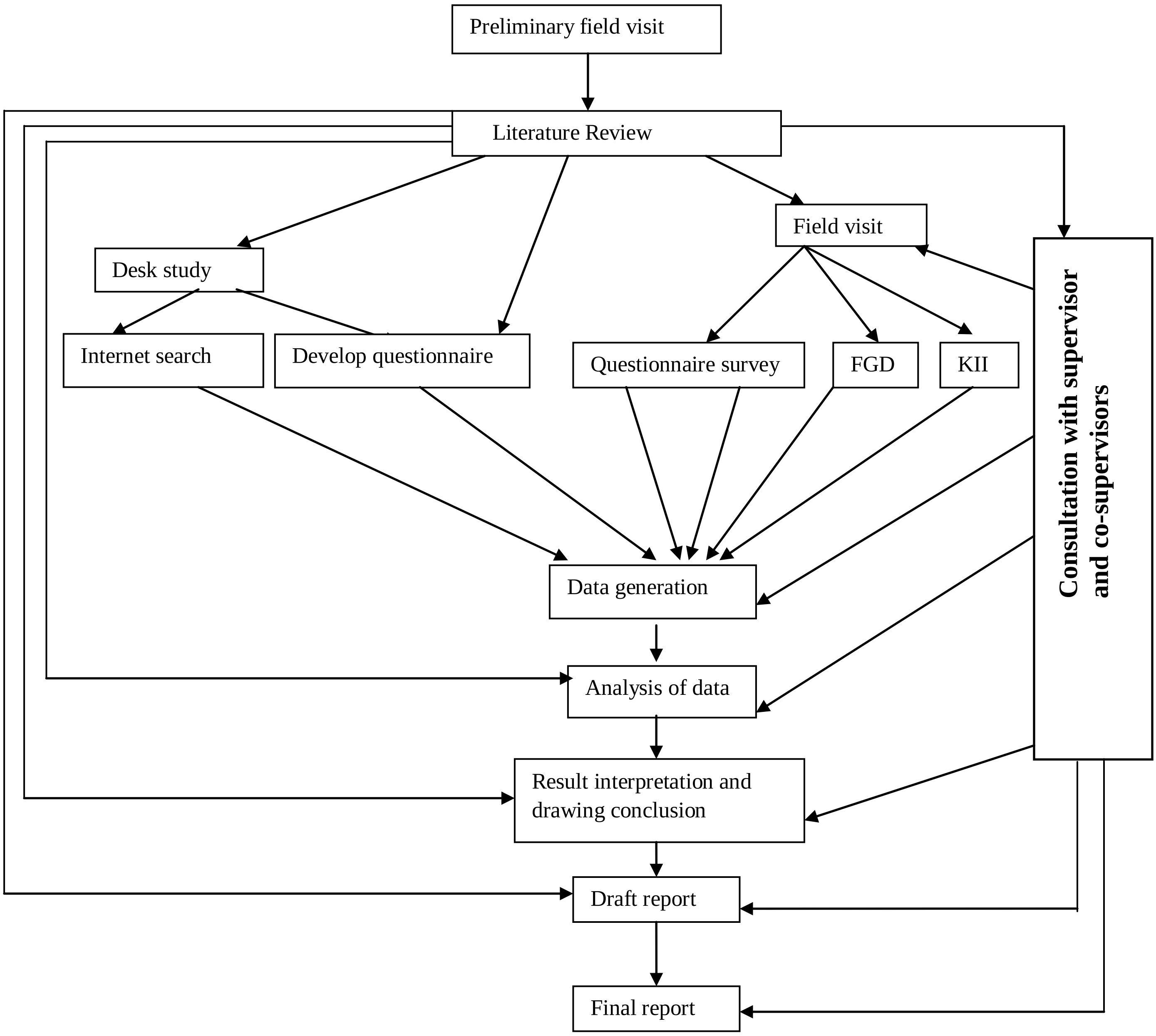

Figure 3.3: Flow diagram of research framework

3.3. Pre field methodology

3.3.1. Inclusion and exclusion criteria

The households with biogas plant but insufficient energy demand from BGP were excluded from sampling frame. For the fulfillment of energy demand they use LPG excess than that of the biogas which do not give the significant difference between the baseline and project GHGs emissions.

3.3.2. Sampling method

A linear systematic sampling was done to select the households to be surveyed. For this; the population was considered as the BGP having households from the BSP record book.

3.3.3. Sample size

The numbers of household to be surveyed were calculated by using the formula given by Arkin and Colton, 1966 (cited in Paudyal, 2007) which was as follows:

$$\text{Sample size } n = \frac{NZ^2.P(1-P)}{[Nd^2 + Z^2.\ P(1-P)]}$$

Where,

n= sample size

N= total number of Households

Z= Confidence interval (at 95% level Z=1.96)

P= Estimated population proportion (0.05 this maximizes the sample size)

d=error of limit of 5% (0.05)

3.4. Field data collection methodology

Household level questionnaire survey, community consultation, discussion/meeting with local stakeholders, Focus Group Discussion (FGD), Key-informants Interview (KII), with potential target groups was done to quantify the volume of fuelwood consumption before and after the installation of BGP. Then using the conversion factor given by IPCC 1996 the volume of GHGs was calculated. Direct observation and personal interview was done for the identification of health and sanitation condition, indoor air pollution and general health condition of the respondents.

3.4.1. Primary data collection

Primary data were collected by the following approaches:

3.4.1.1. Household survey/Questionnaire survey

Structured questionnaire was done to get the every information regarding the researches. The total of 80 questionnaires survey were conducted with the biogas user at the study area.

3.4.1.2. Focus group discussion (FGD)

Discussion was conducted by gathering of stakeholders at different ward of Damak municipality to get information about the past and present dependency on forest for the fuelwood, health condition of the local specially related to respiratory tract and benefits of using biogas. Two focus group discussions were conducted. One was with the women's micro credit group and the next was with the local stakeholder of ward number 4 of Damak municipality.

3.4.1.3. Key informants interview (KII)

Informal interview were carried out with key informants of the study area that helps to find out the people's perception on using biogas plant. The key informants were those persons who have biogas plant for at least 10 years and head of the organization which are working on the promotion of biogas on local level.

3.4.1.4. Field survey/Observation

Important observations were noted and noticeable changes were marked by direct observation and eye inspection method for the indoor air pollution condition, sanitation condition and health related issues. At the time of field visit the wall of the kitchen and cookking utensils were observed.

3.4.2. Secondary data collection

3.4.2.1. Review of Relevant literature and Information

In order to broaden the ideas and concept about the study, relevant reports and documents were reviewed. In addition to these, study reports, reports of other organizations related to biogas, distribution pattern of the energy, extent to which level the rural people depend on these sources, advantage and disadvantage of alternative sources of energy and their impacts on human especially female health were also reviewed.

3.5. Calculation

For the interpretation of result, fuelwood demand before and after the project (BSP) was collected from the selected HHs by using already prepared structured questionnaire. The collected data were then analyzed with the help of computer based software MS excel 2007 and Statistical Package for Social Science (SPSS) 16.

3.5.1. Calculation for emitted volume of GHGs

The following steps given by Climate Change Information Center (2003) were followed for the calculation of the baseline, project and reduced emission of GHGs at the study area.

Step 1: Identification of baseline and project emission sources

The baseline sources for the emission of GHGs i.e. before the BGP were the fuelwood, LPG and kerosene consumption. And the project source i.e. after the BGP was the emission of GHG from fuelwood, LPG, kerosene and leaves twigs and agricultural residue. For this the total volume of the consumption of the fuelwood were quantified by the structured questionnaire (Submitted in the Annex 1).

Step 2: Identification of emission factors

The emission factor for the fuelwood, LPG and the kerosene were followed according to the conversion factor given by IPCC 1996 this was done separately for fuelwood, LPG and kerosene.

Step 3: Identification of activity volumes

At this step total fuel saved per household after the BGP were calculated on the basis of baseline and project fuelwood consumption scenario and the methane leakage from the digester were calculated according to emission rates given by BSP 2006.

Step 4: Calculation of emissions per source

The emission per plant was calculated according to a specific calculation formula given by Ajero (2003), which combines the activity volumes per plant with the emission factor.

Step 5: Calculation of emissions reduction factor

For each plant the emissions for the various sources were aggregated (baseline emissions minus project emissions) resulting in the total emission reduction per plant. And finally the calculation was done to calculate the reduced volume of GHG the following formula given by Climate Change Information Center 2003 (Ajero, 2003) was adopted.

Baseline emission of $GHG_{Baseline} = A \times EF$

Where,

A = Activity factor

EF = Emission factor (kg of CO_2/kg of fuelwood consumption)

Project emission of $GHG_{Project} = A \times EF$

Where,

A = Activity factor

EF = Emission factor (kg of CO_2/kg of fuelwood consumption)

Reduced volume of GHG = $GHG_{Baseline} - GHG_{project}$

3.5.2. Benefit estimation

Benefits of biogas plant were estimated by the saving of fuelwood for cooking purpose and emission reduction benefits. And the benefits were calculated as follows:

3.5.2.1. Fuel saving benefits

Cost of fuelwood = C_{fu}

Annual saving of the fuelwood = M_{fu}

Annual fuelwood saving benefits = $C_{fu} \times M_{fu}$

3.5.2.2. LPG saving benefits

Cost of LPG = C_{LPG}

Annual saving of LPG = M_{LPG}

Annual LPG saving benefits = $C_{LPG} \times M_{LPG}$

3.5.2.3. Emission benefits

a. Emission from fuelwood

- CO_2 emission from fuelwood = 1.406 kg of CO_2 per kg of fuelwood consumption.

- CH_4 emission from fuelwood = 0.004 kg of CH_4 per kg of fuelwood consumption
- N_2O emission from fuelwood = 0.000091 kg of N_2O per kg of fuelwood consumption

Overall emission factor from fuelwood = (CO_2+CH_4 + N_2O) emission from fuelwood.

b. Emission from LPG

- CO_2 emission from LPG= 3.0689 kg of CO_2 per kg of LPG consumption.
- N_2O emission from fuelwood = 0.0001 kg of N_2O per kg of LPG consumption

Overall emission factor from LPG = (CO_2 + N_2O) emission from LPG.

c. Emission from kerosene

- CO_2 emission from kerosene= 2.457 kg of CO_2 per kg of kerosene consumption.
- N_2O emission from fuelwood = 0.000063 kg of N_2O per kg of kerosene consumption
- CH_4 emission from kerosene = 0.00035 kg of CH_4 per kg of kerosene consumption

Overall emission factor from kerosene = (CO_2+CH_4 + N_2O) emission from kerosene.

d. Total emission reduction = (Total CO_2eq reduction from fuelwood + Total CO_2eq reduction from LPG + Total CO_2eq reduction from Kerosene)

Transaction cost of CO_2 = \$ 7/tons CO_2eq

Total benefit = \$(Annual CO_2 emission reduction from fuelwood and LPG (tons) ×7

CHAPTER IV

4. RESULT

4. 1. Socioeconomic status of the sampled household

4.1.1. Sex composition

Among the 80 HHs which were surveyed on the study area, 60% of them were found to be female and rest of 40% were found to be male.

4.1.2. Education status of the respondents

Most of the respondent in the sampling frame were found to have taken only school level education. Approximately 62% of the respondents were under S.L.C., rest of 18% had passed S.L.C., additionally 8% of respondents participated in intermediate level education and rest of 12% have taken the Bachelor level education.

4.1.3. Occupation

The majority of the respondents on the study area were dependent on agricultural activities. Approximately 80% of the respondents work in agricultural field. Rests of 13.75% of the respondents were engaged in business and only 6.25% of the respondents were engaged in government job like teacher, army and other.

4.1.4. Sources of drinking water

Most of the respondents were found to have tube well water as a main source of drinking water. About 73% of the respondents were found to be using tube well water for domestic and drinking purpose. Only 26% of the respondents had access for the drinking water supply from municipal water supply. There was still in practice of consuming the dug well for the source of drinking water but the proportion was too less. Only 1% of the respondents were found to be using dug well for drinking purpose. . The percentage of HHs with different sources is presented in the figure 4.1.

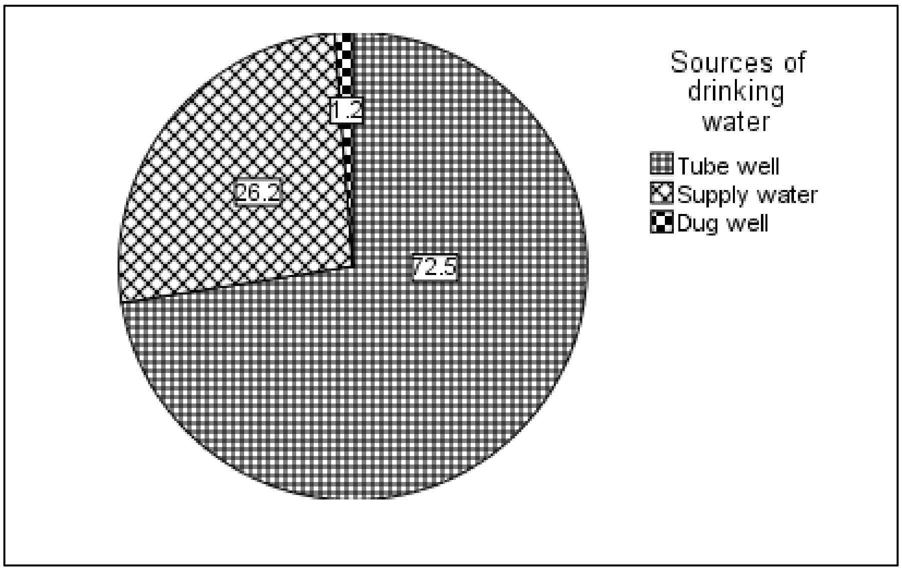

Figure 4.1: Sources of drinking water of the respondents

4.1.5. Types of toilet

Although the toilet waste can be use as a source of biogas most of the respondents do not attach their toilet with biogas plant due to their religious belief. As shown in figure 4.2, 66% of the respondents were found to have septic tank type of toilet at their home, 25% of the respondents attach their septic tank to biogas plant, 8% of the respondents have pit latrine, and rest of 1% have toilet pit with slab. There were no any respondents who do not have toilet at their home.

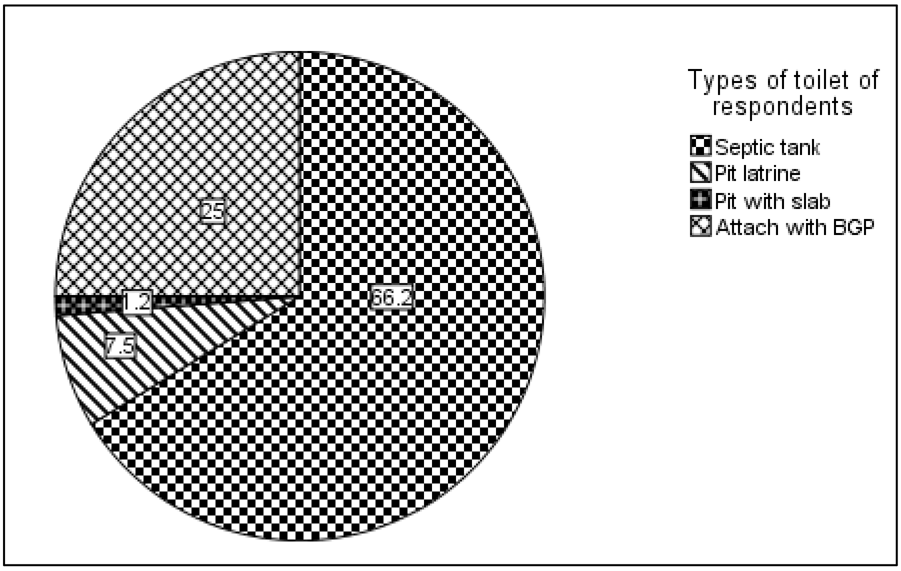

Figure 4.2: Types of toilet of the respondent

4.2. Perception of local on biogas plant

4.2.1. Collection of urine of animal for BGP

Urine has a great potential to produce methane gas on biogas plant. There is in practice to use urine instead of water for better performance. About 60% HHs are being collecting urine to use for biogas where as rest of 32 i.e. 40% do not collect the urine as solvent. The main reason behind for the not collection of the urine for the biogas plant was the absence of plastered floor of cattle shed.

4.2.2. Advantage of having biogas plant

When asked with local about the main advantages of biogas plant, 37% answered that due to biogas there reduces the smoke at kitchen. The next groups of 27.2% of respondent answered biogas helps to reduce the consumption of fuelwood. Other 21.2 % respondent said biogas helps to save the time at that time they can do other household works. There were very few respondents who were conscious about the environment; only 4% said BGP is environment friendly. And 6% of the respondents were benefited with improved health condition. Some respondent were noticed about the double benefits of the biogas plant. But at the time of calculation the benefits was estimated on the priority basis. The following figures 4.3 show the opinion of respondent about the benefit of biogas plant.

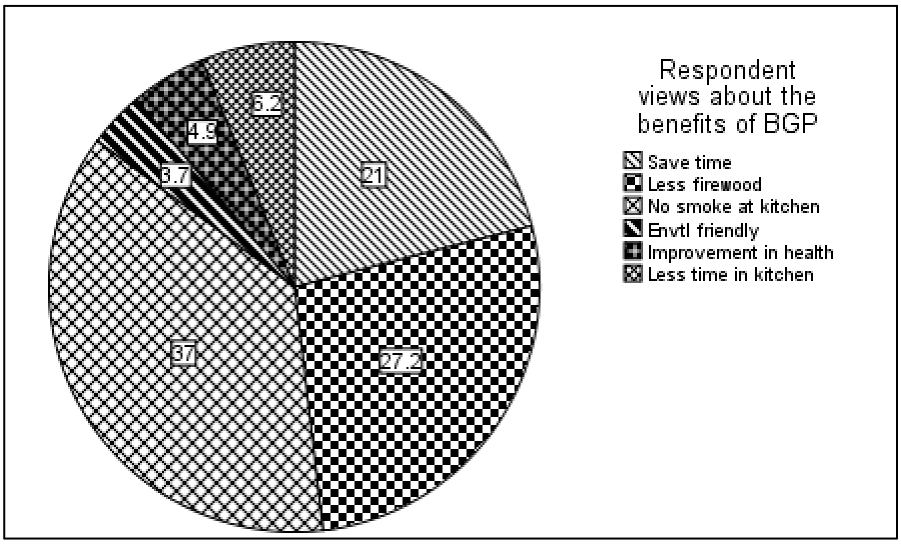

Figure 4.3: Respondent view about the benefit of BGP

4.2.3. Disadvantage of having biogas plant

Most of the respondents were satisfied with the installed BGP. When we asked them about the disadvantage of the BGP, half of the respondent (59.3%) reported that the installation cost is very high. There were some respondents who are not happy with the compost prepared by the BGP. About 27.2% of the respondent noted that the compost prepared by the BGP is not effective for their farm land. About 4.9% of the respondent says that they have to spent time for the collection of dung for digester feeding. There was another group of people (8.6%) who says that the biogas is insufficient for the fulfillment of the daily needs (Figure 4.4).

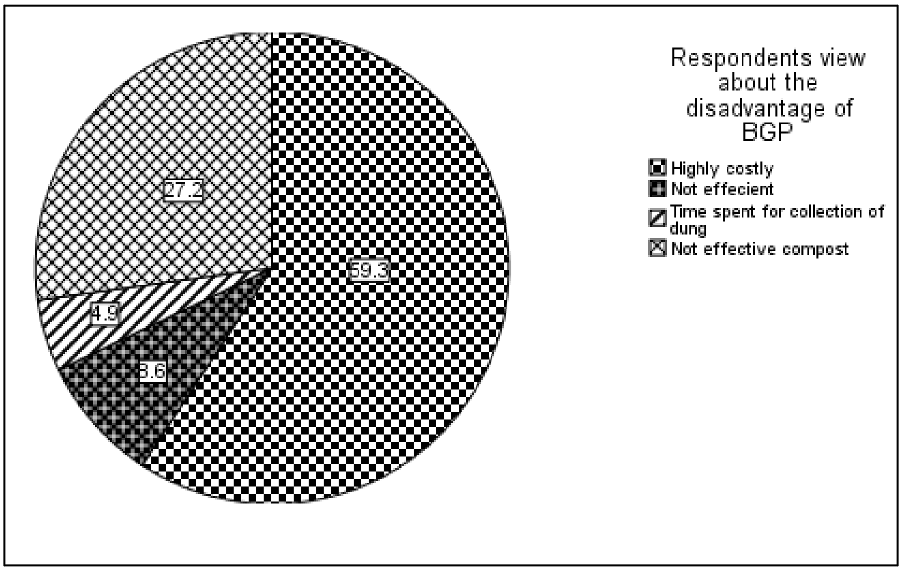

Figure 4.4: Respondent view about the disadvantage of BGP

5.2.4. Sufficiency of the BGP

According to BSP, (2005), the production of gases decreases by 15% in winter season because of lowering in temperature. The lowering in temperature decreases the metabolic activities of the methanogenic bacteria. This excludes special occasion when there is a demand for other fuel sources as well.

For 16.2% biogas was sufficient to meet the gas demand. According to them since the installation of BGP no other cooking fuel is being required during the normal summer season, but there is always insufficient in the winter season. Rest of 5% of respondent reported that there is a regular need of additional cooking fuel like agricultural residue, LPG or any other fuel type. The following figure 4.5 gives the detail about the facts.

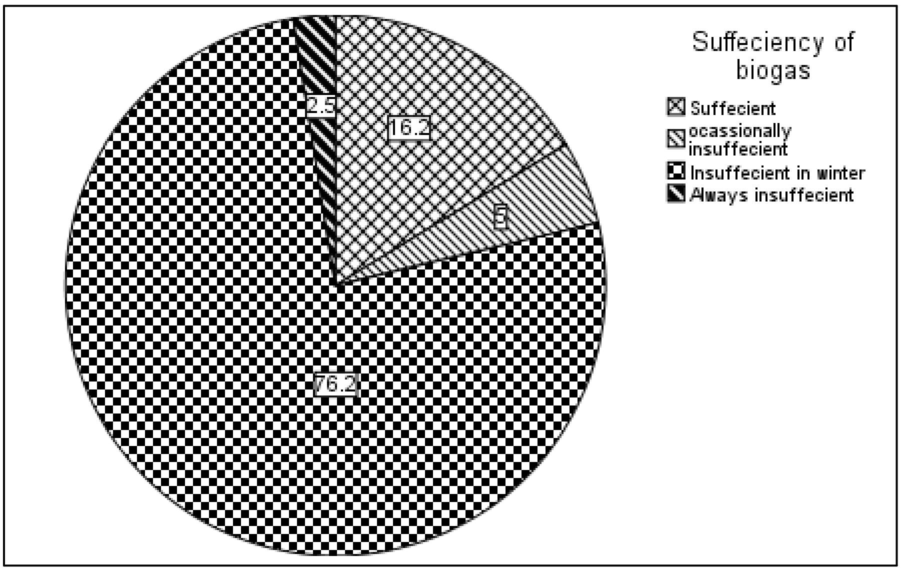

Figure 4.5: Sufficiency of BGP

4.3. Consumption, types and sources of fuelwood

4.3.1. Sources of fuelwood

The people were dependent on private forest and community forest for fuelwood. Fuelwood was used to collect from community forests namely Humse Dumse community forest, Patalae forest, a government forest of Morang district and Chure forest of Ilam district. The community forest management team provides permission to collect fuelwood for two months Jan-Feb each year. During that period the local people collect fuelwood and store for whole year. The following table shows the sources of fuelwood for the various HHs under the sampling frame.

Table 4.1: Sources of fuelwood

Sources of Fuel	Number of HHs	Percent of HHs (%)
Community forest	12	15
From own land	26	32.5
Nearby District	8	10
Purchases +own land	34	42.5

4.3.2. Tree species use for fuelwood

The main tree species used for fuelwood purpose were *Dalbergia Sisoo* (Sisoo), *Melia aziderach* (Bakaino), *Bambosa tulda* (Bas) and dead and fallen parts of *Shorea robusta* (Sal). These were commonly found tree species in the private and community forests.

4.3.3. Estimation of weight of a Bhari

According to operational plan of Humse Dumse Community Forest one Bhari contains an average of 29 kg (HDCFOP, 2006/08 to 2014/15).

4.3.4. Fuelwood consumption pattern

The average fuelwood consumption was 366.43 kg/month i.e. about 12 Bhari of fuelwood before the biogas plant and the average fuelwood consumption after the biogas plant was 29.62 kg per month i.e. about one Bhari of fuelwood per month.

4.3.5. Kerosene consumption at Damak

In the municipality, use of kerosene was limited for lighting purpose only. This was due to irregular electricity supply from the NEA. The average kerosene consumption in the municipality was 21.6 liters/yr/HHs.

4.3.6. Demand of fuelwood

From the questionnaire survey it was found that the amounts of fuelwood consume per households was being reduced by replacing the fuelwood demand by biogas. The average fuelwood demand before the biogas per HHs was 8.7 Bhari/month which reduced to 0.76 Bhari/month.

4.4. Potential of biogas in Damak from the municipal waste

According to Mital, (1996), 1 kg of kitchen waste produces 0.036 m^3 gases and 1 kg of Municipal waste produces 0.031 m^3 gases and 1 kg of organic waste generated from human being can produce 0.06 m^3 of gases. According to Hada, (2009), Primary energy required per household is 5.5 Gj/HHs/year with the family size of 5 persons in the urban area of Nepal. According to Dawadi, (2008), 0.22 kg/person/day organic waste is developed.

Six ton of solid waste was being generated per day at the present study area. Among 6 ton of solid waste; 83.33% is composed of organic waste i.e. 5 ton/day. The efficiency of collecting solid waste is 85% (DMO, 2066). If construct a large scale BGP at Damak municipality there would be the generation of 155 m^3 of gas daily {kg of municipal waste produces 0.031 m^3 gases (Mital, 1996)}.

There is another huge settlement of Bhutanese refugee at Damak municipality. The total population of these refugees is 47,760 (LWF, 2009) in number. Thus from the human settlement of Bhutanese Refugee camp there can be 10,507.2 kg of waste is being generated daily. Thus from Bhutanese camp there can produce an average of 630.432 m^3 of gases per day can be produced.

Thus from the municipal waste collected by the municipality and the kitchen waste from the Bhutanese camp an average of 785.43 m^3 of gases per day can be produced. This becomes an annual production of 286,682.86 m^3 of gases. This is equivalent to 6,450.36 GJ of energy annually (conversion factor is submitted at the Annex). The produced gas is sufficient for the fulfillment of the 1290 families of Damak municipality of having family size 5. This fulfillment of the energy demands covers an average of 11.76% of the HHs at the study area. According to Damak municipality Annual report there are 10964 HHs at the study area having average family member of 5.

4.5. Benefits estimation of BGP

4.5.1. Economic benefits of BGP

4.5.1.1. Financial analysis for the reduction of the fuelwood

There was a considerable saving of 336.8 kg of fuelwood per month which is 4041.8 kg per year per household after the biogas installation. This reduction in consumption of fuelwood reduces 91.9% on consumption. This contributed to an average saving of NRs. 20896 per household per year at the rate of NRs. 150 per "Bhari" in the study site. The average fuelwood consumption before and after the BGP and percentage of saving in fuelwood of the surveyed HHs is given in table 4.2.

Cost of fuelwood (C_{fu}) = Rs.5.17/kg (1Bhari contain 29 kg, and one Bhari cost Rs.150)

Annual saving of the fuelwood (M_{fu}) = 4041.8 Kg

Annual fuelwood saving benefits ($C_{fu} \times M_{fu}$) = NRs.20,896

Table 4.2: Average fuelwood consumption

Particulars	Average fuelwood consumption			
	Before	After	Energy saved	% saving
per month/HH (kg)	366.4	29.6	336.8	91.9
per year/HH (kg)	4397.1	355.3	4041.8	
Annual expenses in fuelwood/HHs (Rs)	22733.5	1837.4	20896.1	

1 Bhari = 29 kg, and cost of one Bhari = Rs.150

The correlation coefficient between the money expenses before and after is found to be -0.49657. The correlation coefficient between the money expenses before and after the biogas is negatively correlated. This shows that installation of biogas reduces the expenditure to purchase the fuelwood.

4.5.1.2. Financial analysis for the reduction of LPG consumption

There is a small consumption of LPG in the study area because the study area is in rural part of the country. Before the BGP the average LPG consumption was 0.35 cylinders per household per year, this is reduced and becomes 0.11 cylinders per year per households. This also saves the money of NRs. 318 per year per households. The table 4.3 shows the average cylinder consumption and money spent for purchasing the LPG before and after the BGP and total annual saving form the BGP.

Cost of LPG (C_{LPG}) =Rs.1325 (June 2011)

Annual saving of LPG (M_{LPG}) =0.24 (0.35 - 0.11 = 0.24)

Annual LPG saving benefits ($C_{LPG} \times M_{LPG}$) = NRs.310.54

Table 4.3: Economic saving from LPG

Particular	Average cylinder consumption (number/HH/year)	Money expenses for the LPG(NRs)	Total saving due to BGP (NRs.)
Before BGP	0.35	463.75	310.55
After BGP	0.11	153.20	

4.5.2. Local environmental benefits of BGP

4.5.2.1. Estimation of equivalent forest area protected from reduction in fuelwood consumption

According to BSP, (2009), by the installation of the single biogas plant there is a reduction of 26 ton/HH in fuelwood consumption and protects over 0.06 ha of forest per year. At present there is 1310 biogas plant in Damak municipality (BSP, 2009). Thus accordingly 78.6 ha forest is being protected each year due to the installation of the biogas plant.

4.5.2.2. Number of trees saved from BGP

According to BSP, (2009), a single biogas plant can save 11.6 trees per year. On the basis of this fact the total of 15196 trees are being saved per year, because there are 1310 biogas plant at Damak municipality at the end of the fiscal year 2067/68.

4.5.3. Global environmental benefits of BGP

4.5.3.1. Reduction in fuelwood consumption and GHG emission

Fuelwood was the major sources of GHG emission at the rural area. On the present context only three major GHG CH_4, CO_2 and N_2O were considered for the calculation of GHG volume (IPCC 1996). Before the BGP total emission was of 6.67 tons (6,675.9 kg) of CO_2eq/HH/yr and after the BGP installation the volume reduced to 0.53 tons (539.6 kg) of CO_2eq/HH/yr. This indicates that after the BGP installation there was reduction in 6.13 tCO_2eq/HHs/yr (6136.3 kg). Table 4.4 show the average fuelwood consumption and greenhouse before and after the biogas plant.

Table 4.4: Fuelwood consumption and greenhouse gas emission

Particulars	Fuelwood consumption kg/HH/yr	GHG	Efi (kg/kg)	GWP	Emission kg/HH/yr	Emission kgCO_2eq/HH/yr	Total emission kg CO_2eq/HH/yr
Before BGP	4397.2	CO_2	1.406	1	6182.5	6182.5	6675.9
		CH_4	0.004	21	17.6	369.4	
		N_2O	0.000091	310	0.4	124.0	
After BGP	355.4	CO_2	1.406	1	499.7	499.7	539.6
		CH_4	0.004	21	1.4	29.9	
		N_2O	0.000091	310	0.0032	10.0	
Reduced amount	4041.8						6136.3

EFi = Emission factor for i GHG, kg GHG/unit fuelwood consumption

GWP of CO_2 = 1; CH_4 = 21 and N_2O = 310 (Randall, 2002 Cited in Shrestha 2007)

4.5.3.2. Reduction in LPG consumption and GHG emission

The consumption of LPG was reduced after the installation of BGP. Before the BGP average cylinder consumption per HH per year was 0.35 which was reduced to 0.115 cylinders per HH per year. This decrease in consumption of LPG consequently reduces the emission of GHG by 0.72 kg of CO_2eq/HH/yr. LPG consumption and emission reduction of GHG is presented in the table 4.5 given below.

Table 4.5: LPG consumption and GHG emission

Particulars	Average cylinder consumption No./HH/yr	GHG	Efi (kg/Kg)	GWP	Emission (kg /yr/HH)	Emission($kgCO_2eq/HH/yr$)	Total emission ($CO_2eq/HH/yr$)
Before BGP	0.35	CO_2	3.068	1	1.07	1.07	1.07
		N_2O	0.0001	21	0.0000035	0.000735	
After BGP	0.115	CO_2	3.0689	1	0.35	0.35	0.35
		N_2O	0.0001	21	0.0000115	0.0002415	
Reduced amount	0.72 kg $CO_2eq/HH/yr$						

EFi = Emission factor for i GHG, kg GHG/unit fuelwood consumption.

GWP of CO_2 = 1; CH_4 = 21 and N_2O = 310 (Randall, 2002 Cited in Shrestha 2007)

4.5.3.3. Kerosene consumption and emission of GHG

In the study area kerosene was limited for the lighting purpose only. This was due to irregular supply of electricity from the National Electricity Authority (NEA). Besides, BGP was installed for the purpose of domestic cooking not for lighting. For this reason BGP do not have any contribution in reducing the uses of kerosene in the area. Total emission from kerosene consumption was calculated to be 633.7 kg of $CO_2eq/HH/yr$. The kerosene consumption and GHG emission from the consumed kerosene is given in the table 4.6.

There were some HHs on which biogas was used for the lighting purpose. But these HHs were out from the sampling frame. During the focus group discussion, local reported that biogas its self is not sufficient so they are in against to adopt the biogas for lighting purpose.

Table 4.6: Kerosene consumption and emission of GHG

Particular	Average kerosene consumption Litre HH/yr	GHG	Efi	GHG	Emission kg /yr/HH	Emission $kgCO_2eq$/HH/yr.	Total
Before the Biogas plant	21.6	CO_2 kg/L	2.457	1	53.07	53.1	
		CH_4 Kg/L	0.00035	21	0.00756	0.2	
		N_2O Kg/L	0.000063	310	0.0013608	0.4	53.7
After the Biogas plant	21.6	CO_2 kg/L	2.457	1	53.07	53.1	
		CH_4 Kg/L	0.00035	21	0.00756	0.2	
		N_2O Kg/L	0.000063	310	0.0013608	0.4	53.7
Reduced amount	0						
GWP of CO_2 = 1; CH_4 = 21 and N_2O = 310 (Randall,2002 Cited in Shrestha 2007)							

EFi = Emission factor for i GHG, kg GHG/unit fuelwood consumption

4.5.3.4. Uses of leaves and twigs and GHG emission

The use of leaves and twigs was limited for the preparation of food for livestock only. It was not used for the preparation of food for the human being. Thus the BGP has no any contribution in reduction in the consumption of leaves and twigs, and also for the reduction of GHG from the combustion of leaves and twigs. Total emission from the leaves and twigs was 3032.19 kg of CO_2eq per HH per year (Table 4.7).

Table 4.7: Emission of GHG from leaves twigs and crop residue

Particulars	Average consumption kg/HH/yr	GHG	Efi kg/kg	GHG	Emission kg/HH/yr	Emission $kgCo_2eq/HH/yr$	Total emission $kgCo_2eq/HH/yr$
Before BGP	2091.75	CO_2	1.2874	1	2692.92	2692.92	3032.19
		CH_4	0.00749	21	15.67	307.49	
		N_2O	4.90E-05	310	0.10	31.78	
After BGP	2091.75	CO_2	1.2874	1	2692.92	2692.92	3032.19
		CH_4	0.00749	21	15.667	307.48725	
		N_2O	4.90E-05	310	0.1024	31.7477	
Reduced Amount	**0**						

EFi = Emission factor for i GHG, kg GHG/unit fuelwood consumption.

GWP of CO_2 = 1; CH_4 = 21 and N_2O = 310 (Randall, 2002 Cited in Shrestha 2007)

4.5.3.5. Total reduction of GHGs and carbon abetment revenue

Reduction in emission from saving of fuelwood was found to be 6.1 tons CO_2eq/HH/yr and emission reduction from the saving of LPG was found to be 0.00071 tons CO_2eq/HH/yr. But there was no any reduction in emission of GHGs from kerosene and leaves and twigs at the study area. Thus an annual emission reduction of GHGs at study area was found to be 6.10 tons CO_2eq/HH/yr after the installation of the BGP.

Here 80 HHs were surveyed thus total annual emission reduction from fuelwood was found to be 488.06 tons of CO_2eq.

Emission reduction per HHs = (Emission reduction from fuelwood + Emission reduction from LPG + Emission reduction from kerosene + Emission reduction from leaves and twigs)

= (6.13 + 0.00071 + 0 + 0) tons

=6.13 tons

At the study area there are total of 1310 HHs having BGP. According to result drawn from the surveyed HHs each BGP reduces 6.13 tons CO_2eq/HH/yr due to the saving from the LPG and solid biofuel. Thus in total there is an annual 8037.3608 tons of CO_2eq reduction in the study area.

According to UNFCC (2006), the market value of 1Kg of GHG costs $7. Here from the study we found that each biogas plant reduces 6.13 tons of CO_2eq/HH/yr so there can earn $42.91 per annum from the installed biogas at the study area if claimed under the international carbon trade market.

4.5.4. Social benefits

4.5.4.1. Time saving from the BGP

For the smooth running of the biogas plant local have to spend some time for different activities such as collection of water, fetching of water and mixing of slurry. But this helps to reduce the more time consuming work like collection of fuelwood and cleaning of utensil. The table (4.8) shows the detail about the time allocation for the smooth running of biogas and saves in time due to biogas plant.

Table 4.8: Time allocation for the smooth running of the biogas plant

Daily Works	Time allocation for work per day (Minutes)		
	Before BGP	After BGP	Save time
fuelwood collection	45	0	45
Cooking	65	25	40
water fetching	0	25	-25
Cleaning Utensil	45	25	20
Live stock caring	40	40	0
Dung collection	20	30	-10
Mixing of slurry	0	25	-25
Total	**215**	**170**	**45**

The following figure shows the time allocation for different work after and before the installation of BGP.

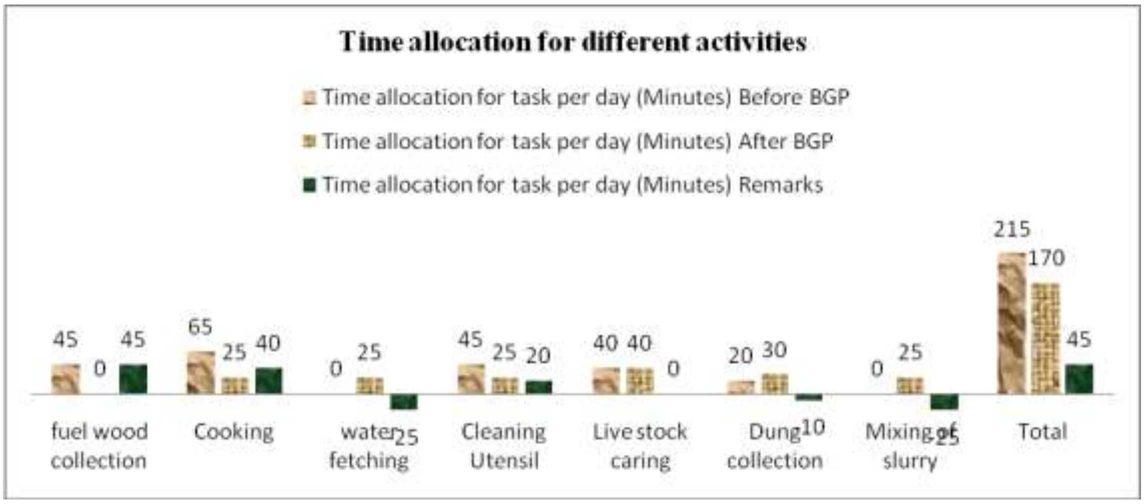

Figure 4.6: Time allocation for different work after and before the BGP installation

4.5.4.2. Health impact of BGP on respondents

Being the clean energy and the smokeless indoor environment the BGP has the direct positive impact on health of the local people. After the adoption of biogas plant there was no any indoor air pollution because biogas and reduces the uses of solid biofuel. Reduction in consumption of fuel wood reduces the emission of particulate matter also. Besides better management of dung there was less chances of spreading of the diseases causing organism too. The following table shows about the diseases occurrences among the respondents.

Table 4.9: General health condition and occurrences of diseases among respondents

Particulars	Before		After			
	Presence	Absence	Same	Cured	less	Not now
Headache	72	8	13	30	34	0
Eye Pain	65	15	10	35	35	0
Tuberculosis	2	78	0	2	0	78
ARI	40	40	0	0	40	40
Problem in heart	38	42	40	5	35	0
Typhoid	51	29	8	17	0	55

4.6. Estimation of methane leakage from the biogas plant

The total methane leakage per annum from the surveyed HHs was calculated to be 26508.125 kg/yr and the average methane leakage in the municipality was 9341.719 kg/yr/plant (Table 4.10)

Table 4.10: Methane leakage from the sampled HHs

Particulars	Plant size				
	4	6	8	10	15
Average methane leakage/plant m^3/day	0.5	0.75	1	1.25	1.88
Number of plants	0	48	16	15	1
Total Methane leakage m^3/day	0	36	16	18.75	1.88
Total Methane leakage m^3/yr	0	13140	5840	6843.8	684.38
Total Methane leakage in kg	0	9329.4	4146.4	4859.1	485.91
Total Methane leakage = 18820.77 kg/yr					
Total Methane leakage = 62131.12 CO_2eq					
Average plant size = 7.26 m^3					
Average Methane leakage = 0.9075×365=331.2375 m^3/yr/plant					
Average Methane leakage = 331.2375×21 = 4938.751125 kg CO_2eq/yr/plant					
12.5% leakage of CH_4 is considered for the estimation (IPCC, 1996), (BSP, 2005)					

4.7. Trend of BGP installation and their cumulative GHG mitigation potential

The BGP installation was started from the fiscal year 2051/52 at Damak municipality which gradually was increasing trend till 2010. With the increase in BGP there was gradual increasing in the cumulative GHG reduction in the area. The following figure shows the detail about the number of BGP and the GHG reduction potential of the area.

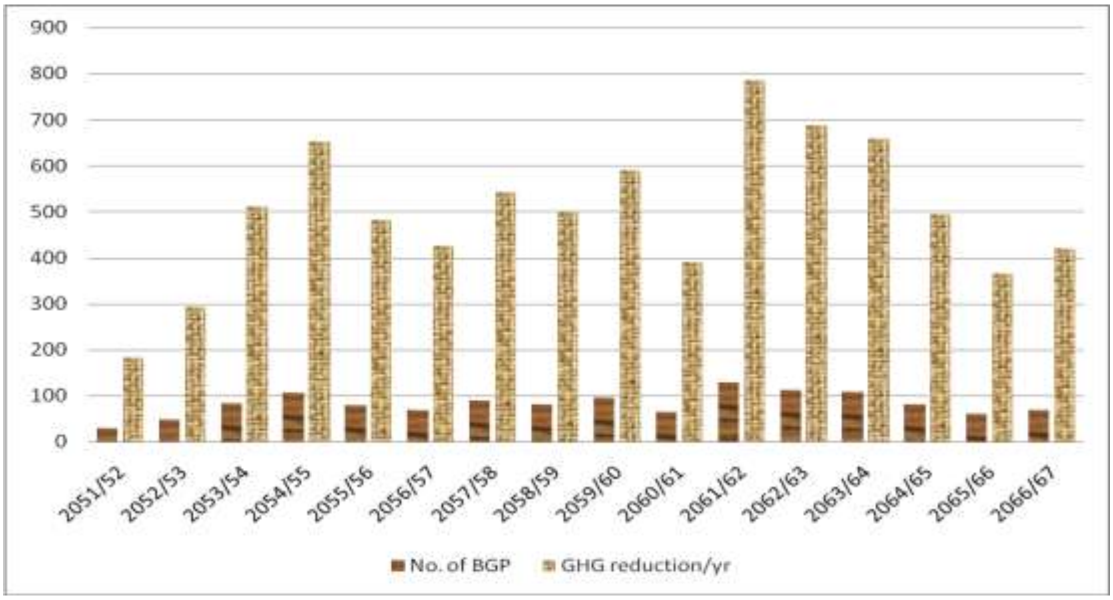

Figure 4.9: Trend of BGP installation and their cumulative GHG mitigation potential in ton CO_2eq

4.8. Total GHG emission in the area

Total GHG emission from different sources at the study area was found to be 9144.50 kg of CO_2eq/HH/yr. The emission from different sources and average annual GHG emission in the study area is given in the table 4.11 below.

Table 4.11: Average annual GHG emission

Fuel type	Emission (Kg of CO_2eq/HH/yr)	Total resultant emission (kg of CO_2eq/HH/yr)
Firewood	539.5585	9144.50
LPG	0.36007	
Kerosene	633.6793	
Leaves/twigs	3032.1529	
Methane leakage from the Digester tank	4938.75	

4.9. Payback period of the BGP

According to BSP 2006 the initial investment cost for the BGP of 8 m^3 at terai region cost an average of NRs. 35,000. For the smooth running of the BGP there must feed the dung, collection of water and dung as well. For the different activities to run biogas plant local biogas user invest 15 minutes. According to the recent labor cost of NRs.33/hour it becomes an annual cost of NRs.3011. Due to simple operation and maintenance mechanism there was no high investment for the maintenance of BGP for which biogas user noticed an average of NRs.600/yr. Household having BGP used tube well water for feeding the plant. Electric water pumps were used for this purpose. Hence about 0.5 units of electricity was consumed per day. The annual cost of electricity became NRs.1460/HH (1 unit cost NRs.8 according to NEA).

The fuelwood saving due to the installation of the BGP was high; which was NRs. 20,906/year and annual saving from LPG was only about 305. There was no any contribution of kerosene consumption in the study area.

Being the terai district the government subsidy for the installation of BGP is NRs.6,000. Here the average size of the plant was nearly equal to 8 m^3. Some HHs also gets economic incentives of NRs. 2,000 from Humse Dumse Community Forest to install BGP.

Thus payback period for the BGP at Damak municipality was calculated to be 2 years and two months without subsidy from BSP and without economic incentives from community forest. Likewise payback period for the BGP which gets subsidy from BSP and economic incentives from community forest was found to be one year and seven months.

CHAPTER V

5. DISCUSSION

5.1. General information about the respondent

People's livelihood at Damak municipality depends on agriculture. About 80% of the respondents depend on agriculture for the main source of income. This dependency on agriculture is comparable to the national living standard survey 2003/04; accordingly 78% of the HHs depends on agriculture.

Out of total 26% has access to safe drinking water supply from municipal water supply. The water supply from municipality is safe and meets the entire water quality standard for drinking purpose. This is comparable to national living standard survey 2003/04; accordingly 25% HHs have safe drinking water facility.

5.2. Emission reduction of GHGs

Due to the less consumption of the fuelwood after the installation of the BGP there was a drastic reduction in the emission of the GHGs. Due to the installation of the BGP there was reduction in the consumption of the fuelwood and LPG. But there was no reduction in the consumption of the kerosene. In the study area kerosene use was limited for the lighting purpose only. And there was no HHs (in sampling frame of the present study) which uses the biogas for the lighting purpose. They use kerosene for the lighting when there was interruption of the electricity from NEA.

5.2.1. Emission reduction from fuelwood

Before the BGP total emission was of 6.67 tons (6,675.807 kg) of CO_2eq/HH/yr and after the installation of BGP the amount becomes 0.0539 tons (539.55 kg) of CO_2eq/HH/yr. This indicates that after the BGP installation 6.136 tons (6,136.30kg) of CO_2eq reduces per HHs/yr; this nearly equal to 6 ton of CO_2eq/HH/year. Here for estimation of the CO_2eq all GHGs (CO_2, CH_4 and N_2O) were converted to the CO_2eq.

The average plant size in the study area was found to 7.6 m^3 that becomes nearly equal to 8 m^3. This value of GHGs emission reduction from Damak was low as compared to Winrock and Eco securities 2005 according to which 8 m^3 plant in terai region saves an average of 7.56 tons of CO_2 eq/plant/yr. This difference in GHGs emission may be due to differences in the ecological region. The present study was conducted at terai belt where as studied conducted by Winrock and Eco securities was in hilly area. At the hilly area more fuelwood is consumed for the internal heating of the room. But at the study area no fuelwood is required for the internal heating. Thus the more consumption in fuelwood results more emission of GHGs.

And again the value of GHGs reduction per plant per year from the Damak municipality was low as compared to that BSP 2009. According to which 7.4 tons of GHGs emission can be reduced per plant per year. Here the difference in emission of GHGs may be due to the difference is ecological zone and availability of the fuelwood. The study done by BSP was based three ecological zones of Nepal i.e. terai, hill and mountain but the present study was conducted in terai region.

According to WWF, (2009), there was emission reduction of 3,034.56 tons of CO_2eq from 1,620 BGP, which becomes 1.87 tons of CO_2eq for the year 2007 and 9,090.49 tons of CO_2eq from the 1065 BGP, which turns 8.53 tons of CO_2eq for the year 2008. Here the emission reduction of the year 2008 is high as compare to 6 tons of CO_2eq from Damak municipality.

Shrestha found the total annual GHG emission of 3.66 tons of CO_2eq/HH/yr and 6.02 tons of CO_2eq/HH/yr for biogas and non-biogas households respectively. This is comparable to the Damak municipality.

5.2.2. Emission reduction from LPG

The consumption of LPG is reduced after the installation of BGP. Before the BGP average cylinder consumption per HH per year was 0.35 which is reduced to 0.11 cylinders per HH per year. This decrease in consumption of LPG consequently reduces the emission of GHG by 0.71 kg of CO_2eq/HH/yr.

There was no any significant reduction in emission from LPG was observed. This may be due to the fact that the study area was rural area of Damak municipality. There was less consumption of the LGP for cooking purpose.

5.2.3. Emission reduction from kerosene

At the study area the average kerosene consumption per HH per year was 21.6 L/HH/year and there was no role of BGP in reducing the kerosene consumption because the BGP in the study area was limited to cooking purpose only. None of the HH uses the BGP for lighting purpose and there was no practice of using kerosene for the cooking purpose before and after the BGP. Kerosene was limited to occasional lighting purpose due to irregular electricity supply from the NEA. Thus in the study area, biogas has not yet been able to contribute in reducing kerosene consumption. This result is comparable to Shrestha 2010. According to BSP 2004 biogas can be used for the lighting purpose however in the study area uses of BGP is limited to cooking purpose only. According to BSP 2009 each BGP saves an average of 6.4 liters of kerosene per HH per year this is also in against the result drawn from the present study. This may be due to that there is no any practice of using biogas for the lighting purpose.

5.2.4. Uses of leaves and twigs and GHG emission

The use of leaves and twigs was limited for the preparation of food for livestock only. It was not used for the preparation of food for the human being. Thus the BGP has no contribution in reduction in the consumption of leaves and twigs, and also for the reduction of GHG from the combustion of leaves and twigs. Total emission from the leaves and twigs was 3,032.15 kg of CO_2eq/HH/yr.

5.3. Benefits of BGP

5.3.1. Benefits from replacement of fuelwood

The study showed, in the Damak municipality each HHs consumed an average 4.39 tons of fuelwood annually before the installation of BGP and consumed an average 0.355 tons of fuelwood annually after the BGP. At present the HHs used leaves twigs and agricultural residues for preparing animal feed locally called "Khole". For making alcohol and Khole HHs is being used an average of 2.01 tons annually.

At the studied municipality the average size of the BGP was 7.26. Each BGP saves an average of 2 tons of fuelwood per annum. But here in the study area the BGP saves an almost double the fuelwood than assumption. At Damak municipality the practice for the installation of the BGP was started from 2051, at that time there were sufficient fuelwood. They used to use excess than their real needs. At that time the forest was in natural condition but now the forest area turns to Bhutanese refugee camp so there is less chance for the availability of the fuelwood.

Each BGP saves over 2 tons of fuelwood annually and protected over 0.06 ha of forest is being saved per year which was comparable WINROCK and Eco Securities (2004). According to WINROCK and Eco Securities one biogas can save 0.061 ha of forest per year. The study showed 78.6 ha of forest is being saved. At the study area there is a total of 512 ha of forest. So we can say that out of 512 ha forest 78.6 ha of forest is being saved due to total installed 1,310 BGP at the study area.

5.3.2. Benefits of biogas on health and sanitation

The study in the Damak municipality showed that there was no any HHs without toilet which has BGP. This showed increased toilet construction among the biogas HHs. Being the clean indoor environment; the occurrences of diseases like problem in eye, headache and chest pain is gradually being reducing in the study area. This is comparable with Shrestha 2010. and also comparable with biogas user's survey 2000 conducted in India in the report of ICAR 2000 there indicate that the occurrences of asthma, eye infection and lung problems were decreased after the installation of the BGP.

5.3.3. Economic benefits

In the surveyed municipality the installation of BGP reduced the annual fuelwood consumption by approximately four tons/HHs and provided each BGP an equivalent saving of 139.37 Bhari of fuelwood per year at the local rate of NRs. 150 per Bhari. According to which there is annual saving of NRs. 20,905.87. The high economic saving from BGP in the study area may be due to the fact that less availability of the fuelwood due to settlement of Bhutanese Refugee at the forest area as well. As said earlier there was no contribution of the BGP in reducing the consumption of the kerosene in the study area so the economic benefit gain due to less consumption of the kerosene in the area can't achieve.

Shrestha, (2010) estimates that due to BGP the economic benefit from not consuming the fuelwood was NRs. 2,755.6 per HH. In her study she assumes that 1 Bhari of fuel cost only NRs.40. Devkota, (2003), estimates that there was an annual saving of NRs.2, 000. He considers the amount of fuelwood was NRs.1.5/kg. Here in the study area, the high annual economic saving may be due to the fact that the high market price of the fuelwood (NRs.150/Bhari, 1 Bhari contain 29 kg).

5.3.4. Time saving and workload reduction

Here in the study area there is an average saving of 45 min per day per BGP containing households. According to the field survey there is a considerable saving of the time for not collecting the fuelwood. Before the biogas plant, the villagers used to collect the firewood from the nearby community forest at the winter season and store for whole year. After the BGP there is a considerable decreases in the fuelwood collection for the cooking purpose so, there need less fuelwood. The demand of fuelwood for the family drastically reduced. In the study area, biogas households used the saved time in better care of family, maintaining cleanliness, collection of fodder for livestock, social gathering and engage in income generation activities like microfinance.

Shrestha, (2010), in her study found there was a considerable saving of 60 minutes per day. According to BSP 2009 there is a saving of three hours daily each household. Vliet, (1993), says there is time saving of minimum one hour to maximum two and half of hour’s day due to the installation of the biogas plant. According to ICAR, (2000), due to BGP there is a saving of 2.73 hours per day. These all are comparable to the present study.

5.4. Payback period of the biogas plant

In the surveyed municipality the payback period of the BGP without any subsidy from BGP and economic incentives from community forest was found to be two years and two months; whereas those biogas plants which got the subsidy from BGP and economic incentives from community forest was one years and seven months.

This payback period is very less as compared to that of Shrestha 2010 and Devkota 2003. This difference in payback period between two studies may be due to the difference in initial investment cost, ecological region, cost of fuelwood at two different places, amount of subsidy received and cost of labor as well.

CHAPTER VI

6. CONCLUSION AND RECOMMANDATION

6.1. Conclusion

- Before the construction of the BGP average fuelwood consumption per HHs was 4397.19 kg/HH/yr which is reduces to 355.39 kg/HH/yr thus reduction of fuelwood consumption reduces in the emission of 6.13 tons of CO_2eq/HH/yr.

- Before the biogas plant LPG consumption was 0.35 No./HH/yr cylinder per households per year this becomes reduces to 0.115. Reduction in consumption of the LPG reduces 2.20 kg of CO_2eq/HH/yr.

- There was no contribution of the biogas plant in the reduction in consumption of kerosene because biogas is confined for the cooking purpose only. So there was no any reduction in emission of GHG from kerosene consumption in the study area.

- The methane leakage from the digester tank was estimated to be 9341.79 kg/HH/yr.

- Due to less consumption of firewood at the study area after the biogas installation there was an annual saving of NRs. 20,905.87 and an annual saving of NRs. 304.68 due to less consumption of LPG after the installation of the BGP.

- 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 HHs.

- Each biogas system in the study area would reduce approximately 6.1 tons of GHGs per year per system. Based on the study, if claimed under CDM, each biogas plant in the municipality was likely to bring Nepal an Annual Revenue of around US $ 42.70 per year.

- There was an annual saving of 15196 trees and consequently saves 78.6 ha of forest after the installation of 1,310 biogas plant in the study area.

- According to the key informants interview with Community Forest Management Team most of the local people of Damak municipality depends on nearby Community Forest for fuelwood. This creates huge problem in the forest management practices. For the proper management of the community forest, community forest user group started to provide the subsidy for the installation of the BGP. Thus there is increasing trend in the BGP construction in the study area. Thus there is somehow reduces the pressure on the community forest for the fuelwood.

6.2. Recommendation

6.2.1. For local people

- Normally, gas production decreases in winter by 15 % (BSP 2005). During the survey period most of the respondents noted that there is insufficient of gas during the winter. So local people are advised to fill the top of the dome with at least 40 cm soil and cover it with dry materials like husks, straw etc.

- Instead of feeding the digester in the morning, local are advised to mix the dung with water in the morning and keep it inside the inlet and let the mixed sludge into the digester in the evening allowing the day time sun to warm the feeding materials. This helps to keep the digester warm and produces more gas.

- Local people having biogas plant without attachment of the toilet are advised to connect their toilet to the biogas digester since the gas produced from cattle dung and from human excreta is no different in terms of purity and hygiene. If constructed and maintained properly, all the harmful pathogens are killed in the digestion process. In this way, there is no difference between the sanitation of a toilet-attached plant and that of a non-toilet attached plant. This will also helpful in proper management of the toilet waste and better health and sanitation condition of the area.

- The smallest size is 4 m^3 and largest is 10 m^3. Local are encouraged to select the size depending on the availability of dung and the time taken for cooking or by the family size. In general, a 6 m^3 plant is the ideal size to meet the cooking needs of the average rural Nepali family.

6.2.2. For programme implementer

- Subsidies should be provided to those who are poor and cannot afford biogas installation cost.

- Provision of microcredit to those who are relatively well off, with ability to pay in future would be the best option as this scheme would reduce the financial burden of the governments and also promote better use of the existing scare resources.

- Community level biogas can be installed by using the kitchen waste generated from the Bhutanese refugee camp. The biogas can thus replace the coal consumption recently distributed to them.

- By utilizing the organic waste daily collected by the vehicle of municipality a community level biogas can be installed. This can produces the biogas for the municipality office and solve the problem of dumping site too.

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ANNEX-1

Questionnaire for the local

Introduction and consent

Namaskar, my name is Bimala Adhikari. I am a student of Central Department of Environmental Science, T.U. Kirtipur. I am conducting the municipality level survey mainly based on the effectiveness of biogas and fuelwood type, which you are recently using and used to use in past time.

As part of the survey I would like to ask some question about your households. All of the answer you give will be confidential. If I should come to any question you don't want to answer, just let me to know and I will go on the next question or you can stop the interview at any time as you feel uneasy. But I hope you will participate in the survey since your views are very much important for the completion of this survey.

Do you want to ask me any question about this survey?

May I begin the interview now?

Signature of the interviewer, Date……………………..

Respondent agrees to be interview…………………

Respondent does not agree to be interviewed………… → End

Name of the tol…………………Ward Number………Cluster number…………

Number of households at that cluster…………………….

Name of the household Head………………………………

Name of the respondent………………………………………….

Result ☐

Completed, respondent at home at the time of visit =1

Entire household absent for extended period of time=2

Total absent=3 Postponed=4 Refused=5

Dwelling vacant or address not a dwelling=6 Dwelling destroyed=7

Dwelling not found=8

I. Other………………………

Language of the questionnaire…………………………………….

Language of the interview………… Nepali=1, Dhimal=2, other=3

Translator used yes=1, No=2

Socioeconomic survey

1. **Did ………………….. (Name), attend school at any time during his/her lifetime? If Yes continue if no skip** Under SLC=1, Completed SLC=2, Grade 11, 12=3, Bachelor Degree =4, Above Bachelor Degree =5
2. **What are the main sources of drinking water for domestic purpose for members of households?** Tube well=1 Supply water=2 Public tap=3 Dug well=4 Water from spring=5 Rainwater=6 Surface water=7 other=8
3. **Do you do anything to the water to make it safer to drink? If yes=1 No=2→skip** Filter=1 Boil=2 SODIS=4 bleach/chlorine/piyush/water guard=3 Other=5 (Specify)
4. **What kind of toilet facility do members of your household usually use?**
   Flush to septic tank=1 Flush to pit latrine=2
   Flush to somewhere else=3 Ventilated improved pit latrine=4
   Pit latrine with slab=5 No toilet=6
5. **Do you have own agricultural land?** Yes=1 No=2
6. **What is the total area of agricultural land owned?**
   Less than 1 Bigha=1 1-4 Bigha =2 4 and above =3
7. **What is your main occupation?** Farmer =1 Businessman =2 Teacher =3 Government job=4 Others (specify) =5

Energy requirement and fulfillment

1. **What type of fuel does your household member mainly use for cooking before BGP?**
   Fuelwood=1 Biogas=2 Electricity=3 LPG=4
   Charcoal=5 Agricultural waste=6 Animal dung=7
   Other =8
2. **For how many months the fuelwoods from your own land fulfill your need?** ……………….. Months
3. **What is the main source of lighting in your household?**

Electricity=1 Gas /oil/kerosene=2 others (specify) =3

4. **If it does not fulfill throughout the year, what are your alternative sources to get fuelwood?** Community forest =1 Forest =2 Agriculture residue=3 Bought=4 Others=5
5. **Do you have any problem in collection of firewood?** Yes=1 No=2
6. **If yes, what sort of problems have you faced?** Collection site is far=1 Not easily available=2 others =3
7. **What type of Fuelwood do you use?** Compact wood=1 Loose wood=2 Leaves and twigs=3 Other =4
8. **Which species of tree do you use as firewood?** Sal=1 Sisoo=3 Chanp=3 Bakaino=4

1. Comparative observation

Activity	Before Biogas	After Biogas
Frequency of collection of firewood	Once in ……………….day	Once in ……………….day
Time spent in collection	…………hrs/day or week	…………hrs/day or week
Fuelwood requirement	………..bhari/week, month,yr	………..bhari/week, month,yr
FW collection by male adult	………..bhari/week, month,yr	………..bhari/week, month,yr
FW collection by female adult	………..bhari/week, month,yr	………..bhari/week, month,yr
Handling of stove	Easy=1/ difficult=2	Easy=1/ difficult=2
Frequency of repair and maintenance of the stove	Less=1/ more=2	Less=1/ more=2

Time spent in collection, 1 Day=1, 5-7 hours=2, 3-5 hours=3, 1-2 hours=4, less than 1 hours=5

Fuelwood requirement 3-4 Bhari/week=1, 2-3 Bhari/week=2, 1-2 Bhari/week=3

FW collection by male adult 3-4 Bhari/week=1, 2-3 Bhari/week=2, 1-2 Bhari/week=3

FW collection by female adult 4-5 Bhari/week=1, 3-4 Bhari/week=2, 2-3 Bhari/week

Kitchen type

1. **Is the kitchen** Enclosed=1 Semi-open=2
2. **Is the kitchen:** Separate rc 'tached to rest of main house=2

   Part of main living area in house=3 In separate building=1
3. **Type of roof in the kitchen:** Mud=1 Thatch=2 Ferro-cement=3

   Tiles=4 Wooden Tiles=5 Other=6 If 'other' please specify
4. **Walls** Type of walls in room with stove=1 Mud or mud blocks=2

   Soil/cement blocks=3 Wattle (woven sticks / reeds / bamboo) =4

   Iron sheets=5 Bricks=6 Stone=7 other=8

Windows & doors

1. How many windows are in the room where cooking is done? ………

Status of Kitchen after the use of these technologies

a. **Cleanliness** Satisfactory=1 Unsatisfactory=2
b. **Comfort ability** Satisfactory=1 Unsatisfactory=2
c. **Ventilation** Satisfactory=1 Unsatisfactory=2

Biogas

1. **Are you aware of the biogas technology?** Yes=1 No=2 Partly=3

Do you feel any advantages in Biogas over TS? Yes=1 No=2

2. **Biogas plant can be used for?**

   Cooking stove=1 Lightning=2 Fertilizer replacement=3

   Fuelwood replacement=4 Time saving=5

   Hygiene and sanitation improvement=6 Others (specify)=7
3. **How did you know about this technology?**

   Through publicity media=1 through government officials=2

   Through service providers=3 through friends/relatives=4

   Through other biogas owners=5 Through NGO/CBO=6

   Other (specify) =7

4. What are the reasons for not installing a biogas plant?

Do not know about the technology=1 No trust in the technology=2

No understanding of the benefits=3

Family members/community do not like it=4 High investment cost=5

Not enough livestock/feeding materials=6 Others (specify) =7

4. **If you save time by the use of biogas where do you spend the time?**

Other household work=1 Business=2 Gardening=3

Involved in organization=4 Others (specify) =5

5. **How much of the fuel consumed for cooking in a month?**

   Wood/firewood (kg/mon'

   Dung (kg/month) …………

   Leaves/rubbish/straw/thatch (kg/month)……….

   LP gas (kg/month)…………….

   Kerosene (liter/month)…………

   Bio gas (unit)……………

   Others (specify)……………

6. **When you installed the Biogas plant?** Before 20 years=1
   before 10 years=2 before 5 years=3 recently=4
7. **For which purpose do you use the biogas?**
   For cooking=1 Lighting=2 other =3
8. **Do you get any subsidy to install the biogas?** Yes=1 No=2
9. **If yes from where? ………………………………..**
10. **Does the Bio gas is sufficient for your household?** Sufficient=1 occasionally it will shortage=2 In winter it will shortage=3 Always insufficient=4 other =5
11. **How many time do you had to spend to collect the fuelwood?**
    Whole day=1 Half day=2 2-3 hours=3 Minutes=4
12. **Before installing the plant how much fuel do you consume per week? ....**
13. **Before installing do you use kerosene for cooking purpose?** Yes=1 No=2
14. **How much kerosene do you used to consume for cooking? ....**
15. **After the installation of biogas plant how much fuel do you consume per week? ....**
16. **How much money do you used to spend to purchases the fuelwood before installing the plant? ....**
17. **If you think so that the money is being safe after the biogas plant?**
    Yes=1 No=2
18. **If yes annually how much money are you saving? ………………………..**

Adaptation Trend

1. **How do you find the trend of use of biogas in recent years?**
   Increasing=1 Decreasing=2 Stable=3
2. **What do you think about the people's response in the use of Biogas?**
   Positive=1 Negative=2
3. **Is biogas helps you in generating income?** Yes=1 No=2
4. **If yes, please mention the reasons?**
   …………………………………………………

Health condition

1. **Have you ever heard of illness Acute Respiratory Tract Infection?** Yes=1 No=2
2. **Do your family member got ARI?** Yes=1 No=2
3. **If yes please can you tell me when and how many times it gets and to whom?**

Whom	When	How many times	Cured/uncured

4. **Have you ever heard of an illness Tuberculosis or TB?** Yes=1 No=2
5. **Do your family member got TB?** Yes=1 No=2
6. **How much money do you have to spend annually to cure the diseases like that? ……………………**
7. **Do you feel any improvement in your health after installing the Biogas plant?**
   Yes=1 No=2
8. **Please tell me some benefit that you are gaining from Biogas plant?**
   Safe time to collect the fuelwood=1 Safe of firewood=2

   No smoke in the kitchen=3 environmentally friendly=4

   Improvement in health=5 Consume less time in kitchen=6

   Other =7Specify

9. **Do you have any disadvantages of having biogas plant tell me some disadvantages of it?** High installation cost=1 Not efficient=2

Takes time to collect the dung=3 No effective compost for the agriculture=4

Other =5 (Specify)

10. How do you feel after the installation of biogas?

		Before	After	
I.	Eye pain	☐	☐	
II.	Headache	☐	☐	Same=1
III.	Nausea	☐	☐	Less occurrences=2
IV.	Vomiting	☐	☐	Cured=3
V.	Chest pain	☐	☐	
VI.	Respiratory tract infection	☐	☐	
VII.	Problem in heart	☐	☐	
VIII.	Diarrhea	☐	☐	
IX.	Malaria	☐	☐	
X.	Typhoid	☐	☐	
XI.	Other			

11. Where you used to collect it from?

From self garden=1 From nearest jungle=2 Purchase it=3

Use animal wastes animal dung cake=4

ANNEX-2

Checklist for the project implementers/ programme level respondents

Name of the respondents……………………………….position………………………

Organization……………………………………Place………………………………

Years started working in the project………………Work place………………………

Education attended……………………………Marital status……………………….

1. What are your responsibility in the office and field?
2. How many staffs are involved in the project? Do you think the number is adequate to achieve the project objectives? If no what is the adequate number of staff?
3. Have you attended any training, workshop, seminar and conferences since you join the project? If yes give the information.
4. Is there any change in the management practices such as selection of fertilizer, pest control practices waste management practices after the implementation of the project?
5. How did the project provide the technical supports to the participants and in what manner?
6. What were the training conducted to the biogas user?
7. What problems do you encounter in the successful implementation of the project?
8. Did you observe any increases in the income level of the biogas user?
9. How do you feel the attitude of the user towards the biogas plant?

ANNEX -3

Energy contents of various fuel type at different unit

S.N.	Fuel type	Unit	kcal(000)	GJ	TCE	TOE	Other	
1	Traditional fuel							
1.1	Fuel wood	Tonne	4000	15.5	0.57	0.364	1.43	M3
1.2	Charcoal	Tonne	7100	29.3	1.01	0.688	2.86	M3
1.3	Agricultural waste	Tonne	3000	12.5	0.43	0.293		
1.4	Animal Dung	Tonne	2600	10.9	0.37	0.256		
1.5	Biogas	(000)m3	5800	22.5	0.83	0.528		
2	Commercial fuel							
2.1	LPG	Tonne	11760	47.3	1.68	1.14	1.637	Kl
2.2	Kerosene	Kl	8660	35	1.24	0.85	0.78	Tonne
2.3	Electricity	MWh	860	3.6	0.12	0.08		

WECS, 2006, as cited in Jun Hada 2009

Name of the respondent and their plant size with location ward

Serial No.	Fiscal Year	Owner Name	Vdc Np	Ward	Size
1	2055/2056	SITA DEVI CHUDAL	DAMAK	1	6
2	2056/2057	GANGARAM KOIRALA	DAMAK	1	6
3	2058/2059	DILLI PD. SHIVAKOTI	DANDAGAUN	1	6
4	2063/2064	MUKTI PD. BHANDARI	EKATA TOLE	1	6
5	2065/2066	KAMALA BUDHATHOKI	PANCHAMUKHI	1	6
6	2066/2067	KHANG KUMARI KERUNG	AANKHA AASPATAL	1	6
7	2053/2054	Ambar Bdr. Kumal	DAMAK	1	15
8	2061/2062	EK RAJ GURAGAIN	HIMABICHOWK	2	6
9	2061/2062	PARBATA THAPA	JIRAYAT	2	6
10	2062/2063	MAN BDR TAMANG	KHARKHARE	2	6
11	2056/2057	INDRAMAYA ADHIKARI	DAMAK	3	6
12	2058/2059	NIRMALA DEVI SAPKOTA	BELDANGI	3	6
13	2059/2060	NARMAYA SAPKOTA	BHANGBARI	3	6
14	2060/2061	CHANDRA BDR. SARU	BHAGBHARI	3	6
15	2060/2061	DEVI MAYA ADHIKARI	BHALUKUDI	3	6
16	2060/2061	BHANU BHAKTA FUYAL	BHANGBHARI	3	6
17	2053/2054	KOPILA MANI SIWAKOTI	DAMAK	3	8
18	2054/2055	Dev Narayan Shrestha	DAMAK	3	8
19	2058/2059	DEV NARAYAN SAPKOTA	BHANGBARI	3	8
20	2051/2052	Tulasi Ram Dangal	DAMAK	3	10
21	2056/2057	BIJAY PD. BARAL	DAMAK	4	6
22	2063/2064	RAJ KUMARI SHRESTHA	DAKINI	4	6
23	2053/2054	Chhabi Lal Dulal	DAMAK	4	10
24	2056/2057	KUMARI MANMAYA POKHREL	DAMAK	5	6
25	2058/2059	YAGYA PD. POUDEL	DUMSE	5	6
26	2060/2061	GOMA DHAKAL	BAGKHOR	5	6
27	2061/2062	LILANATH GURAGAIN	GOLATAR	5	6
28	2062/2063	BIR BDR POUDEL	BHALUKUDI	5	6
29	2062/2063	DHAN KUMARI NIRAULA POUDEL	DHUKURPANI	5	6
30	2064/2065	SHAMSHER BDR. RAI	DUMSE	5	6
31	2054/2055	Santa Kumar Basnet	DAMAK	5	8
32	2058/2059	DHAN KR. SHRESTHA	DAVGACHHI	6	6
33	2060/2061	PURNA PD. POUDEL	DHUKURPANI	6	6
34	2061/2062	INDRA PD. GURAGAIN	DHUKURPANI	6	6
35	2063/2064	MANMAYA DULAL	DHUKURPANI	6	6
36	2064/2065	TRILOCHAN ACHARYA	DIPU	6	6
37	2054/2055	PUNYA PSD DHAKAL	DAMAK	6	8
38	2056/2057	RAM DEVI POKHREL	DAMAK	6	8
39	2053/2054	Omkanta Chapagain	DAMAK	6	10
40	2061/2062	MAN MAYA MAGAR	GOLATAR	7	6
41	2061/2062	DEVI PD. POKHAREL	GOLTAR	7	6
42	2063/2064	HEMANTA BDR. KARKI	GOLATAR	7	6
43	2064/2065	PRATIMAN BHATTARAI	GOLATAR	7	6
44	2055/2056	BHANU BHAKTA GAUTAM	DAMAK	7	8
45	2062/2063	SUMITRA DAHAL	KRISHNA MANDIR	8	6
46	2054/2055	Tanka Bdr. Pande	DAMAK	8	8
47	2054/2055	Ganga Maya Baral	DAMAK	9	6
48	2062/2063	RISHIKESH POKHREL	KHARKHARE	9	6
49	2064/2065	PADMA DEVI SHRESTHA	ADIYAMAHAL	9	6

50	2053/2054	Indra Devi Khadka	DAMAK	9	15
51	2062/2063	HOM BDR KHATRI	GANESHTOL	14	6
52	2054/2055	KHADKA BAD. KUNWAR	DAMAK	14	10
53	2056/2057	INDRA BDR.L SHRESTHA	DAMAK	15	6
54	2059/2060	RAJU THAPA	LAMATOLE	15	6
55	2061/2062	SOM BDR. DHIMAL	CHAKADPADA	15	6
56	2061/2062	DILLI RAM SITAULA	CHIYADOKAN	15	6
57	2061/2062	MAN BDR. KHADKA	KHARKHAREY	15	6
58	2062/2063	RISHIRAM NEUPANE	BIKASH MARG	15	6
59	2051/2052	Jagat Bdr. Dhimal	DAMAK	15	10
60	2052/2053	Tika Maya Dahal	DAMAK	15	10
61	2053/2054	Harka Bdr. Chhetri	DAMAK	15	10
62	2060/2061	PRATIBHA DAHAL	KRISHNA MANDIR CHWOK	16	6
63	2062/2063	DILLIRAM CHUDAL	ARNAKHADI	16	6
64	2062/2063	BISHWA NATH DAHAL	DAKHINNAKALI MARG	16	6
65	2055/2056	AGNI PD. BHETWAL	DAMAK	16	8
66	2053/2054	Ram Bdr. Rai	DAMAK	16	10
67	2066/2067	MAN PD. GHIMIRE	BUDHABAREE	17	6
68	2066/2067	BAM BDR SHRESTHA	NALABARI	17	6
69	2055/2056	MANORATH BHATTARAI	DAMAK	17	8
70	2052/2053	Menuka Devi Guragai	DAMAK	17	10
71	2062/2063	MAN MAYA LUITEL	GHARANE	18	6
72	2066/2067	DAMBAR KUMARI KARKI	DHARANE	18	6
73	2055/2056	HOM BDR. KHADKA	DAMAK	18	8
74	2056/2057	DILLIRAM BARAL	DAMAK	18	8
75	2053/2054	Shuresa Lawati	DAMAK	18	10
76	2056/2057	DEVENDRA SHRESTHA	DAMAK	19	6
77	2059/2060	CHET KUMARI SIMKHADA	12 GHARE	19	6
78	2059/2060	SARITA NEUPANE	BARGHARE	19	6
79	2052/2053	Chhabi Raman Dhakal	DAMAK	19	10
80	2054/2055	Mukunda Kharel	DAMAK	19	10

ANNEX 4

Member of FGD at Samaj Sudar Pratisthan,		Member at FGD with Women's Group of Damak 4	
1	Mr. Narayan Gimire	1	Mrs. Santosh Kumari Pokherel
2	Rr. Uma Kanta Adhikari	2	Mrs. Tulasa Sapkota
3	Mr. Tek Bdr. Dhimal	3	Mrs. Durga Devi Adhikari
4	Mr. Damber Kumar Ownem	4	Mrs. Januka Bhattarai
5	Mrs. Sushma Adhikari	5	Mrs. Santi maya Shrestha
6	Mr. Om Nath Bhattarai	6	Mrs. Bhima Dhimal
7	Mr. Kedar Bista	7	Mrs. Jagani Dhimal
8	Mr. Bhagirath Sapkota	8	Mrs. Shanti Maya Dhimal
9	Mr. Bijaya Pd. Baral	9	Mrs. Gita Sapkota
10	Mr. Purnanda Pokherel	10	Mrs. Nira Bhattarai
11	Mr. Vim Pd. Pokherel	11	Mrs. Ambika Baral
12	Mr. Gyan Kumar Sapkota	12	Mrs. Anju Sigdel
13	Mrs. Tulasa Sapkota	13	Mrs. Kalpana Kafley
14	Mr. Bipin Ojha	14	Mrs. Parbata Shrestha
15	Mr. yogesh Guragain		
16	Mr. Agni Pd. Sigdel		
17	Mr. Ram pd. Mishra		
18	Mrs. Sunita Bista		

ANNEX-5

Photographs

Photo 1: Newly constructed BGP at study area

Photo 2: Questionnaire with biogas user

Photo 3 : FGD with women’s group

Photo 4 : Under construction biogas plant at study area

Photo 5: Interaction programme with local

Photo 6 : Toilet attached biogas plant at study area

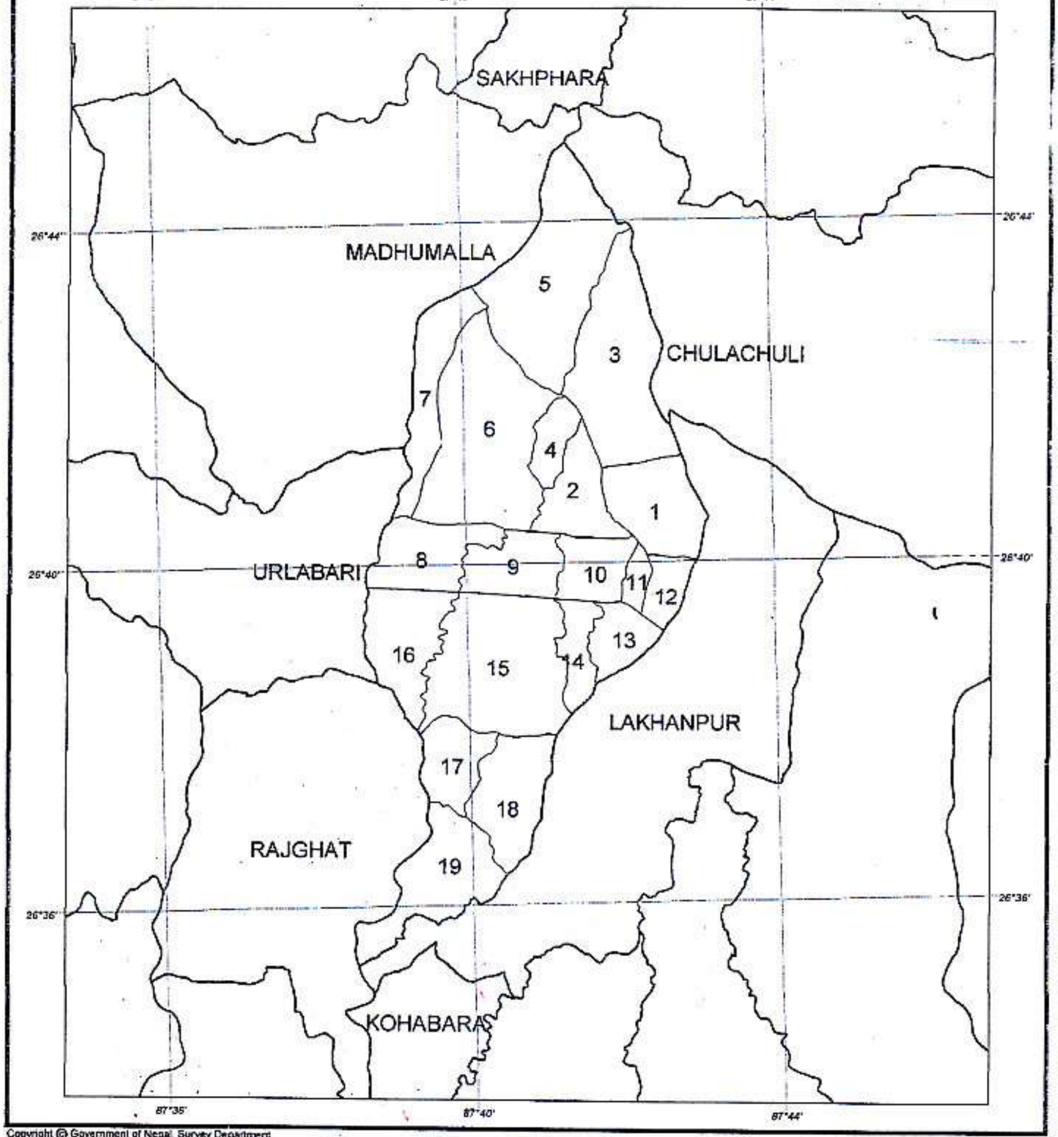
Photo 7: Clean indoor environment with biogas plant

Photo 8 : Collection of leaves and twigs for the preparation of animal feeding

DAMAK MUNICIPALITY

DISTRICT : JHAPA

VDC Code : 4012



SCALE 1 : 125000

2500 0 2500 5000 Meters

LEGEND

VDC Boundary

Ward Boundary

BUKHEL VDC Name

5 Ward Number

DAMAK MUNICIPALITY

Area :70 Sq.Km.(Approx.)

HORIZONTAL DATUM

Spheroid Everest 1830
Projection MUTM
Origin Longitude 84° E., Latitude 0° N.
False coordinates of origin 500 000 m. Easting, 0 m. Northing
Scale Factor at Central Meridian 0.9999

Map compiled from National Topographic Database at scales 1:25 000 and 1:50 000, 2002. Internal administrative boundaries are not demarcated on the ground. Map produced by the Survey Department, National Geographic Information Infrastructure Programme, (NGIIP). Kathmandu.

JHAPA DISTRICT
VDC Location Map