CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The Government of Nepal (GoN) and External Development Partners supporting Nepal's rural and renewable energy sector have designed National Rural and Renewable Energy Program (NRREP). AEPC has been shouldering with the responsibility on program implementation for upcoming five years starting from mid –July 2012 to mid-July 2017.

Biogas is an alternative source of energy and also a source of income for a country like Nepal (BSP,2010). In the country like Nepal, there is high potentiality of Biogas plants and some of the areas it has been successfully implemented. So the mentioned study is designed to examine its environmental aspects and its utilization in a particular region of Gandaki Rural Municipality,Gorkha.

Biogas is a combustible gas produce by anaerobic fern mentation of organic materials by the action of methanogenic bacteria. The gas is principally compose of methane (CH_4) and carbon dioxide (CO_2). It is produced by mixing biodegradable materials i.e. cattle dung, human excreta and other organic wastes with in temperature of 26° to 36°for a certain period. It is mainly compose of 50-70% methane, 32-40% carbon dioxide, 5-10% hydrogen and other required gases. (BSP, 2003). Biogas is 20% liter

than air. It is colorless, odorless and smokeless gas that burns with clear blue flame similar to LPG.

In the history, in Nepal Biogas technology was first initiated in the mid-$1950_s$by father B.R.Sauboll, a Belgium teacher at Godavari St. Xavier's school who built a demonstration plant. Only a few farmers were interested in bio gas technology and they installed a few Biogas plants after 1967 under the design of Khadi and Village Industry Commission (KVIC) model of India. The world energy crisis in 1973/74, dragged a global interest in this sector.InNepal, Biogas Developed Committee(BDC) was formed 0 as a part of Energy Research and Development Group(EDRG), under Tribhuvan University in 1975 (New Era,1985). The observation of the fiscal year 1975/76 as the 'Agricultural year', included Biogas as a special program for its effectiveness in controlling deforestation and preventing burning dung cake. Interest free loans were provided to the framers willing to install the Biogas plant. In the beginning, the government did not take interest to support this activities, however, Biogas was given priority as an alternative energy sector during the seventh five year plan (BSP, 1994).

In 1992,''Biogas Support Program'' was introduced at three different stages for massive dissemination of technology in the country with the long-term objectives of; reducing deforestation and environmental deteriorations, improving health and sanitation of rural population especially women; and increasing the agriculture productivity by promoting the use of digested slurry. It has successfully completed its third phase in June 2003 and have stated 4^{th} phase from July 2004. Biogas program is being developed as the ''Clean Development Mechanism ''project in Nepal. The Biogas program has been launched in 65 districts to the till date (BSP, 2004).

Nepal is an agricultural country where still above 80% of the people follows this occupation to earn their living. On the other hand animal husbandry is an integral part in the rural areas. So, it is obvious that there is huge generation of animal bio-product and agriculture wastages which are primarily the major sources of biogas production.so, it can be fully utilized for the generation of the Biogas. Therefore, Biogas stands in the front in search of the alternate sources of energy in the Nepalese rural context.

The time elapsed on the collection of fuel wood or making dung cakes will definitely be cut down very highly through the biogas and the spare time could well be utilized for other productive, benefits biogas technology is one of the most trusted and popular alternative sources of energy.

Biogas plays an important role in economic development. Understanding the link between economic growth and energy consumption is a key to socio-economic impact analysis. It is familiar that energy consumption and economic growth are related, but the direction of this relationship is not always clear. As well as reducing the environmental impact associated with imported fuels, biogas can increase diversity of energy sources and potentiality, contribute to energy security and to the long-term availability of energy supply.

From the date 1986 to July 2013, total number of biogas installation reached up to 2,94,011. It was viewed in different phases conducted by different programs.

In Gandaki Municipality, Biogas plants has been very much popular and appreciated and acquired by lots of households over 300 for their energy supply.Biogas plants has been under operation since last 15years. This research study is designed to examine its utilization in relation to environment conservation in the targeted area of Gorkha district.

1.2 Problem Statement

As energy is critical component, the demand is increasing day by day. It is directly connected with human's universal progress as in cooking, heating and so on. The major share of energy consumption is met through traditional sources. Most of the people depend on forest sources. Similarly, firewood being the main source of energy is resulting to depletion of forest areas on one hand and on the other hand the smoke emitted through the firewood is totally polluting the environment as well as it is very badly affecting the health of Nepalese women.

In this 21st century, due to the rapid population growth the energy problem is one of the main problem of developing countries and there is no doubt that Nepal could not remain untouched with this problem. Shortage of energy is serious constraint to the development process and for achieving sustainable development. But we are well

aware and known about the fact that the area of resource is constant and limited and with this limited resource all the demands are to be fulfilled. Therefore, it can be generalized that without the vision or management of alternate source of energy the demand goes on increasing and increasing. If these problems are not addressed on time then on coming days the entire human society has to suffer a lot.

So, realizing on the mentioned facts the study tries to find out the impact of biogas in the proposed study area on the subjects like:

- Does it meet the economic aspects for all kinds of families?
- What are the major products people have been using to produce gas?
- Does it help in the improvement of health, sanitation and environmental conservation?
- Increment of agricultural productivity through biogas plants.
- The quantity of firewood saved and protection of forests area.

1.3 Objectives of the Study

The general objective of the study are to find out the various uses of biogas energy with relation to environmental conservation. The specific objectives are:

- To find out the various uses of biogas and its condition.
- To examine the economic benefits of biogas plants.
- To study the role of biogas in the improvement of health, sanitation and environmental protection.

1.4 Significance of the Study

Nepal is an agricultural country and livestock farming is one of the important components of agriculture. In relation to this, biogas technology is more feasible in comparison to other renewable resources like solar, wind energy, and costly micro-hydro power. Biogas being cheaper, easy to maintain, environment friendly plus other lots of positive aspects makes it very important in the Nepalese context. Biogas as an alternative source of energy certainly comes handy as a substitute for electricity,

workload, time and money. Especially in relation to environmental conservation, biogas has the following points of significance:

- By using biogas, we can minimize ongoing power crisis.
- It helps in preservation of forest areas.
- It minimize environmental pollution.
- It helps to improve agricultural productivity.
- Installation of biogas plant is economically, technically and socially viable.
- It helps to improve the status of women's health condition.

So this findings of study will definitely help the related people to decide about the installation of biogas plant study as well as it will be helpful in improving status and economic activities of the users in the study area.

1.5 Limitation of the Study

The present study is based on household survey of biogas users in the study area of the research targets to study the use of biogas in relation to environmental conservation of Gandaki Rural Municipality. The following are the limitation of this study:

- Altogether 60 households were taken as sample size out of 520 biogas users. In this sample size, out of 8 wards, 2 wards (6, 7,) were selected for biogas user's perception survey.
- Studywas mainly based on field visit with primary data collection from (60 sampled households and biogas companies) as well as secondary information collected from internet, google, AEPC BSP/Nepal and other related companies.
- Time factor was another constraint.

1.6 Organization of the Study

The first chapter is the 'introductory' chapter which discusses about the background information, statement of the problem, objectives, significance, etc. literatures related

to energy and biogas as a source of renewable energy and its uses in relation to environmental conservation has been reviewed on the second chapter under the heading of 'literature review'. The third chapter is all about the research methodology applied for this research study. Chapter four discusses about the analysis of data interpretation and lastly the fifth chapter deals with the summary, key findings guided by objectives, conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW

This chapter presents the summary of the outcomes of various research studies carried out to evaluate the welfare gain achieved from the installation of the biogas plants by the users. The literature was reviewed from various sources such as those presented by former researchers included reports, and paper presented at seminars, articles published in various bulletins, journals and newspaper, plans and policies ,published and unpublished documents, and information published by concerned agencies**.**

2.1Conceptual Review

As Nepal is a rural and agricultural country, many people resides in rural areas, the main source of living is agriculture and livestock farming is the main occupation. From this we can review that Biogas Technology is more reliable and has highest potentiality. Biogas is an important alternative source in relation with other sources like solar, hydropower. It is an important alternative source of energy and also a source of income for a developing and agricultural country like Nepal (BSP, 2010). It has several direct and indirect benefits. As Nepal is an agriculture country and more than 80% population produced from any biodegradable organic materials and it doesn't produced smoke. It is used for mainly cooking and lighting purpose especially

in rural areas, which has cut down the use of traditional biomass and imported commercial energy sources. Biogas has positive impact on human health, workload reduction, forests conservation, environmental protection and it can be implanted as ‘’Clean Development Mechanism’’.

Although the use of biogas gained popularity only after 1970, various studies on different aspects of biogas have been performed since then. In the context of Nepal, the technology is appreciated and used mainly as the alternative source of energy for cooking, lighting and the digested slurry as better organic manure for agricultural crops and vegetables (BSP, 2004).

2.1.1 Conceptual Framework

The conceptual framework Figure 1 gives a diagrammatic representation of the variables in the study. Adoption of biogas technology in this study is the depended variable defined as production and use of biogas and is influenced by various independent variables which are interrelated.

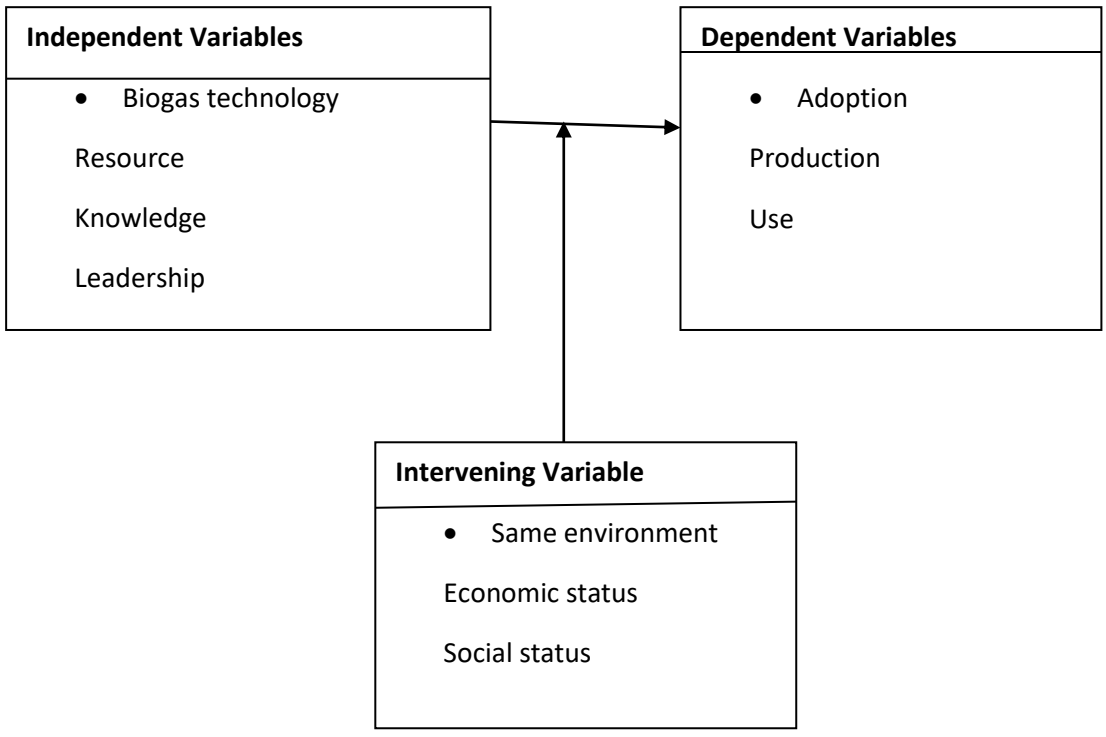


Figure 1: Conceptual framework depicting the adoption of biogas technology

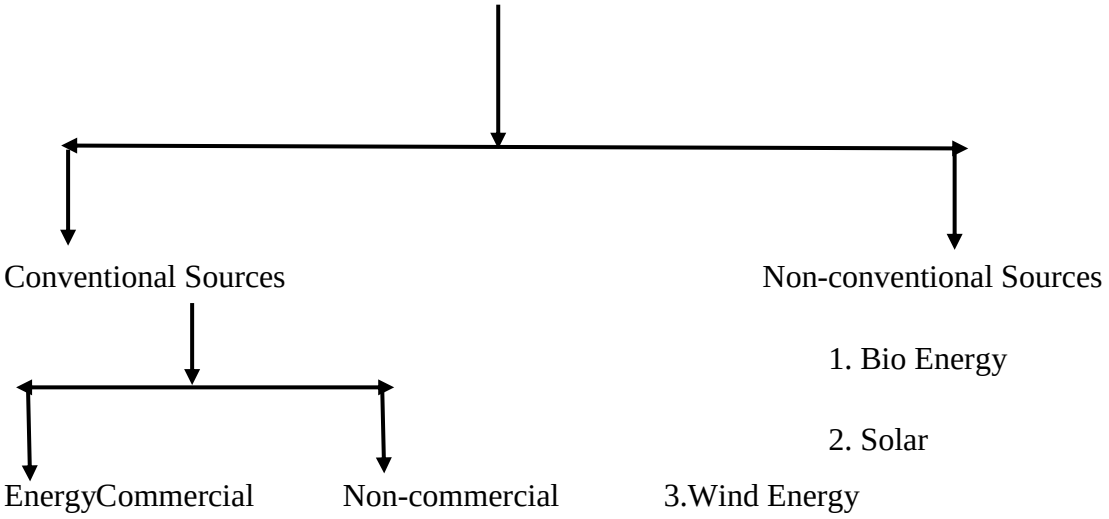
The conceptual framework indicates that resources in terms of household income, size of land, number of cattle and size of household could influence the decision to adopt biogas technology. Further, knowledge about the technology and maintenance of the biogas plants could affect adoption. Leadership role played by the innovators in the community is an important aspect in technology adoption as their decision to take up an innovation to other community members positively. The study was carried out in a homogeneous environment where the leadership, economic status and social status are the same.

2.1.2 Energy

Energy is one of the most important component of economic infrastructure. It is the basic input to sustain economic growth. There is direct relation between the economic development and per capital Energy Consumption. Simply speaking more developed 9 country; higher is per capital Consumption of energy and vice versa. (Metha, 2016).

Energy Sources can be broadly divided into two distinct groups. They are stated as:

Energy Sources (using process)



2. Petroleum 2. Dunk cake
3. Electricity 3. Straw

SOURCE: (Metha, 2016).

2.1.3 Conventional Sources of Energy

Conventional energy is one of the source of energy on the basic of its using process. These energy are such type of energy sources that has been used from ancient time like firewood, animal dung, coal, petrol, etc. which are used before developing modern energy in the world. It directly mean the energy source which are fixed in nature; like oil, gas and coal. It is also termed as non-renewable energy source. Their use leads to increased greenhouse gas emission and other environmental damage. (Jha, 2016).

Conventional energy sources are shown in the table 1 as:

Energy	**Percentage (%)**
Natural gas	7
Crude oil	7
Nuclear energy	8
Coal	29
Hydro energy	29
Total	**100**

(Jha, 2016).

Excessive use of conventional energy reduce the sources in one hand and in other hand these sources have adverse effects on environment but the alternative/non-

conventional sources can play the role to reduce the exploitation over those resources which can be cheaper as well.

2.1.4 Non-conventional Sources of Energy

As an alternate of conventional energy sources many non-conventional sources has discovered like. Solar, ocean, wind, etc. which are also termed as renewable energy sources. (Jha, 2016). They don't cause environmental pollution. Moreover, they do not require heavy expenditure.

2.2. Biogas: Concept and Development

Biogas or Gobar gas is a combustible gas which is produced by mixing different biodegradable materials like cattle dung, human excreta, water and otherorganic wastes by the reaction of methaneogenic bacteria in air or water-tight container called biogas plants. It burns with clear blue flame without giving smoke. Its flame temperature is upto 800 degree Celsius and it has a calorific value of 5650 k cal per cubic meter of gas (Adhikari, 1996)

Biogas technology was first introduced in Nepal in 1995 having overcome several obstacles. At present more than 39 private companies were actively involved in the construction but due to lack of awareness program many households were not interested, and in 1991/92 with the technical support of Netherlands Development Organization the program started flourishing in different rural areas of Nepal. It was possible because of standardization of plant design and support through subsidy by the government. Up till now, biogas has been used by many households because of its direct and indirect benefits. Some benefits are:

- Reduce pollution
- Reduce reliance on fossil fuel
- Reduce time wastage while collecting firewood
- Lowers fuel import bill
- Saves on the environment
- Improves living standard in rural areas, etc.

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

The Biogas Program is successful model of development cooperation; technological innovation, engineering and market development that have addressed some of the social, economic, energy and environmental needs of rural people of Nepal. (BSP). Biogas plants were constructed in over 65 district and increases 10 to 26% construction each year. Plants construction was reduced in 2001/02 as result of poor security situation and the early monsoon. Biogas Program is environment friendly and can implemented Clean Development Mechanism (CDM) in Nepal(BSP,2004).

2.3 Energy Consumption Trends of Nepal

Traditional sources of energy still hold majority when it comes to the necessity and supply of energy. Despite several efforts made towards using renewable energy traditional consumption rate is still high. Likewise, though sources of renewable energy mainly hydropower and solar energy have enormous potentials; energy crisis has continue to grow for failing to capitalize these resources.

2.3.1 Table showing Energy Consumption Status

Table 2: Energy Consumption Status

(In ToE: Tons of oil Equivalent)

Sources	**Fiscal Year 2013/14 (000 toe)**	**Fiscal Year 2104/15 (000 toe)**	**Fiscal Year 2015/16* (000 Toe)**
Traditional	8983	9104	6069
Firewood	8154	8264	5509
Agriculture Resides	403	408	272
Cow Dung	426	432	288
Commercial	1958.96	5256.90	4609.77

Coal	320	465	192
Petroleum Products	1264	4294.62	4143.46
Electricity	374.96	397.28	274.31
Renewable	291	291.64	291.86
Total	**11232.96**	**14652.54**	**10970.63**

Source: Ministry of Energy *of first eight months

In the first eight months of the current fiscal year the total energy consumption has reached 10,970.63 tons oil equivalent (ToE), while such consumption during the corresponding period of previous fiscal year was 41 percent higher than this. During the same period of previous fiscal year, the energy consumption was 7,781 ToE.

While looking at the statistics of the last eight months, the consumption rate of traditional, commercial and renewable energy stood at 55.33 percent, 42 percentand 2.67 percent respectively. Such ratio in previous fiscal year had remained at 62.13percent, 35.87 percent and 1.99 percent respectively. This observation hints that traditional energy users are slowly attracted towards using petroleum products,which are not produced in Nepal but to be imported.

2.4 Review of Previous Study

Biogas is an alternative source of energy and also a source of income for a country (BSP,2010). It has different direct and indirect benefits. The use of biogas is justified not only from economic ground but also it is a substitute for expensive petroleum fuel and protects environment, improves health, saves time and is convenient as well. Although its use flourished only after 1970, different research on biogas have been performed since then. In the Nepalese context, it has been used only as alternative source for household purposes and the digested slurry as better organic manure foragricultural production. Some of the review on previous studies:

Karve (2005) studied use of different type of gas and its problem as well as environment degradation. He tries to make new biogas model which provided minimum carbon (5%) and mixed methane. It is because biogas is a clean burning fuel and it doesn’t give smoke and help to save environment as well.

Sagagi, et al. (2009) presented result of the study on biogas production from fruits and vegetables waste materials and their effects on plants when used as fertilizer. It has been observed that the highest weekly individual production rate is recorded for the cow dung (control) slurry with average production of 1154cm3, followed by pineapple waste which had 965cm3of biogas, and then by orange waste which had 612cm3 of biogas and lastly pumpkin and spinach wastes which had 373cm3 and 269cm3 respectively. The result obtained showed that differences in the production of biogas to a large extent depends on the nature of the substrate. All the substrate used appeared to be good materials for biogas production and their spent slurries can be used as a source of plant nutrients.

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

Bista (1981) concluded that biogas is considered as the most reliable alternative energy resource replacing fuel wood of which the greatest part is used for cooking especially in rural areas of Nepal. It helps to save environment and conserve forests area. It means that there is an urgent need for substituting rural energy through non-conventional energy source.

2.5. Theoretical Framework

Biogas is renewable energy technology that improves the quality of life especially of the rural areas. It is environment friendly technology which has different direct and indirect benefits. Biogas is appropriate technology for adoption of pro-poor villagers of Nepal.

2.5.1 Benefits of Biogas

According to USAID, there are 5 main benefits of using biogas plants. They are stated below:

- Quick

  Biogas can be turned on instantly .No need to spend time on collecting firewood and making a fire.

- Healthy

  Smoke from charcoal and wood stoves is harmful. Biogas produces very little smoke.

- Environmentally Friendly

With biogas there is no need to cut down trees for firewood. It saves natural environment.

- Cheap

  No need of buying firewood or charcoal and wood stoves. Resources can be available in locality such as human/animal waste, dead plants and water, etc.

- Clean

Helps to clean up animal and human waste to prevent spread of diseases.

Others

- Economic benefit
- Workload reduction
- Managements of household wastage, etc.

2.6 National Plans and Policies Review

The Perspective plan (1991-2017) has recommended for development and promotion of alternative energy resources and technologies including biogas as an integral part of overall development activities. The proposed Renewable Energy perspective plan of Nepal, 2002-2020:An Approach (REPPON) prepared by CES/IOE has envisaged

the development objective of biogas sector so as to direct the national biogas program from technical, financial and socio- economic sustainability perspective. The current three year plan has targeted to install additional 100,000 plants.

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

Renewable Energy Technologies have increasingly received due attention in periodic plans since the seventh plan (1985-1990) where, for the first time, a targeted approach amongst other policy measures was established for its development.

The Eighth plan (1992-1997) envisaged the need for a coordinating body for large-scale promotion of alternative energy technologies in Nepal and the Alternative Energy Promotion Centre (AEPC) were thus established as an executing body.

The Ninth Plan (1997-2002) formulated long term vision in the science and technology sector which has the fundamental goal of rural energy systems developed as to increase employment opportunity through gradual replacement of traditional energy with modern energy. Renewable Energy Subsidy-2000 and the Renewable Energy Subsidy Delivery Mechanism-2000 were formulated and implemented to realize the objectives set out in the plan.

The tenth Plan (2002-2007) gave priority to suitable and relatively smaller size systems. It also encouraged research on expansion of biogas systems in the Himalayan Region andtowards reducing the costs.

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

All the above mentioned studies have mainly indicated that installation of biogas plants have positive impacts on farmers as well as in environment. However, it has also been heard that some users have experienced its negative impacts like: high cost, as well. In order to encourage the more installation of biogas plants the government

has also provided different subsidy to the users. Likewise, different institutions, NGO/INGOs have played important role in making this program success. This study has aimed at addressing positive aspects and benefits of the biogas plant as reliable and important alternative source of energy.

2.7 Research Gap

As Nepal is an agricultural and rural country, there is high potentiality of biogas energy, but due to the numerous reason the progress achieved in this sector is not much encouraging. There is lack of adequate information on the socio-economic and environmental impact of biogas plant. So for this, further studies is necessary in this sector. Increasing population with increasing demand for fuel automatically leads to explore the viability of biogas as an alternative source of energy

CHAPTER THREE

RESEARCH METHODOLOGY

This chapter discusses about a set of methods, which are applied for conducting the research. The whole study was carried out on the basis of primary as well as secondary data. The primary purpose of this chapter is to discuss and design the framework of research. Different procedures of research design methodology are stated as:

3.1Research Design

The study was carried out on the basis of explanation and descriptive research designs because the study mainly focus is to investigate the utilization of biogas in relation to environment protection and its benefit to them. Moreover the study has tried to find out the economic benefits of biogas plants with respect to forest resources conservation, health condition, agriculture production as well as the demerits of the plant which is the main objective of the study. To fulfil these objectives information werecollected from the related field survey.

3.2Rationale of the Study Site Selection

The universe of the study is Gandaki Rural Municipality of Gorkha district which does have the great potentiality of biogas, as an alternative source. The particular area is chosen for the study as it is easily accessible and heterogeneous in socio economic cultural and geographical structure. Hence, the area is selected to change the socio-economic status of people through alternative resource and to make to pro-poor.

3.3 Sampling Procedure

In the study area, biogas users were the targeted people of the research. In Gandaki Rural Municipality, out of total 7250 households 520 have biogas plant and among them 60 of those were selected. The total 520 biogas households has been taken as the universe and simple random sampling technique was followed for the selection of samples.

3.3.1 Sample Design

The universe of the study was the biogas user household of Gandaki Rural Municipality of Gorkha district. The survey is based on multistage sampling of probability sampling. Firstly, the area was selected purposively. Secondly, the wards was selected. The area consists of 8 wards. Out of these, 3 wards was selected having large number of biogas plant. Thirdly, household was selected. Then, the sample size was determined according to the number of the households using biogas. Then, the households were selected purposively. Hence, the survey were on the 3 stage of multistage sampling.

3.3.2 Sample Size

The sample size was based on the density of the biogas plant using households of the study area. The total sample size was 60 in the study area Gandaki Rural Municipality. 7 and 8 wards were taken purposively keeping in view the number of households using biogas in each wards.

3.4 Data Collection Tools and Techniques

For successful collection of data in the field, a set of questionnaire, focus group discussion schedule and an observation guide were used to collect data as primary sources and for the secondary sources different journals, articles, booklets, newspapers and magazines, books related to topics and published sources of data on internet and google were used to collect data.

3.4.1 Questionnaire

A set of semi-structured questionnaire was developed and administered to respondents. The questionnaire was useful in collecting general information about opinions, attitudes and perceptions on biogas adoption among households. It also helped in obtaining suggestions on promoting biogas plant and its use.

3.4.2 Focus Group Discussion

A focus group discussion of ten respondents was organized to help in tackling issues which needed more clarification of questionnaires. The focus group was composed of women, men and the youth and it offered general opinions on factors influencing

biogas adoption, awareness, attitude and suggestion on the way forward to promote the utilization of the biogas plant.

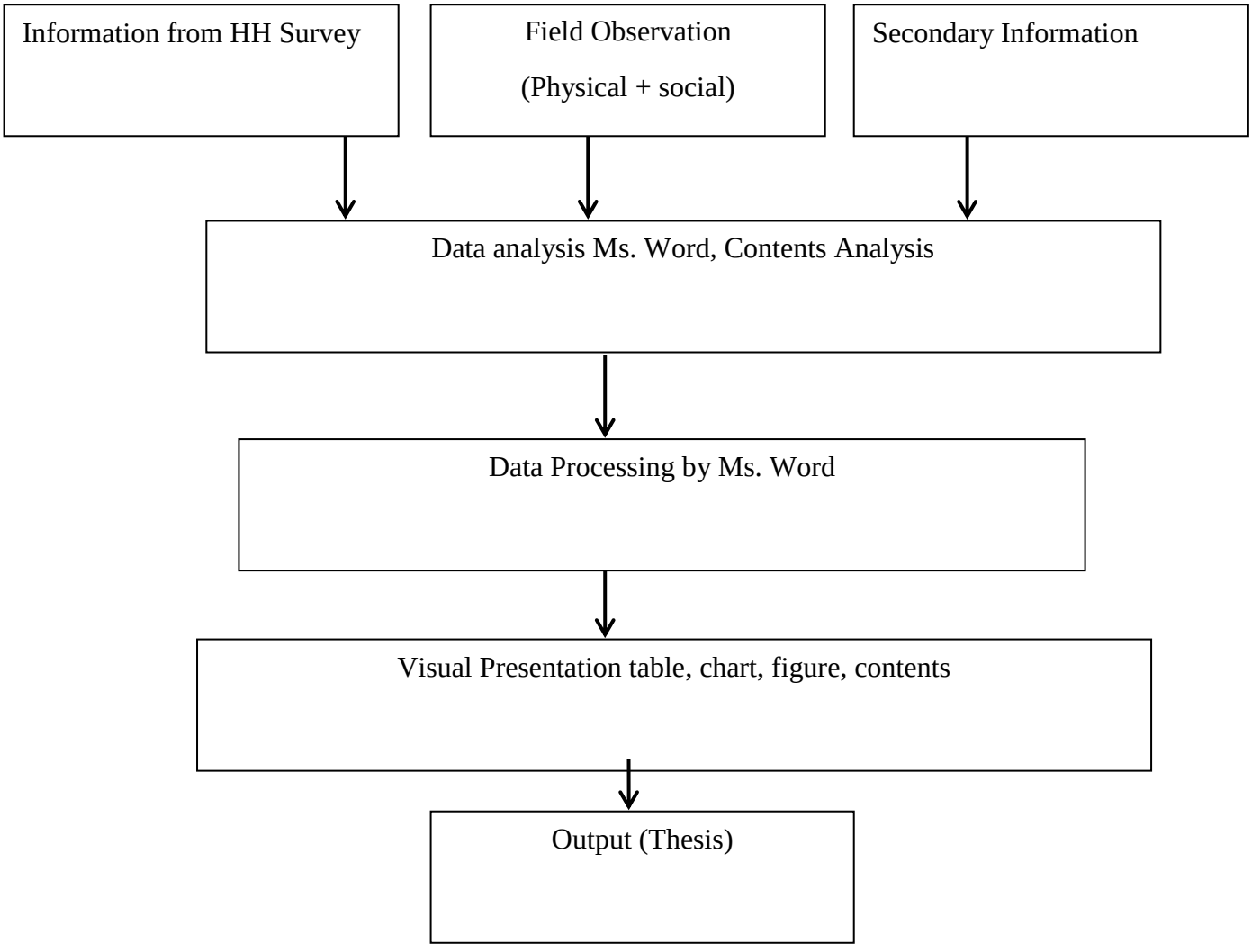
3.4.3 Observation

An observation method was developed to gather information in the field study that helped to provide opportunity to have better understanding of what was actually happening in the particular area.It helped in understanding the conditions of the biogas plants and the substrates used.

3.5 Analysis and Interpretation of Data

The help of computer program was taken. Simple statistical tools like tables, graphs, pie-chart, co-relation and other necessary tools were used for data analysis. Descriptive method was used for qualitative data. The shematic framework can be shown for convenient study as:

Figure 2.5.2: Schematic Framework of Data Analysis



3.6 Reliability and Validity

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

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

CHAPTER FOUR

DATA ANALYSIS AND INTEPRETATION

The chapter attempts to analyze the collected data and information for pursuing objectives of study and deriving the major findings for the study. First of all, it presents a brief introduction of Gorkha District and Gandaki Rural Municipality with demographic features. It also includes the economic impacts for biogas users and beneficiary aspects.

4.1 Introduction of the Study Area

A part of Gandaki Pradesh, is one of the seventy seven districts of Nepal and connected historically with the creation of modern Nepal and the name of legendry Gurkha soldiers.

Gandaki Rural Municipality is a Rural Municipality in Gorkha district, Province no. 4, Nepal. The total area is 124 sq. km, which is located in eastern part of this district. The study area lies in the Hilly region of the eastern Nepal. As per National population census 2011, the total population of the village stands at 23,262, with a male population of 10,568 and a female population of 12,694.

The people in this district are mainly involved in agriculture. Out of total 7250 households, 520 have biogas plants. After 2072, biogas users have decreased because of earthquake.

The land in the study area is fertile for cultivation, well facility of irrigation for easier agricultural production. Agriculture, poultry, animal husbandry, fishery, etc are common sources of livelihood. While the infrastructure are ratherly increasing and the forest area are slowly decreasing.

4.2 Analysis through Objectives of the Research

The analysis of the research study followed through objectives and guided by questionnaires, FGDs and observation are described as follows:

4.2.1 Various Uses of Biogas and its Conditions

Biogas as an alternative energy, it can be used in various conditions which are explained as:

4.2.1.2Size of the Plant

The size of the biogas plant was determined by the numbers of family members and the number of cattle. 90 percent of the respondents have constructed the biogas plant of 6 ghana meter size while 10 percent of them have installed the biogas of 8 ghana meter in the study area in which the information was gained through questionnaire survey. According to FGD, the households having 6 g.m size were willing to join the plant of 8 g.m in the following days for further comfortable life style. The table of the plant's size is shown as:

Table 4.2.1.1: Size of the Biogas Plant

S.N.	Size	Number	Percentage (%)
1.	8 g.m (Ghana Meter)	6	10.00
2.	6 g.m	54	90.00
	Total	**60**	**100.00**

Source: Field Survey, 2018

4.2.1.2 Main Purpose of Installing Biogas Plant

According to FGD, most of the respondents in the study area consider biogas as a source of cooking purpose. Among the surveyed 60 households, 75 percent respondents answered that they have installed the biogas for the purpose of cooking while 10 percent answered because of environmental benefit. Likewise, only 5 percent said that it was installed for the lighting as well and the remaining 3.33 percent answered for other some purpose like saving time, smokeless kitchen and so on. The table is as follow:

Table 4.2.1.2: Main Purpose of Installing Biogas Plant

S.N.	Purposes	Number	Percentage (%)
1.	Cooking Purpose	45	75.00
2.	Lighting Purpose	3	5.00
3.	Environment Benefit	10	16.66
4.	Others	2	3.33
	Total	**60**	**10.00**

Source: Field survey, 2018

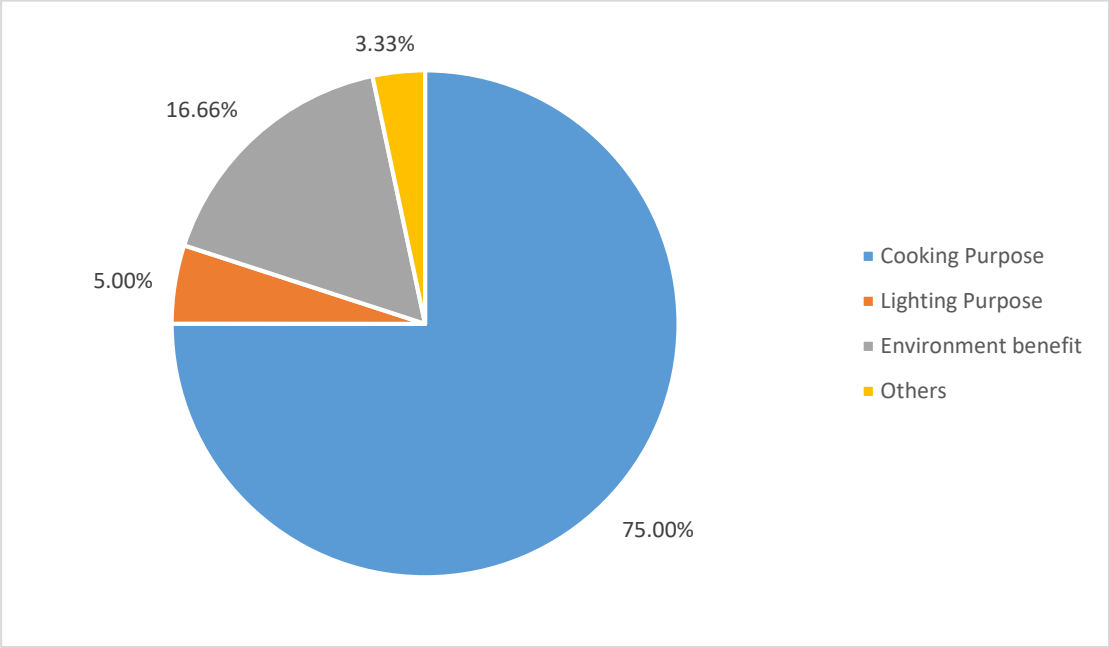


Figure 4.2.1.2: Main Purpose of Installing Biogas Plant

In the FGD, from the women participants they opined that, the energy use pattern seem to have changed significantly after the installation of biogas in the study area. Before that there was mainly used of firewood, LP gas and kerosene oil. The result after installing plant seems to have changed the life style and standard. This resulted

in relief of women with respect to their health and sanitation, reduction in workload, conservation of forest areas, reduction of diseases, utilization of time and costs, and so on.

In the present context, there seems to have problem in using biogas plant after earthquake of 2072.Most of the plant remain unused after the disaster because of building new houses. The condition of the plant seems better those who are using in the present context.

4.2.1.3Connection of Toilet

Construction of toilet plays vital role in construction of biogas plant. In the study area, all the houses have constructed toilet for the daily uses. Among the surveyed houses, 81.66% of the respondents have connected toilet to the biogas plant and the rest 18.33% household have not connected toilet with biogas. According to X respondent in the questionnaire survey, he answered that because of superstition belief, sufficient with animal dung he doesn't connect toilet with his biogas plant. The table obtained from the study is shown as follows

Table 4.2.1.3: Connection of Toilet

S.N.	Connection of toilet	No. of Households	Percentage (%)
1.	Yes	49	81.66
2.	No	11	18.33
	Total	**60**	**100.00**

Source: Field Survey, 2018

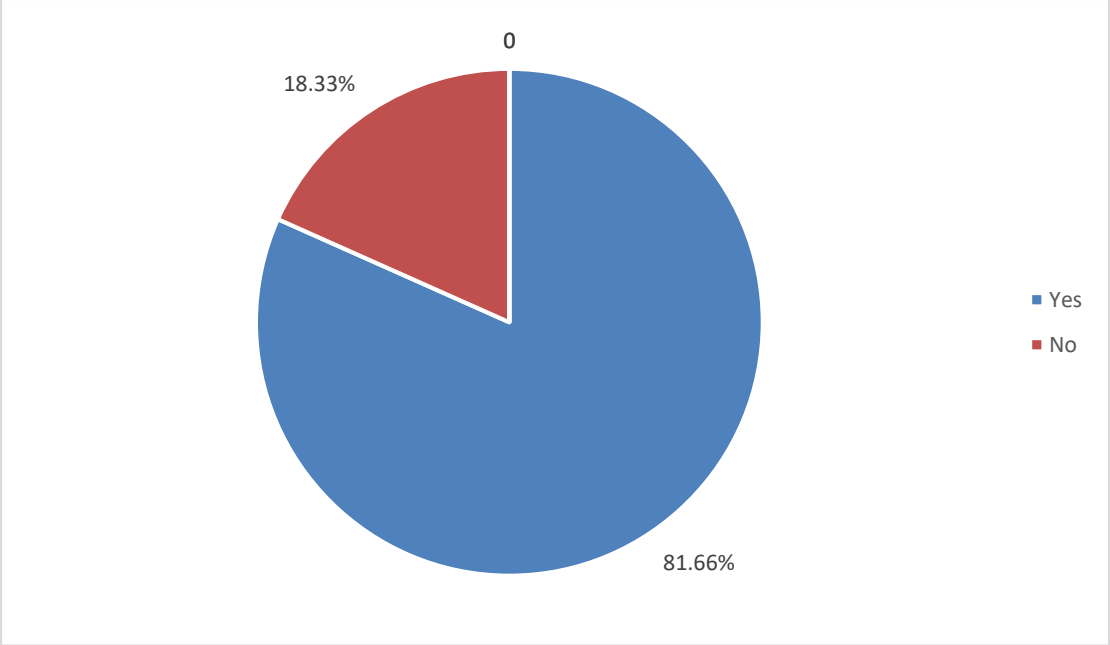


Figure 4.2.1.3: Connection of toilet

4.2.1.4 Increment in Livestock Population

In the study area, it was observed that there was no house without livestock. Most of the households have buffaloes and cattle and some of the households have cow/ox and hens, ducks, etc as well. The dung of these animals were used for biogas production.

From the Y participants in the FGD, it was also said that the urine of goats helps to produce more gas than other animals. Buffaloes were more admired by the respondents. It was also answered that there was high increase in livestock, it was because of high creation of gas through their dung and urine.

In present context human excreta, kitchen wastages, plants and every decadable substances were used to produce gas.

The table is stated as:

Table 4.2.1.4: Increment in Livestock Population

S.N.	Livestock	Number	Percentage (%)
1.	Buffalo	125	16.96
2.	Cow/ox	69	9.36
3.	Goats	543	73.67
	Total	737	100.00

Source: Field Survey, 2018

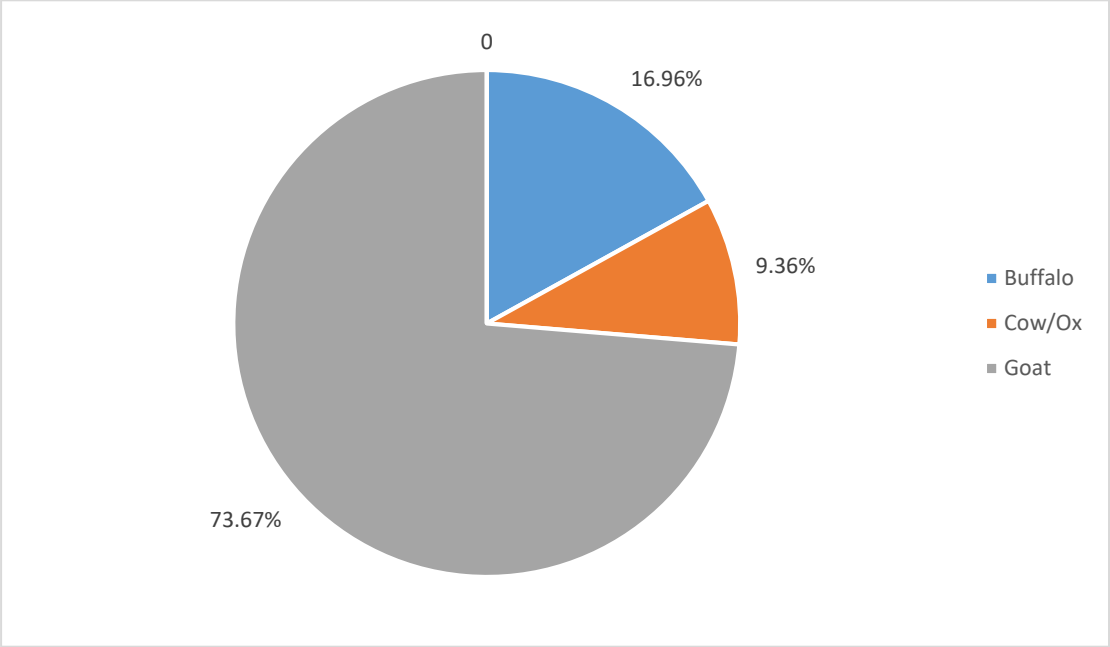


Figure 4.2.1.4: Increment in Livestock Population

4.2.1.5 Slurry and Its Use

Fertilizer or manure is the most essential input for any crop. Bio slurry or slurry is the liquid discharged at the bio digester outlet after gas has been tapped for energy. It is also known as organic manure. The slurry is said to be rich in various plant nutrients

such as nitrogen, phosphorus, potash etc. Well fermented biogas slurry improves the physical, chemical and biological properties of the soil resulting qualitative and quantitative production of crops. The encouraging thing is that, 100 percent of the plant owners of the study area use slurry as fertilizer.

The slurry is said to be rich in various plant nutrients which helps to improve the quality of the soil and increase the production. In the household survey, the respondents answered in their own experienced of using slurry as manure. The answer received from the respondents with regard to the effect of slurry is shown as follows:

Table 4.2.1.5: Slurry and its Use

S.N.	Agricultural Production	Number	Percentage (%)
1.	Increased	16	26.67
2.	Decreased	9	15.00
3.	Remain Same	22	36.67
4.	Can't Say	13	21.66
	Total	**60**	**100.00**

Source: Field Survey, 2018

In the study area, a huge majority of the respondents 36 percent said that the production remain same before and after the use of bio- slurry as manure. Only 26.67 percent revealed that the use of slurry have enhanced the production of crops whereas 15 percent did not enjoy the use of slurry as they experienced the decrement in the production of crops after its use and 21 percent of the respondents could give no answer regarding this question. Overall the use of the slurry seems no more qualitative in the production.

4.2.1.6 Other Uses of Biogas Plant

Biogas plant as an important alternative source of energy, it has other various uses. The various uses of biogas are explained as:

- Lighting
  In the focus group discussion, X participants opined that, biogas can be used for lighting in non- electrified process. However, it is not so popular in Nepal. Special type of gauze mantle lamps are used for household lighting. Such lamps emit clear and bright light equivalent to 40 to 100 candle powers.
- According to female participants, she viewed that, biogas can also be used in a gas engine to convert the energy in the gas into electricity and heat.
- One of the social worker in the study area opined about biogas that biogas is qualifies for renewable energy subsidies in some parts of the world. It is because of its production and re- use cycle which is continuous process and it generates no net carbon dioxide.
- Also it was said in the discussion that biogas can be used for absorption type refrigerating machines operating on ammonia and water an equipped with automatic thermo-syphon.
- Etc.

Thus**,** the data was obtained from focus group discussion.

4.2.2 Socio- economic Benefits of the Biogas Plant

4.2.2.1 Educational status of the Respondents

Education enhances the ability and capability of human being. It also plays vital role in energy use pattern. It is the source of knowledge, attitude and behavior in energy use pattern. So the actual figure of the education attainment of the respondents of the study area has been shown below:

Table 4.2.2.1: Educational Status of Respondents

S.N	Education Level	Number	Percentage (%)
1.	Literate (General reading)	8	13.33
2.	Illiterate	29	48.33
3.	Lower Secondary 6 to 8)	4	6.67
4.	Secondary (9 to 10	13	21.67
5.	Above +2	6	10.00
	Total	**60**	**100.00**

Source: Field Survey, 2018

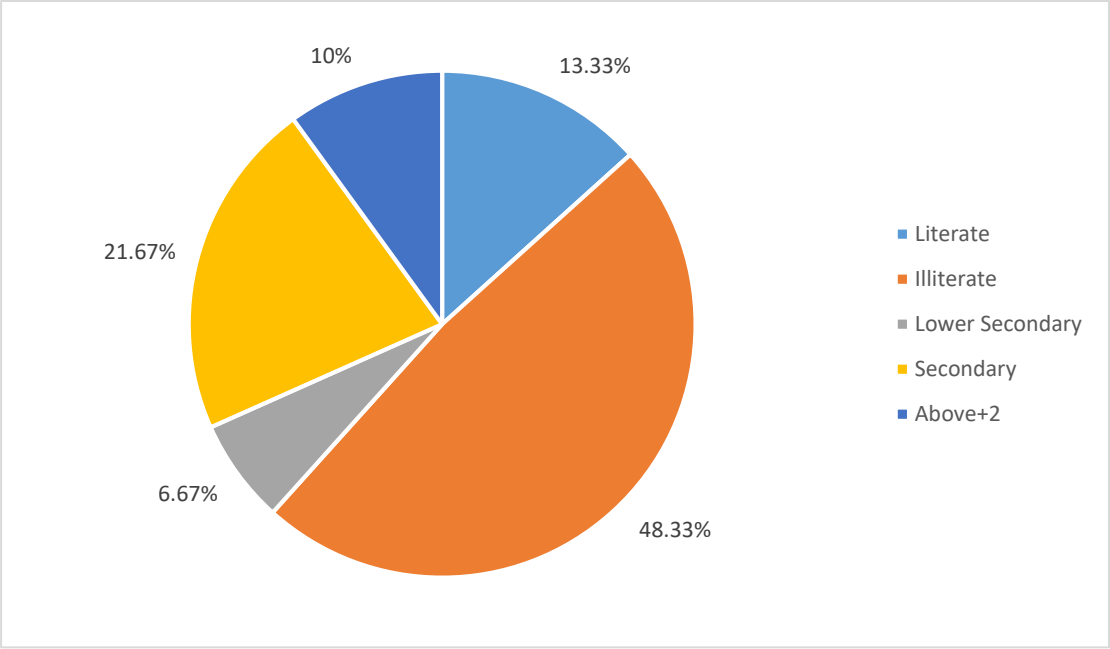


Figure 4.2.2.1: Educational Status of Respondents

According to FGD, some of the respondents viewed that they were helped by the service provider in energy (biogas) use pattern. They also added that their children are utilizing the saved time in their study as before they were mostly involved in collection of firewood, water and cleaning of cooking utensils after and before school time. One of them added that mostly the children and women are the main beneficiaries and their educational opportunities have been improved tremendously.

4.2.2.2 Gender Benefit

The biogas technology is famous as women friendly technology in most of the areas. Women participation in household decision making process is the most essential. In the FGD, the questions were asked to the respondents about women's work load reduction, participation in social and economic activities and so on. In that sense on of the user, Ms. X shared that she was very happy to have biogas in the kitchen. No smoke is produced and fast processing for cooking meals. She added, it is god gift, very easy to clean utensils and no delayed in household works. This technology is more gender friendly especially for women group.

4.2.2.3 Others

Likewise the other socio- economic benefits discussed in the FGD are as follows:

Though the households have observed significant economic changes directly after the installation of biogas plant, most of the respondents agree that biogas has helped them to manage time for financial earning activities.

The installation of biogas reduces the expenses on fuel for cooking and to some extent lighting.

The high quality bio-fertilizer contributes for high yield of crop and vegetables, which eventually help for generating income.

The digested slurry coming out of the biogas plant has more nutrition value more than the traditional farmyard manure, which ultimately enhances the production of crops.

The installation process also helps in creation of job opportunity for skilled and semi-skilled human resources.

The time saved from the collection of firewood could be used on other productive, beneficial and income generating activities like poultry farming, pig farming and other different skills like handmade crafts and so on.

Utilization of time for other activities even while cooking like knitting, tailoring.

Hence it can be said that biogas technology have many socio- economic benefits in the standardization of human life style.

4.2.3Benefits in improvement ofHealth, Sanitation and Environmental Protection

In the study area,from the respondents in the FGD, the environmental benefits can be listed as:

Reduction of GHGs
Protection of soil nutrients
Reduce the consumption of fuelwood
Conservation of forests
Waste management
Eco-friendly environment, etc.

4.2.3.1 Reduction in Disease

The most positive benefit of installing the biogas plant is the betterment of the health condition of the household. The female respondents in the survey opined that before that the life of the rural people were miserable and suffering. Most of the housewives were suffering from respiratory, burning, headache, eye problem, coughing due to the smoke and flames of firewood. So for this, biogas could be one of the noble technology to get rid of those problems. In the study area, the respondents felt reduction in health problem after installing biogas plant. The major impact on the reduction of disease is demonstrated in the household survey as follow:

Table 4.2.3.1: Reduction in Disease

S.N	Problems	Number	Percentage (%)
1.	Eye Problem	20	33.33
2.	Coughing	8	13.33
3.	Headache	12	20.00
4.	Throat Problem	17	28.33
5.	No Change	3	5.00
	Total	**60**	**100.00**

Source: Field Survey, 2018

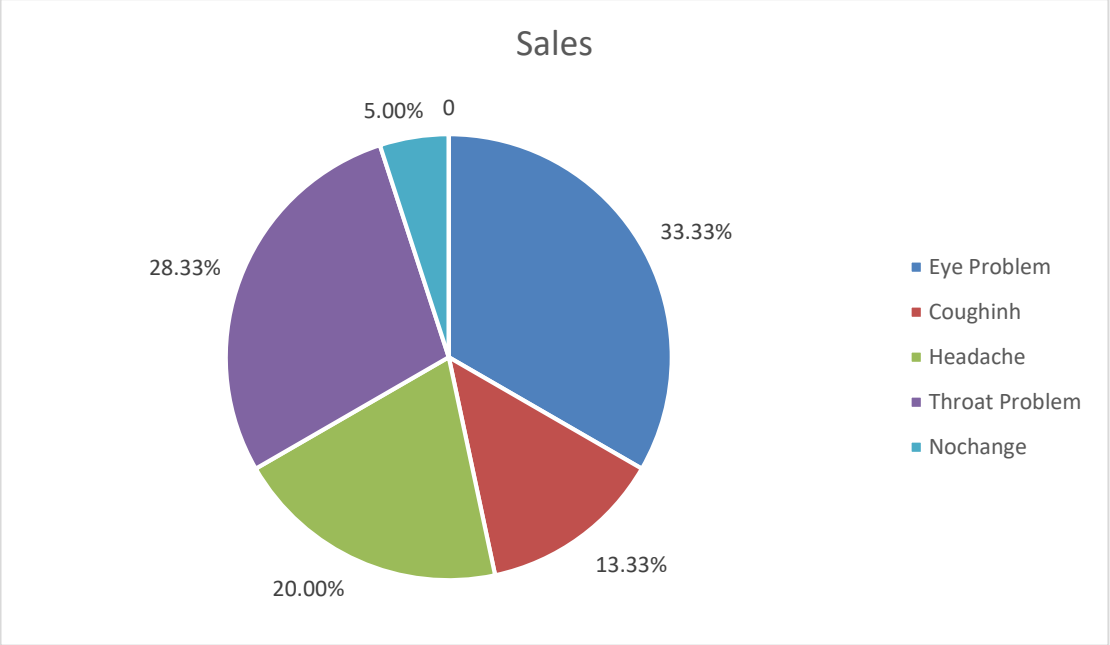


Figure 4.2.3.1: Reduction in Disease

From the data obtained from household survey, the above table shows that the most relief of the people found was in the case of eye problem as 33.33 percent answer

consisted that the problem has been reduced. Likewise, 28.33 percent answer that the throat problem was reduced, followed by 2. Percent headache problem, 13.33 percent coughing problem and 5 percent of the answer was that there was no change in respect to illness before and after installation of the plant.

4.2.3.2 Effect on Insect and Mosquito Prevalence

According to FGD, increase in the prevalence of insects like fly, mosquito and various insects was one of the drawbacks of biogas installation regarding the view of the respondents in the study area. Most of the households said that the concentration of the insects was very high in the outlet of the biogas plant and the deposit pit of slurry provides a breeding space for insects and mosquitoes. The effects is stated as follows:

Table 4.2.3.2 Effect on Insect and Mosquito Prevalence

S.N	Insect/mosquito Prevalence	Number	Percentage (%)
1.	Increased	38	63 .34
2.	Decreased	6	10.00
3.	Remain Same	16	26.66
	Total	**60**	**100.00**

Source: Field Survey, 2018

The table describes that 63.34 percent of the respondents argued that the prevalence of the insects and mosquitoes have been increased after the installation of biogas plant. Only few 10 percent observed the decrement whereas 26.66 percent observed no change in this respect before and after the installation of the plant.

4.2.3.3 Others

The opinions discussed in the FGD were noted as follows:

The introduction of biogas plant has reduced the consumption of fuel wood which can be a visible evidence of forest re-growth in Nepal. There can be substantial savings in emissions of greenhouse gases, including CO2 from avoided fuel wood and kerosene use and nitric oxide from synthetic fertilizer. This helps to keep the environment clean and fresh as well as this can keep diseases far away from the society.

Likewise, the big problem for the rural people especially to the women working in the kitchen are the main beneficiaries of the plant as biogas is smokeless and pollution free technology. Biogas reduces the smoke exposure and significantly improves the air condition inside the kitchen which ultimately brings improvement in the health condition especially eye infection, respiratory diseases, cough and headache.

Improved sanitation with the construction and connection of toilets lead to better hygiene conditions. Better sanitation condition through biogas helps to reduce the infant mortality rate.

Hence, these above mentioned can be a visible evidence in which biogas plant play vital role in the maintenance and the improvement of family standard, social status, health, sanitation and environmental protection.

CHAPTER FIVE

SUMMARY, CONCLUSIONAND RECOMMENDATIONS

5.1 Summary of Findings

The study was carried out to find out the uses of biogas in relation to environmental conservation among households in Gandaki Rural Municipality. The main objective was to find out various uses of biogas and economic benefits that helps in the improvement of health, sanitation and environmental protection among households. In the study area in collaboration with various organizations has continued to promote biogas technology as an alternative source of energy and consequently conserve the environment. The specific objectives that guided the study were:

- Various uses of biogas and its condition
- Economic benefits
- Role of biogas plant in the improvement of health, sanitation and environmental protection.

The study used descriptive research design. The design was appropriate as it allowed for gathering of information concerning the current status of the phenomena and describes it as it exists. Purposive sampling was used to get respondents who had biogas plant for their comfortable life style. Data was collected on the current status of biogas technology adoption, the underlying reasons for factor that influence biogas technology adoption and strategies to enhance biogas technology adoption in Gandaki Rural Municipality. Frequency tables, pie chart and percentages were used to analyze the data.

The followings were the findings:

- The status of biogas technology adoption among households was average. Out of total 7250 households 520 have biogas plant. The plants were greatly damaged due to the earthquake of 2072.
- The main occupation followed by the households was mainly agriculture by 73.33% with a reasonable number. The average land holding of the respondents was found to be around 20 ropani with highest land holdings and

the lowest below 5 ropani. The cattle holding per family was high as 73.67 % and cow/ox was found to be only 9.36 %.

- The influencing factors for biogas technology adoption were: unavailability of technical services, size of household, average monthly household income, number of cattle owned, access to land and credit facilities high smoke from fuel wood, kerosene, waste of time, loss of forest area and so on.
- The main sources to inform the installers about biogas were the respective biogas companies (58.33%), followed by the service provider (26.66%). The foremost purpose for installing plant was for the cooking purpose as 100% of the households use biogas for cooking and some of them use for lighting purpose as well. The size of biogas plant was maximum of 6 ghana meter. More than 80% household use fuel as firewood before the installation of biogas plant while some of them use modern gas (LPG) and kerosene oil.
- The condition of biogas plant was found to be satisfactory, most of the plant was collapsed during the earthquake 2072 which creates maximum loses to human beings.
- About 82 percent of the households have connected toilet with biogas and the rest have not connected because of cultural belief and enough number of cattle rearing.
- About 95 percent of the households realized the reduction in the effect of diseases like eye problem, coughing, headache, throat problem, burning, etc. Although every member realized the benefit of the biogas to them, the main beneficiaries were the women.
- All of the households were found to be using the digested slurry for the manure purpose.

Though the biogas has uncountable benefits, some of the constraints of this technology were witness or suffered in the study area. The main problems were:

- Pollution from bio slurry
- Increase of unwanted insects
- Loss of gas in winter season
- Requirement of more sunlight
- Repair and maintenance problem

- High cost for maintenance materials, etc

Also the people in the study area were complaining about the freely not availability of machinery parts and also people are not happy with the result of the crop yield through the use of slurry as37 percent argued that the used of slurry did not change which means remain same the crop production. Similarly, the slurry acts as a great host for flies, mosquitoes and other insects, thus resulting in the prevalence of those insects.

Hence, to solve those problems the suggested strategies to support the promotion of biogas technology include: education, sensitization and awareness creation, provision of technical service, setting up demonstration centers, formation of community based groups, subsidy for livestock improvement and so on.

5.2 Conclusion

A brief gist or conclusion of the above discussed chapters is an attempt to be made in this chapter. The main objective of the research is obviously to study the role of biogas in the rural livelihood and focusing on this factor. Hence the following conclusion are generated as:

The study provided an innovative problem analysis with respect to the current situation surrounding problems with biogas plant in the study area. The biogas plant play a vital role in farming systems and add value to agricultural waste and livestock excreta as well as human excreta. This technology offers significant advantages, especially in regard to energy, the environmental and economic development. The maximum use of plant was for the cooking purpose also some households were found to be enjoying the lighting facility. Women were the main beneficiaries of the plant and ample amount of time was saved through biogas for the reasons like cooking food, collecting firewood, washing up utensils and so on. The women were basically getting opportunity to involve in social participation like aamasamuha,, skill generating activities like tailoring. Also the surrounding environment condition of the home was found to be better as the emission of smoke was controlled and illness through the smoke emitted during cooking in firewood was found to be reduced in satisfactory level. Also the heap of firewood as well as pieces of firewood were not seen scattered around and the forest area was protected and the environment was also

fresh as well. The installation of biogas has emphasized people to construct toilet along with it which is a great achievement in keeping up with good health and sanitation.

On the other hand, biogas plant in the study area have created some of the minor problems as it helped to increase the mosquito, flies and other harmful insects prevalence as the slurry pit provides a big home for those insects to survive. Usage of slurry as manure was not found to be fruitful to enhance the yield of the crops and other cash crops. Certain breakage, leakage and other maintenance problem has been a bit tedious for the users of the study area. The creation of gas was less found in the winter season.

5.3Recommendations

The study showed the need for further research into the eradication of problems with this technology.

- There is a need for further education and on- going training regarding the technology and should be supported by a higher frequency of technical visits.
- Biogas is a boon for rural areas as an alternative source of energy in this time of energy crisis, so it should be promoted thoroughly all around by giving ample subsidies to economically poor groups.
- Training should be given to suggest the technical way of mixing dung or bio degradable matters to get the maximum output from the limited available resources.
- Maintenance training to all the biogas users should be given compulsorily so that they do not have to depend on company for the days to maintain and repair.
- The cause of increased prevalence of mosquito and other insects should be studied. It might happen that proper composting of slurry would reduce the chance of breeding of mosquito andreduce their prevalence.
- Insufficiency of the gas in winter season has been the major problem for the biogas users. So alternative design of biogas plant suiting that condition is urgent.
- The government should formulate some terms and conditions against biogas company so that biogas users can get more subsidies.

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Annexes

Annex-A

QUESTIONNAIRES

Uses of Biogas in Relation to Environmental Conservation in Gandaki Rural Municipality of Gorkha District

Field Survey

A. Questionnaire for Household Survey

Respondent No.:

Name of Enumerator	
Conducted Date	

1. **Respondent Information**

Name of the Household Head/Interviewee:

Age: **Gender:** **Caste:**

Municipality: **Ward:** **Tole:**

Occupation: Primary: **Secondary:**

2. **Brief Demographic Information**

2.1.Details of family member's

SN	Name of Family Member	Sex(M/F)	Age	Education	Main occupation
1					
2					
3					
4					
5					
6					
7					

8					
9					
10					
11					

2.2 Land holdings: Khet--------Ropani Bari----------Ropani Total-------- Ropani

2.3 No. of Livestock: Ox and Cow-------

Buffalo----------

Goats----------

Total----------

2.4 Annual average family income and expenses: Income NRs:---------- Expenses NRs:--------

Sources of Income (Monthly):

1. Agriculture: NRs----------
2. Livestock: NRs----------
3. Industry: NRs----------
4. Trade/Business: NRs--------
5. Pension: NRs----------
6. Remittance: NRs----------

Total: NRS----------

Sources of Expenditures (Monthly):

1. Food: NRs----------
2. Clothing: NRs----------
3. Education: NRs---------
4. Medical: NRs----------
5. Agriculture: NRs---------
6. Energy: NRs----------
7. Others**:** NRs----------

3. Information on Biogas Installation

Name of plant owner	
Size of the plant	
Year of installation	

Name of biogas company	
Total investment cost NRs	
Subsidy amount NRs	

3.1.How do you come to know about biogas plant?(Tick)

Biogas companies	Gov. Offical.	Service Provider	NGO/CBOs	Community leaders	Friends/Relatives	Others(Specify)

4. Main objectives of installing of biogas

.....

5 .Various Uses of biogas plants

.....

6. Condition of biogas plants after installation

.....

7.Economic benefits of biogas plants

.....

8.Roles of Biogas plants in relation to health, sanitation and environment

.....

9. Health and Environment

9.1 Have you constructed toilet in your house?

a. Yes b. No

9.2 Is toilet connected to your biogas system? Yes or No(specify)

.....

9.3 What do you think are the health benefits of smoke reduction?

.....

9.4 What do you think are the environmental benefits of installing biogas?

.....

9.5 Other than health and environment benefits, what do you think are the other benefits?

.....

10. What are the major problems you are facing for biogas conduction?

.....

11. Do you use the biogas slurry for farming?

a. Yes b. No

12. How much has it increased agricultural production?

a. Increased b. Decreased c. Remain same d. Can't say

13. Does women's workload decrease after biogas installation? If yes, what are the reasons?

.....

14. What has been the effect to insects and mosquito's increment or decrement?

a. Increased b. Decreased c. Remain same

15. Are you satisfied with the biogas plants?

a. Yes b. No

16. Is there consumer's committee in your area?

a. Yes b .No

17. Has the expenditure on your health reduced after biogas plant installation?

a. Yes b. No

18. Has your participation increased in social and economic activities?

a. Yes b. No

19. Do you feel that biogas has increased your life standard and prestige?

a. Yes b. No

20. What are the problems you have been facing from biogas plants?

.....

21. Do you have any suggestion about biogas plants?

.....

22. What steps shall be taken to improve the socio-economic status of biogas users in future?

.....

23. Suggestions to improve the overall performance of biogas plant.

.....

24. Overall Field Observation by Interviewer

Social parts observation

.....

Economic parts observation

.....

Environmental parts observation

.....

Key issues as observed by interviewer

.....

Annex B

Observation Schedule

1. **Biogas Plant**

   Present……..

   Absent……....

2. **Status of plant**

   Complete……..

   Incomplete……

3. **Structural problems**

   Cracked digester……..

   Chocking of outlet/inlet……

   Broken or leaking pipes……

   Shortage of animal dung……

   No gas……...

4. **Construction of toilet**

Yes…….

No…….

5. **Connection of toilet**

Yes……..

No…….

6. **Presence of Cattl**e……..

7. **Reduction or Increment of unwanted insects**……

8. **Bio slurry and its use**……

9. **Conservation of forest area**…….

10. **Socio-economic benefits**…….

11. **Improvement in health and sanitation**……

12. **Improvement in life style**……

13. Problems faced by biogas users

.....

14. Impact of biogas plant in the study area

.....

Annex C

Focus Group Discussion

1. What are the major energy sources in your area?

2. What is the acceptance status of biogas technology in your area?

3. What are the main purpose of installing biogas plant in your area?

4. Have you connect toilet with the biogas? If yes why and if not why not?

5. What do you think the relation between biogas and livestock, have you notice biogas help in the increment of livestock population?

6. Some people opined that bio slurry provide maximum nutrients to the plant. Do you people agree with this.

7. What do you think are the various uses of biogas?

8. List in order of importance what factors affect biogas adoption

   Age of household

   Size of household

   Economic status of household

   Number of cattle reared

   Size of land

   Cost of Traditional fuel

   Environmental Problem

   Gender of household level

   Water problem

   Educational status

9. What are the socio-economic benefits of biogas installation?

10. Some people adopted the technology and stopped using it in the way. What could be the reasons?

11. Are people really aware of health and environmental problems that come as a result of using firewood as a source of energy?

12. Then what are the benefits in improvement of health, sanitation and environmental protection?

13. The saved time after the installation of plant, where have you utilized?

14. Some people think biogas technology is not appropriate technology and its advantages are less compared to its disadvantages. What is your opinion?

15. Do you have enough knowledge about biogas to the extent of being able to share the information with others? If not what areas do you think need more education/training?

16. In your opinion what kind of strategies can be put in place to enhance adoption of biogas in your area?

17. What do you think could have contributed to other people adopting the technology and others not?

18. Is there enough water in this region for biogas production and what about geographical condition?

19. Have you know any other opinion related to biogas technology?

The End