ECONOMIC IMPACT AND TREND OF BIOGAS ENERGY IN NEPAL

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By

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LETTER OF RECOMMENDATION

This thesis entitled "ECONOMIC IMPACT AND TREND OF BIOGAS ENERGY IN NEPAL" has been prepared by Mr. Pushpa Paudel under my supervision. I hereby recommend this thesis for examination by the Thesis Committee as a partial fulfillment of the requirements for the Degree of MASTER OF ARTS in ECONOMICS.

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Assistant Prof. Naveen Adhikari

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Date: 2019/04/07

APPROVAL LETER

We certify that this thesis entitled "ECONOMIC IMPACT AND TREND OF BIOGAS ENERGY IN NEPAL" submitted by Pushpa Paudel to the Central Department of Economics, Faculty of Humanities and Social Sciences, Tribhuvan University, in partial fulfilment of the requirements for the Degree of MASTER OF ARTS in ECONOMICS has been found satisfactory in scope and quality. Therefore, we accept this thesis as a part of the said degree.

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Puspa Paudel

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ABBREVIATIONS/ACRONYMS

ADB/N	:	Agricultural Development Bank Nepal
AEPC	:	Alternative Energy and Promotion Centre
ALRI	:	Acute Lower Respiratory Infection
ARI	:	Acute Respiratory Infection
BSP/N	:	Biogas Support Programm-Nepal
CBS	:	Central Bureau of Statistics
CDM	:	Clean Development Mechanism
CEDA	:	Centre for Economic Development and Administration
CES	:	Centre for Energy Studies
CMS	:	Consolidates Management Services Nepal (P) Ltd.
GDP	:	Gross Domestic Product
GGC	:	Gobar Gas Company
GNP	:	Gross National Product
GON	:	Government of Nepal
GT	:	Gigajoules
HH	:	Household
IAP	:	Indoor Air Pollution
KFW	:	Kreditanstalth Fur Weiderautau
LP gas	:	Liquefied Petroleum Gas
MOF	:	Ministry of Financ
MW	:	Mega Watt
OPEC	:	Organization of Petroleum Exporting Countries
PM	:	Particular Matter
POL	:	Petroleum
PPP	:	People Participation Programme
SNV	:	Netherlands Development Organization
VDCs	:	Village Development Committee
WECS	:	Water and Energy Commission Secretariat
WHO	:	World Health Organization

CHAPTER - I

INTRODUCTION

1.1 Background of the Study

The consumption of solid biomass forms of energy has a dominant role in the Nepalese energy consumption patterns. 83.7 percent energy is fulfilled by traditional sector, 15.6 percent by commercial sector and 0.7 percent by renewable energy sector (MoPE, 2016). The above result of energy consumption patterns proves that, people still have to heavily depend on traditional sources of energy to fulfill their energy needs. Looking into this energy demand scenario of Nepalese society, one can easily realize the strong and immediate needs of alternative source of energy. In search of finding appropriate source of energy, a very promising sustainable source of Biogas energy was introduced in Nepal, before three and half decades (AEPC, 2017).

Biogas energy is popularly known as *gobar* gas in Nepal which is combustible gas produced by anaerobic fermentation of organic materials (gobar) by the action of methanogenic bacteria. Biogas is mainly composed of (50-70) percent methane, (30-40) percent of carbon dioxide, (5-10) percent Hydrogen, (1-2) percent Nitrogen, (0-1) percent water Vapor and trace Hydrogen Sulphate. It is virtually colorless and is invisible in bright day light. It burns with a clear blue flame without smoke and non-toxic. Biogas produces more energy than kerosene, fuelwood, charcoal, dung-cakes. The specific gravity is 0.55, critical temperature 82.5^0c and pressure for liquefaction 5000 psi, air requirement for combustion is 9.33 m^3 and the ignition temperature is 650 degree centigrade (BSP, 2017).

Biogas plant is a tank which has the concrete inlet and outlet basins. Fresh cattle dung is deposited into a charge pit which leads into the digestion tank and remains there. After laps of time depending upon ambient temperature sufficient amount of biogas is accumulated in gas tank which is used by households on various purposes. Digested sludge is removed from the outlet basin and is used as fertilizer. The waste materials of plant and animal origins consists carbohydrates, lipids, proteins and small amounts of metabolites which are insoluble in water. If these materials are incubated in anaerobic condition, a combustible gas is produce by the action of bacteria known as methane gas. Generally, the biogas energy is used on the purpose of cooking, lighting and boiling water instead of fuelwood, LP gas, kerosene and electricity. Biogas systems, established in regions causes an increase of savings and income. It decreases that affected by general economic fluctuations by means of the local energy and fertilizer production. It reduces dependence for energy and foreign fertilizer on macro-level. The total required volume of gas for cooking $0.48m^3/h$, for boiling one liter of water $0.11m^3/h$ and for lighting $0.155m^3/h$ (in average).

In biogas systems, all kinds of organic waste have been processed and produced electrical energy in biogas production plants. In addition to the production of biogas electricity, formation of environment and air pollution caused by waste is also reduced to the minimum. Remaining waste of biogas is called bio-fertilizer. It is very efficient plant fertilizer, which is used in sustainable agriculture. Electricity generation from Biogas has been increasing rapidly in recent years. Generated electricity is given to the public power network. Besides, heat that occurred during this process is used to warm the facilities, which are located close to plants, such as greenhouses and housing.

One of them is biogas that is particularly important in rural areas. Developed and developing countries and some international organizations headed towards to biogas and other renewable energy sources because of many reasons, such as it is renewable, cheap, environmental friendly and health friendly etc. It is expected that fossil-based energy reassures will run out after a short period. Nowadays, efficient of existing resources have not been considered as possible. These have forced to use more efficient and more widespread of biogas.

1.2 Statement of the Problem

Globally, people have been hearing information about energy crisis through the media since the last three decades. In general, governments of many countries have been searching the alternative sources of energy after the supply shock of petroleum product in 1973 A.D. by the OPEC countries and have been giving more priorities on the development process of alternative energy sources. Energy is a major component of economic activities which serves to fulfill the basic needs of the people. Biogas energy is not only used for cooking heating and lighting but is also used in various sectors such as transportation, industries, services, agriculture including commercial.

At present the energy demand trend, in Nepal, is increasing every year by 2.4 percent corresponding to the increment of GDP, 2.4 millions households are still using kerosene for lighting, only 39 percent of the households has access to electricity, 88 percent of energy need is being fulfilled through wood and other organic waste (MOF, 2017).

Resources gap has been a serious bottleneck problem on the process of economic development of developing countries and Nepal is also not an exception to this situation. At present, the financial and technological resource gaps are becoming very serious in Nepal. In one side Nepal has been placed in second position after Brazil in potential of water energy but on other side the industries are stopped down due to lack of energy. People are spending their days bearing 14-15 hours loadsheding in the dry season. The nation has made expenditure of its high capital to purchases petroleum products and to import of energy converter devices. It shows the changing trend of governments has impact on investment to purchase energy. Due to low production of energy, the deforestation ratio is rapidly increasing which has direct effect on health as well as educational sectors. This situation leads to increase the dependency ratio on purchasing the commercial energy. Thus the development of the alternative energy sources may be one of the means to reduce the dependency ratio. Alternative energy (biogas, micro-hydro and solar energy) plays a key role in sustainable economic growth. The consumption of traditional forms of energy has a negative effect on the quality of life of people. Since it takes much time to collect wood and causes adverse effects on health. Besides, the use of these traditional energy sources neither sustainable nor desirable form of environmental considerations. Therefore, it is needed to replace these energy systems by the modern forms of renewable energy sources. These renewable energy sources are uninterruptible and infinitely available due to their widespread complementary technologies which can accommodate the country's need of diverse supply.

Biogas energy reduces discrimination of deforestation and maintains the ecological balance by reduction about 500,00 tons of CO_2 annually. Moreover, one biogas plant saves about 2.3 tons of fuel wood per year i.e. it roughly saves about 0.03 hectors of forestland per year. Similarly one plant produces approximately 30 tons of bio-compost per year which is equivalent to 90 percent of the bio-fertilizer used by farmers and energy generated from 1,11,000 gas plants of size $4m^3$, $6m^3$ and $8m^3$ including other size is equivalent to 33 MW approximately (Boitin, 2013).

The problem of energy crisis is increasing at rapid rate. In the present context of Scarcity of reliable fuel and fertilizer, the technology for the production of biogas from animal wastes and other bio-degradable materials has become and activity of paramount importance in rural Nepal. Besides bringing and improvement in the environment by controlling deforestation, indoor air-pollution and soil degradation, it has help in ameliorating the quality of life of rural people particularly the women who have been suffering from daily drudgery and various diseases caused by obnoxious smoke produce from firewood burnings. Moreover the diseases caused by the excessive use of petroleum product and fuel wood is also increasing. At this situation the benefit and important of biogas energy is high to solve these problems and a detailed study is needed. The present study has tried to solve the following problems:

i. What is the trend and status of biogas energy in Nepal?
ii. What type of economic benefits have been received from biogas energy?

1.3 Objectives of the Study

The general objective of the present study is to provide economic analysis of biogas energy in Nepal and the specific objectives of the study are as follows:

i. To analyze the trend and status of biogas energy in Nepal.
ii. To examine the economic benefits of biogas energy in Nepal.

1.4 Significance of the Study

It has been widely accepted that an inadequate volume of domestic resources mobilization is an important factor in holding back the process of growth and improvement in living standard of people. Especially in developing country, the demand of energy is positively related to the development of economy because it may be powerful instrument for mobilization of domestic resources.

In Nepal, the demand of fuel wood for energy is increasing due to increase of population. A big problem for rural housewives is indoor air pollution and smoke exposure inside the kitchen while cooking. Poor indoor air quality is one of the major risk factors for acute respiratory infection, cough, headache and eye aitments with housewives, infant and children. The use of biogas energy significantly improves the air quality by banishing smoke and soot from rural home by improving the health of rural wives and children by preventing these diseases caused by conventional cooking. Harmful enteric, bacteria, viruses and intestinal parasites due to the connection of toilets on plants and makes rural people free from flies and mosquitoes and it contributes to make better health and sanitation situation in rural and remote areas.

One of the primary impacts of biogas energy is poverty alleviation by reducing expenditure on fuel for cooking and extent to lighting. At national level it helps in reducing the cost of country to import the chemical fertilizers and petroleum products. Installation of biogas plants also helps to reduce unemployment for skilled and semi-skilled human resources which also contribute in rural poverty alleviation. The farmers of rural area may improve their living standard by selling the cattle and their products (milk meat, slurry). There may be several other indirect benefits of biogas energy plant in terms of developing social, educational and recreational aspects. Due to such significant value, the demand of biogas plants installation is rapidly increasing now a day in Nepal and the technology has been gaining popularity day by day in both urban and rural communities.

A lot of studies have been conducted on the sectors of biogas. These studies have mainly focused on smoke free kitchen aspect, increment on level of women empowerment and decrement in use of other resources (petroleum products, fuel wood, and electricity) for various purposes. Moreover the benefits that can be obtained for a long term have also been related. But the present study relates the contribution of biogas on decreasing health hazards due to use of other fuels for various sectors as per present data, the effects of subsidy policy have also been studied along with the contribution of biogas installation, including employment as well as investment and utilization of saved time. These all studies have been conducted based on tools of variables. The positive effects of biogas on various sectors have been studied and possibility of investment have been recognized. These activities help in poverty reduction by developing animal husbandry which is essential for a biogas plant. The level of development required so as to fulfill the demand of organic matters have been shown. All these data helps the policy maker to get surface data easily and conveniently which is one of the objectives of present study.

1.5 Limitations of the Study

This study is based on the officially published data and field survey on few places within some boundaries. The limitations of the study are as follows:

- Due to the time and resource constraints, less primary and more secondary data and information have been included.
- This study deals with only economic impacts. It does not deal with the technical and other aspects.

Although present research has many limitations and obstacles, it has become possible to explore the economic benefits of biogas on various sectors of economy and the achievements that are obtained from the research are accurate and reliable. The findings of the study are still valid for policy making and do not compromise the quality of the study.

1.6 Organization of the Study

The present study is divided into five chapters. First chapter is the introductory chapter which gives the background of Nepalese economy and short description about biogas energy in Nepal including objectives and limitations of the study. Second chapter is the review of literature which covers the theoretical as well as empirical aspects of the biogas energy from the international point of view and Nepalese context. Third chapter explains the methodology employed in the study. In which description of the sources of data, nature of data, model used in the analysis and the variables introduced are defined. Fourth chapter shows the structure and trend of biogas energy in Nepal, pattern, economic benefits of energy consumption and its contribution to the GDP; and fifth chapter is the last one which deals with the summary of the study, findings of analysis, conclusion and suggestions, recommendations to escape form the problems occurred in smooth functioning of the biogas energy system in Nepal.

CHAPTER - II

REVIEW OF LITERATURE

Energy plays the significant role in the development of economical, social, cultural, psychological, environmental, religions as well as political to name a few. Various studies have been made concerning to different aspects of biogas energy such as structure, role, trend and its contribution to production. The empirical literature review in this study is divided into two classes' i.e. international points of view and Nepalese points of view.

2.1 Concept and Terminologies Used in Biogas

Energy is a critical component of the development process. It is needed in all such major sphere of life which are directly connected with man's survival and progress such as in cooking, lighting heating etc. Due to population growth, the demand for energy is increasing day by day in the country. Major share of energy consumption is met through traditional sources. The renewable energy sources are to be developed and biogas energy promotion will be a significant one to struggle for improving this condition. The per capita energy consumption in Nepal is very low (14.6 GJ) and most of the energy is being used for domestic purpose. In Nepal, the sources of energy are primarily conventional. Therefore the dependency on forests for energy in Nepal is very high and forests are being used beyond their capacity causing deforestation and environmental degradation. Due to many constraints of technology, finance, politics and many others; the country has failed to create a favorable environment to harness the high potential of water resource and other as well.

Energy is a basic requirement of human life for the betterment of human development process. Energy is needed in all major spheres of life which are directly connected with man's survival and progress such as in cooking, lighting and heating etc. firewood, animal dung, agricultural residue and solar energy are used by the household and also in agriculture sector in rural areas of Nepal. Almost all Nepalese people are highly dependent on firewood for energy, which has resulted into degradation of forest resources.

In the Nepalese context, solar, water and wind energy have not been fully exploited. High consumption of fuel wood as a traditional source of energy leading to deforestation results into natural disaster such as soil erosion, flood, landslides and desertification etc. Firewood only has been the most common and traditional source of energy for Nepal that represents about three fourth of total energy consumption which is mainly consume in rural Nepal.

The forest alone is not capable of sustaining the increasing demand of energy for growing population. Although there is huge potentiality of hydropower, only less than 1 percent has been exploited. Other alternative source of energy such as solar power, and wind energy is negligible in use because of high cost of installation.

For the collection of firewood, rural women and children spend more time as well as on cooking and washing utensils. Smoke produced form firewood in poorly ventilated room with traditional stove creates smoke borne diseases such as respiratory problem including long-term asthma, headache and eye burning etc.

In Nepal, considerable amount of domestic energy requirement is met by the direct burning of dung. Such practice of using cattle dung as a source of energy has grave consequence on agricultural productivity. Not putting the manure back on the agricultural land as fertilizer deprives the soil of valuable nutrients and materials which drastically reduces crop production and results into food shortages. Dung obtained from cows, buffaloes and other animals can be better utilized if converted into biogas. Biogas is a reliable alternative source of energy, which replaces other expensive and pollutive energy resources. It plays crucial role for the conservation of forest and environment, reduction of fossil fuels and self sufficient in energy production.

Energy has become the backbone of the people in modern society. Nepal has been facing energy problem of fossil fuel and depletion of forest resources. Non-conventional energy like solar, wind, water power are not utilized properly in Nepal. High rate of using fuel wood invites natural disaster such as flood, land slide, soil erosion, deforestation and ozone lager depletion. 70 percent people still use firewood as a main source of fuel. Therefore, destruction of forest is increasing every day. If develop the biogas technology, then demand of petroleum product will be reduce and foreign exchange may be saved. Adaptation of biogas technology helps to raise the agriculture production in Nepal. Slurry of it is very useful for fertilizer.

The construction cost of biogas plant should be minimized to benefit mass of the people. The government had targeted to install 2,50,000 biogas plants during the tenth five years plan period with the assistance of Netherlands Development Organization (SNV Nepal) and co-financing from the Kreditamstall Fur Wewideranfban (KFW), a development bank of German. For the promotion of biogas, HMG\N has been providing subsides based on geographical region. For the hill region the sum of subsidy is Rs. 8,000,11,000 for mountain and 5000 for Terai for up to 4^3 to 6^3 to 10 m^3 respectively (BSP, 2004).

Biogas plant is a tank which has the concrete inlet and outlet basins. Fresh cattle dung is deposited into a charge pit which leads into the digestion tank and remains there. After laps of time depending upon ambient temperature sufficient amount of biogas is accumulated in gas tank which is used by households on various purposes. Digested sludge is removed from the outlet basin and is used as fertilizer. The waste materials of plant and animal origins consists carbohydrates, lipids, proteins and small amounts of metabolites which are insoluble in water. If these materials are incubated in an aerobic condition, a combustible gas is produce by the action of bacteria known as methane gas.

Many products, byproducts and intermediates are produced in the anaerobic digestion process input materials before the final product is produced. Different species of methanogens are involved in breakdown of complex organic matter into acetate acids which is one of the substrates of methanogenic bacteria and Hydrogen with CO_2 is a general substrate form methanogenesis. Generally the biogas energy is used on the purpose of cooking, lighting and boiling water instead of fuel wood, LP gas, kerosene and electricity (WECS, 2017).

Energy Enhancement

Enhanced energy security and climate change mitigation are the main drivers for the transformation of the energy system from fossil to renewable sources. Biomass has to play a key role in this transformation to a low carbon economy. Worldwide, biomass (including putrescible waste and bio-wastes) accounts for more than two thirds of all renewable energy supplies. Among biomass sources, biogas is an interesting option with a large potential, offering many exciting possibilities to supplant and therefore re-duce our dependence on fossil fuels.

Currently the modern biogas production industry is just at the beginning of wider implementation. With the exception of a few countries, like Germany (which are already demonstrating its real potential) only a tiny part of this global potential has been realized. Reasons for the slow deployment of biogas include: a lack of information about the possibilities of biogas, a lack of a trained labor force, high capital cost for the setting up of commercial plants, generally inadequate and un-reliable government support policies and the competition of natural gas as a cheaper alternative in many parts of the world.

From an economic viewpoint national biogas development is effectively stimulated when a significant cost is put on disposal of putrescible wastes or of free emissions of greenhouse gases arising from this, and also when financial stimulus of biogas production roughly matches the previous levels of stimulus of natural gas sourcing or reticulation. This latter case may be via a carbon tax on fossil fuels, transferred to provide a cost share for biogas production and processing facilities.

A specific advantage of biogas technology is in the utilisation of organic wastes and other organic byproducts for energy production, as opposed to disposal via landfills, which inevitably leads to further emissions of greenhouse gases by the process of slow decomposition.

The purpose of this WBA fact sheet is to offer to the reader basic information about biogas as renewable energy source – the process, the feedstock, the versatility of biogas, the worldwide potential, the cur-rent global significance and the necessary policy measures for further development.

Basics

The term “biogas” is used for a gas produced by anaerobic fermentation of different forms of organic matter. Biogas is also produced under anaerobic conditions in nature, for example in swamps. This an-aerobic process is driven by different varieties of bacteria, in anaerobic digestor tanks this is usually at a temperature of 30–40° C. During this biological process a major portion of the carbon compounds are converted to CH_4, CO_2 and water. Biogas consists mainly of methane, carbon dioxide, and some other minor components. The fermentation process also produces a residue or sludge that can be used as fertilizer, or after drying as feedstock for combustion in district heating or CHP plants.

The process itself occurs in airtight biogas digesters without oxygen. The rate of the process depends on the feedstock and several other parameters. The digestion time varies from several hours (for sugars, and alcohol) to several weeks (in case of hemicelluloses, fat, and protein).

The size of these digesters differs widely. Millions of small digesters are used in connection with family houses or small farms in Asian countries to produce gas for cooking; medium sized digesters can be found on farms around the world to produce mainly electricity and heat, and bigger digesters are in use for the digestion of waste from cities and municipalities, be it sewage sludge, waste from the food industry or collected from house -hold organic waste bins.

A biogas plant on a farm has different elements such as the liquid manure store, the receiving area, the digester, the gas storage and, in case of the combined heat and power (CHP) application, grid connection for the electricity and a connection to the heat user. The cost of investment per kW installed electric capacity is about 5 000 Euro for an installation of about 150 kW in size; the specific investment cost is higher for smaller plants and lower for bigger plants.

After production the raw biogas can be cleaned and upgraded to methane; it is then called biomethane, and in this pure form can be compressed and injected into gas grids or used as transport fuel. The energy content of raw biogas varies between 5 and 7 kWh/Nm3 of biogas depending on the composition; as an average 6 kWh/Nm3 biogas is assumed (i.e., assuming 60% methane content). For pure biomethane the energy content is approximately 10 kWh/m3.

A typical landfill also emits biogas produced as a result of microbial decomposition of wet organic matter in the absence of oxygen; the gas is normally called land-fill gas, and for larger properly managed sites this is captured and used for energy production purposes (usually by fuelling a spark-ignition motor driving a generator), instead of being allowed to escape to the atmosphere and thus contribute to green-house gas emissions. On some landfills it is simply flared so that the methane is converted to the less damaging greenhouse gas carbon dioxide.

Biogas can be produced from most bio-mass and waste materials regardless of their composition and over a large range of moisture contents (although very high moisture content material of under 5% dry matter reduces biogas yield) with limited feedstock preparation. Woody biomass is not suitable for anaerobic biogas production due to its high lignin content. How ever, wood can be converted to methane by a thermal gasification process, the product of which is usually referred to as synthetic natural gas or SNG (this process is not the subject of this fact sheet).

Organic fraction in landfills

By extracting and processing the land-fill gas (by removal of water and possibly hydrogen sulphide) so it can be used for energy purposes – usually as a fuel for gas engine-driven generators. Moreover, land-fill gas utilization reduces green house gas (GHG) emissions.

Sewage sludge

Refers to the residual, semi-solid material left from wastewater treatment. Sew -age sludge can be used as a feedstock for biogas. This is done in many wastewater treatment plants. The residues from digestion can be used as soil conditioner.

Manure

Manure is produced by intensively housed livestock in some countries is stored on farms for several months in liquid or solid form and then used as fertilizer. During storage, anaerobic digestion can take place in the bottom layers of manure producing methane that might be released to the at-mosphere if it were not used for energy or flared. Blending manure with energy crops or other waste streams for anaerobic digestion is an attractive option to increase biogas production. In developing countries, manure is often used in small family-scale anaerobic digesters and the gas is mostly used for cooking, with other applications being domestic lighting or running spark ignition engines.

Use and Application of Biogas

Biogas covers a variety of markets, including electricity, heat and transportation fuels. Whereas using the gas for direct combustion in household stoves and gas lamps is common in some countries, producing electricity from biogas is still relatively rare in most developing countries. In industrialized countries, power generation is the main purpose of biogas plants; con-version of biogas to electricity has become a standard technology. To improve overall efficiency of biogas utilization, combined heat and power plants are often used.

After fermentation the biogas is normally cooled, dried of water vapour and cleaned of hydrogen sulphide to produce a good combustion gas for gas engines. The illustration above gives an overview about the different ways to use biogas.

Emerging Biogas Concepts for Infrastructure and Supply

Different requirements for biogas use, such as heat generation or upgrading the injection into a gas grid, requires different configurations of the biogas plants locations and size. Early on, when biogas was beginning to be used to produce energy, CHP units were often placed at the same location. More recently new concepts have emerged involving the production of the biogas in one place and the subsequent transportation of the biogas to a central CHP plant, or an upgrading station, located near a gas pipeline for injection into the regional gas grid.

"Biogas" is a gas produced by anaerobic fermentation of different forms of organic matter and is composed mainly of methane (CH4) and carbon dioxide (CO2). Typical feedstocks for biogas production are manure and sewage, residues of crop production (i.e., straw), the organic fraction of the waste from households and industry, as well as energy crops including maize and grass silage.

Biogas is supplied to a variety of uses or markets, including electricity, heat and transportation fuels. In many countries using the gas for direct combustion in household stoves and gas lamps is increasingly common, producing electricity from biogas is still relatively rare in most developing countries. In industrialized countries, power generation is the main purpose of most biogas plants; conversion of biogas to electricity has become a standard technology. To improve overall efficiency of biogas utilization, combined heat and power plants are often used, with part of the heat utilized for maintaining reactor temperature and sometimes for heat treatment of the incoming material.

A biogas plant on a farm, for example, has a number of different elements, such as the liquid manure store, the receiving and mixing area, the digester or reactor, the gas storage tank and storage for digester residue. In the case of a combined heat and power (CHP) application, there also needs to be grid connection for the electricity and a connection to the heat user. The cost of investment per kW installed electric capacity is about 5 000 Euro for an installation of about 150 kW in size; the specific investment cost/kW or MW capacity is higher for smaller plants and lower for bigger plants.

The global potential of biogas is large enough to provide a substantial share of future gas demand; estimations show that biogas could cover around 6% of the global primary energy supply, or one quarter of the present consumption of natural gas (fossil methane gas).

Each country should develop and implement an integrated biogas concept in order to promote the increased production of biogas. The big advantages of such a strategy would include better progress in mitigating climate change by reducing national GHG emissions, improving national energy security, and creating new employment in rural regions. International organizations should support these national efforts (Boitin, 2013).

2.2 Review of International Empirical Studies

Kumar (2003) has made a study on the title Renewable Energy on the Indian experience. According to his study, in India, many programs on biogas are being implemented for over five decades and energy is an essential ingredient of socio-economic development and economic growth. Among the rural and urban poor, there is a definite correlation between access to energy on one hand and educational attainment and literacy on the other. The renewable energy sources mainly the biogas energy are diffuse the decentralized, they are appropriate as local energy sources, meeting ever expanding and diversified energy needs and supporting the basic energy needs of rural poor. The technology of biogas energy provides the benefit in zero cost during their operational periods and meeting the basic needs of rural population as well as the rapidly increasing requirements of energy (heating and lighting) associated with high economic growth. It was also added that the certain minimum rural energy is needed for cooking, lighting and pumping. The adoption of energy products, particularly those for cooking and lighting, aim to enhance the quality of life by improving of living environment and reducing the drudgery of women and children associated with fuel wood collection and smoke related health hazards.

Akhter (2003) has made the study on Pakistan on the title Thrust Areas in Renewable Energy For Rural Development. According to the study, the relationship between energy produced and poverty alleviation are prospect in rural poor. An energy deficit country, Pakistan, many of renewable energy sources are available in which biogas energy is the most popular and installation programme was widely spread in the country. Majority of the people living in rural areas has no access to the commercial energy sources. Most of energy services are to be extended to the poorest of the poor to raise their living standards to a respectable level. This can be achieved by using renewable energy (biogas) sources that are widely distributed and freely available.

It was also added that biogas activity was initiated in the early seventy's century and more than 4000 plants of size 5-15 cubic meters were installed in the country. Recently under the project founded by government 12,000 biogas plants are to be installed in four year's period on cost sharing bases, where 50percent cost is invested by plant owner. The research also focused that biogas energy are the means of development for the rural poor, renewable energy may support to fill the gap of energy deficit, joint venture of government and people, on biogas energy development, is more effective in rural sectors and energy will play the significant role to reduce the poverty level.

Abeygunawardana (2005) has made a study on private-public partnership on the promotion of rural energy in Sri Lanka. According to the study there is positive relationship between the energy production and poverty alleviation. The study is compared among the three types of rural villages on energy consumption categories as (a) with grid-connected by electricity (b) Off-gird village with renewable energy and (c) a village without electricity. The result was off-grid village with renewable energy related with agricultural sector i.e. biogas energy is more correlated with economical development than the other types.

It was also added that the types of digestion of biogas technology determine the domestic level of energy (a) linked with cattle sheds and drybatch, (b) linked with paddy farming straw and dray batch which proves the generation of Biogas installation in Srilanka. He also focused that one ton and two tons capacity of biogas plants were installed. The total cost per installed plants was $3000. The private public partnership work must be focused to achieve the goal of biogas energy. Joint effort may be more effective than single on, either done by government or individual.

2.3 Review on Nepalese Empirical Studies

Economics of energy has no long history. During the sixth century, biogas was used for heating bathwater in Persia. Marcopolo mentioned the use of covered sewage tank. It probably goes back to 2000-3000 years ago, in ancient China. In 1630, Van Helmout pointed out the existence of the inflammable gas from wastage and animal dung. About fifteen different gases were examined. It was in 1776, the Volta recognized the presence of methane gas in the marsh or swampy place. Priestly mentioned about this gas in 1790 and Dalton tried to find out its chemical formulae in 1804. In 1808, Humphrey Davy studied the formation of mixture of water and cow dung and he collected one litter of gas. The collected gas contained 60 percent carbon dioxide and the rest comprised of mixture of gas, which was rich in methane and nitrogen gases. But Davy was interested only in the fertilizers aspect but not in potential of this gas as sources of energy and he determined that methane gas was produced during the anaerobic digestion of cattle manure) (CBS, 2011).

It took over hundred years to use the gas for mankind. Biogas plant was set up in 1890 in leper Asylum in India for methane gas production. In 1941, another gas plant was installed in Indonesia. In 1950 about 1000 biogas plants were installed by French. Biogas was so popular at the time of Second World War. Biogas plants were installed by German people during the Second World War, to meet the energy crisis and to draw the attention of many countries towards biogas energy (CES, 2001).

When the late father B.R. Saubale established a model of biogas plant in St.Xavier school in Godawary in 1955, the historically development of biogas energy was started in Nepal. Then after only few individuals were involved in biogas technology until the world energy crisis in 1973. Government of Nepal introduced the biogas programme in 1975 with the aim to control deforestation and to prevent burning cow-dung which can be utilized as valuable fertilizer. During 1975/76, 250 floating dung type biogas plant were installed with the purpose of institutionally development of biogas plant and in 1977 Gobar Gas Company was established. This was the only company that worked for 15 years, until 1991 and constructed nearly 11,000 different sizes and designs of biogas plants.

In 1992, Biogas support program (BSP) was established aiming to develop and disseminate biogas technology from commercially and market oriented point of view. The installation and quality of biogas plants rapidly increased after the establishment of BSP and the policy of subsidy of government was rapidly forwarded after the establishment of Alternative Energy Promotion Center (AEPC) in 1996 under the ministry of science and technology.

ADB/N (2003) has been playing an active role in the promotion of biogas development technology since 1974/75 by distributing loans to the interested individuals for installation of biogas plants. Besides providing loan, the bank is also playing active role to carry out promotional activities such as training and information dissemination. United mission to Nepal, Balaju Yantra Shala, Agricultural Tools Factory were the pioneering agencies to make the biogas programme successful.

Gobar Gas Company and Agriculture Equipment Development Company were established in 1977 as a private company with an objective of promoting biogas technology in the country. Fifteen years, from its establishment Gobar Gas Company remained the one and only organization involved in the promotion of technologies, construction biogas plants, providing training to the masons, users and its staff.

Kanel (1999) has made a research on the title Subsidy scheme for biogas plants. According to the study, high internal rate of return (both financial and economical) even with a decline ongoing subsidy rates, the study on IRR values with different subsidy rate on 8 cubic meter plant shows that they are in profitable condition in Nepal. This is mainly due to high increment prices in the market of cooking and lighting fuels.

According to the study, the internal rate of return of a biogas plant is very high when we include the increase NPV in the slurry of a biogas plant. The slurry produced from the biogas plant is also a substitute use of chemical fertilizers. The economic returns are higher than the financial return in Kerosene and chemical fertilizer. If allowed for higher real prices of firewood, the economic rates of return will still be higher. It also focused that biogas plants are more profitable in Nepal, IRR is very high in biogas plants, slurry will be substitute of chemical fertilizer, biogas plants and means of fuelwood are positively related.

Bajracharya (2001) has made a research on Constrains Faced by the Installation of Biogas Plant. According to the study, formation of biogas plant has many advantages. The features of all under developing countries have affected the existing condition of biogas companies. It was added that the expected return from biogas installation is not being obtained due to lack of additional capital, regularly increasing in the price of plant equipment and its construction materials, low investment of people and nation on biogas installation plants, lack of clear vision of government, lack of skilled manpower and modern technology for the construction of Biogas plants.

It suggested that biogas plant has more benefits but high ambitions of invested companies, low capital factors and resources without getting market promotion are the constraints for plant installation. It also focused that there are other more constraints in the establishment as well as development in the biogas plants such as social constraints, lack of education to determine the merits and demerits of biogas plant especially in rural and remote area, problem of poverty, people being landless, the unfavourable environment for cattle grazing.

Lamsal (2001) showed the mineral values of slurry produced by biogas plant. According to the study, the green plants (vegetables, crops etc) require 16 various nutrition for growth, like other animals. The necessary nutrition's are rich in slurry than in other chemical fertilizers. According to the study, the slurry increases the physical features of soil. It increases the quality of humus in solid and decreases the PH level of soil. Therefore, the micro-organisms increase in soil, which preserves water in it and increases the fertility of soil.

The major finding of his study was ordinary compost manure contains nitrogen (0.5 - 1.0) percent, Phosphorous (0.1-0.3) percent Potas (0.1-0.5) percent, farmyard manure contains nitrogen (0.1-0.3) percent phosphorous (0.1-0.2) percent, Potas (0.5- 0.7) percent Fresh slurry contains (1.5- 3.7) percent, nitrogen, (1.6- 2.2) percent phosphorus, (0.8 - 3.6) percent Potas. Similarly, slurry compost manure contains 1.27 percent nitrogen, 0.73 percent phosphorus, 1.4 percent Potas respectively.

It also suggested that use of the slurry is more effective for the various vegetables production than the use of chemical fertilizer. Generally, the production of tomato, cauliflower, wheat, maize, bean and paddy will grow by 15percent, 8percent, 33 percent, 37 percent, 70 percent and 10 percent respectively than its previous production. He also added that the production of mushroom can also be increased due to use of slurry than other fertilizer. So the use of slurry can reduce the import the chemical fertilizer which saves the foreign currencies for the nation.

Regmi (2002) has made a studied about Women's Empowerment Through Biogas Technology. According to the study, the development of biogas plant changed the status of women in the society. Moreover, socio-economic impact of biogas energy is growing on urban and rural area of country. It found that most of educated and medium class people are interested and have biogas plant in comparison to uneducated and other class of people. More biogas plants are constructed in rural areas rather than urban (cities). The establishment trend of biogas plant is highly increasing after 1998/99 and the popular size is 6 cubic meter. Already facilitated by hydro-electricity area also more positive towards establishment of biogas plant due to irregularities of firewood and its rising prices.

It suggested that the role of women also increased in biogas management program. Due to use of biogas plants, forest returns into green, there is no wastages on the farmlands. Women are getting fresh air in the kitchen and there is no any sign of risk. Their health status is increasing and they have been able to utilize at least six hours a day in creative work and they have increased their economic activities and are able to earn and work like as male. Thus this activities has helped to increase the women is empowerment through biogas program in rural areas of Nepal.

Shrestha (2003) has analysed the impact of biogas plants in rural areas. It remarked that space, money, skilled manpower with expertise is needed to build the biogas plant. To prepare the biogas plant once we need three inputs (dung, water, labour) and it gives two outputs (effluent, gas). In the village of Nepal, people keep cattle's (cows, buffaloes) for their livelihood. Main occupation of people is agriculture and they perform their works themselves. Therefore, dung and labour is easily available in their own households and they manage water from local sources (tap, well, river, pond, spring, collecting rainwater etc.).

It also showed the effects of biogas plants on various sectors. It is used instead of fuel wood and Kerosene consumption. The use of biogas, minimizes the consumption of fuel wood, kerosene and saves foreign exchange. The change in cooking method in house also saves the time. After installation of biogas plants, the forest is preserved and people get clean environment.

The analysis suggested that biogas technology is intended to improve quality of life of rural people. The technology has given benefits to rural people in many ways; especially women can potentially receive benefits from its implementation. Women are the main sources of labour to feed the plant and co-manage it and they play a vital role in its implementing. They are playing secondary role in decision-making process and management of biogas plants which are needed to improve it. As main operators they should receive adequate training to operate and manage the technology.

Dhungel (2004) has made a research on alternative (biogas) energy over the Nepalese Rural about the issues of the existing energy crises. It focused that lack of adequate capital is the main astounding barricade to establish the many energy projects in Nepal. To fulfill the high demand of energy, the best way may be the development of biogas energy. Due to need of less capital and less manpower in the comparison of large energy projects, such small energy plants may be suitable for Nepalese rural economic context.

It also focused that to develop such plants, the local capital and manpower will be sufficient if we add few expertise. The production cost of such plants will be less in the comparison of other, due to mobilization of local resources and labour intensive technique. The development of such plants throughout the country, which promotes employment and enhance the use of local skill, and increases the living standard of people by increasing the level of income with the help of local level energy development programme. The analysis suggested that to establish the energy projects with local capital and labour, focus must be given to establish the small energy plants, local energy plants may support to increase the level of income and employment.

Pokhrel (2007) has made a research on impact of biogas. According to the study the use of biogas saves money which is used to purchase fuelwood. As a result saving fuelwood 5.47 kg per day, per plant protects forest area form deforestation .It also saves money spent on fuel which saves export of Nepalese currency. The use of slurry discharged form biogas plant saves money that is spend on chemical fertilizer. NPK is very rich in slurry compost fertilizer than in chemical fertilizer, which raised the productivity of crops. The biogas reduces the emission of carbondioxide gas and it generate national income by selling carbondioxide gas at $4.5 to $8 per tones. The biogas plant installation is easy because the cost invested on construction is less. They can get more economic benefits on free of cost and it becomes alternative source of energy.

The study found that biogas helps to improve the living condition of target group and at the same time reduced negative impact on the environment. The most important positive ecological impact of the use of biogas is the substitution of equivalent quantities of firewood and the subsequent improvement of the environment and protection of resource. Rural development and infrastructure projects were strength due to the cooperation with local authorities and self –help organizations. The success of biogas technology is increasing due to considerable extent to massive technical and financial assistance, which was granted in the form of direct and indirect subsides to the target group. Thus, it is important to concentrate the next steps on improving the commercial viability and hence the sustainability of the programme.

Panta (2008) has made a study on Measurement of Indoor air Pollution based on 600 rural households in Syangja and Chitwan district of Nepal. According to the study the level of indoor air pollution is reduced by improved cooking stoves but biogas fuel reduces the indoor air pollution 9percent and ICS by 5percent. It added that the cooking fuels (biogas and ICS) available in the rural areas will lead to significant role in reduction of IAP. He assesses the effects of IAP is reducing on the appearance of the symptoms of chronic bronchitis, asthma and ARI on individual members of the household using two approaches i.e. assumes behaviours are exogeneous (using a profit model) and assumes that behavior is endogeneous (using an instrumental variable profit model).

The results from the two types of analysis are found to be different for all three diseases under consideration. The results obtained after correcting endogencity, using the instrument variable profit, gives in one reliable result (i.e. in addition to age and gender) the use of improved stove and it reduces respiratory health problem. Thus, historical estimation of the effect on indoor air pollution on health has to be revised by correcting the endogeneity problem.

The analysis suggests that the problem of respiratory health is more several among older age cohorts, particularly those are female who are generally involving in cooking, more suffer from respiratory problems. Hence, they require special attention from health workers and development partners who are interested in reducing the health effects of indoor air pollution.

Malla (2013) has made a research in rural Nepal and found that most of households are mostly dependent on solid biomass energy for cooking. Only a few (nearly one percent) household use clean fuels (biogas, LPG, electricity, solar etc) along with firewood. The average annual firewood consumption is 2,744 Kg. Due to high consumption of firewood the pollution in the kitchen is very high. The average PM_{10} level is 763 g/m^3 in households within twenty-four hours without control group, which is about 15 times higher than the WHO recommended safe level of $50g/m^3$. In the sample households with intervention found in 24 hours, the average PM_{10} level is $255g/m^3$ which is 66 percent less than the control group.

The finding of the study shows that the indoor air pollution level is very high (15 times higher than the recommended safe level). In the study area where households use solid biomass fuel for cooking on traditional stove is effectiveless. Indoor air pollution is one of the major health problems (mainly ALRI) and result is highly expenditure in terms of treatment and loss of productivity. There is urgent need of increase the access to clean fuel and improved technologies to overcome these problems.

BSP (2017/) had made a survey on the present situation of biogas plants installation in Nepal. The survey shows that all related aspects of biogas installation in different parts of the country covering 77 districts.

Total 2,41,920 biogas plants are constructed under BSP/N. 241,920 HH used clean renewable energy. 3hours/day/p/HH time is saved, 7.4 tons of green house gas reduction per year per HH, 1.25 trees protected per year per plant, connecting 152,410 toilet on plants shows the reduction of unmanaged sanitary system, 2.1 lt. kerosene per HH per month is saved, 1.75 tons of slurry and bio-compost is produced per year, around 75percent plants have crossed their guarantee period, reduction of indoor air pollution due to kitchen smoke in 135,000 households.

The available literature suggested that there are a number of limitations and gaps such as biogas installation programme, controlling of deforestation, increasement on employment and investment in rural and remote areas, decreasement on health cost and reduction of smoke born and water born diseases, reduction on workload, increasement on time saving and utilization of saving time in various sectors, contribution of bio-compost on agriculture production, positive effects of biogas on various resources savings such as LP gas, electricity, kerosene, fuel-wood chemical fertilizer, maintaining clean and healthy environment on kitchen areas, saving burning cow-dung. The present study will contribute to fulfill the gaps.

2.4 Write Research Gap

Most of the studies were performed at national and international level in aggregate form. No research on economic impact and trend of biogas energy in Nepal is found. Not a single research is carried out on location wise data from the household survey for Bhaktapur. None of the research done so far could capture such variables regarding economic impact and trend of biogas energy of Pokhara. Therefore, the data were collected from secondary sources where as primary sources such as observation method, interview method and indirect oral investigation were used. The analysis of Economic impact and trend of biogas energy in Bhaktapur is distinctive and new topic of research in context of biogas sector in Nepal. It gives important outcome for the planning and policy implementation in the biogas development process. Moreover, the present study will yield important benchmark value for the future research as it comprises the detail survey of Biogas impact and its trend in Bhaktapur. Therefore, this study will add some values biogas energy and its impact on economic sector in Nepal and fulfill the existing research gap.

CHAPTER - III

RESEARCH METHODOLOGY

Research methodology is concerned with various methods and techniques which are used in the process of research studies. It includes wide range of methods, including quantitative techniques for data analysis and presentation. The research methodology is followed to attain the basic objectives and goals of this research work.

3.1 Research Design

The design of this study is descriptive approach as well as analytical in nature. In fact, the research design is the conceptual structure in which the research is conducted. This study analyzes the benefits of biogas energy in Nepalese economy on the descriptive and analytical research design. For the systematic presentation of the collected data in this study, descriptive research design has been employed. This provides a comprehensive description on the related topics on various aspects of the available data information. The study is based upon the secondary and less primary data information to fulfill the objectives of the study, which are presented in table and suitable diagrams (bar diagram, pie-chart, line graph etc.). Tabulation and graphical presentation of data are made to make the information visible as well as to make them easily understandable.

3.2 Nature and Sources of Data

3.2.1 Primary Sources of Data

An opinion survey was conducted in Bhaktapur Municipality of Bhaktapur district among 200 households. Stratified random sampling method applied for primary data collection. Their analysis and interpretation are done by applying various statistical methods. Following methods of primary data collection were applied on the present study:

i. Observation method,
ii. Direct personal interview method
iii. Indirect oral investigation

3.3.2 Secondary Sources of Data

The sources of data are the information received from books, journals and articles concerned with the study. The major sources of the secondary data are as follows:

Economic survey of 2016 and 2017, MOF, Energy sector synopsis report of 2016, WECS, BSP yearly book 2016/17, BSP, Final reports (2015, 2016, 2017); Reports of AEPC (2017), Research Studies by CES, IOE, RETROD-03 by CES/IOE, World Development Report 2015/16/17, World Development Indicator 2015/16/17, Statistical Pocket Book 2015/16/17, CBS, Nepal Living Standard Survey 2015/16/17. The study is based on 16 years published data covering from 2001/01 to 2016/17.

3.3 Tools of Data Analysis

Quantitative as well as qualitative methods have been employed for the purpose of data analysis. However, the quantitative tools have been employed widely. It has been seen as the best method for data analysis and also to reach at the conclusion. Different statistical tools such as mean and standard deviation for both estimation and test have been employed as demanded by the objectives specified above with regard to the model used in study, following measures are carried out to check the reliability of the analysis.

3.3.1 Coefficient of Variation

The percentage measure of coefficient of standard deviation is called coefficient of variation. Less the C.V, more is the uniformity and consistency and vice versa. The coefficient of variation measures the relative of dispersion, and capable to compare two variables independently in terms of their variability.

Coefficient of Variation (C.V) = $\frac{\pm}{\bar{X}}$ | 100% (Kothari, 1990).

Where |∃ = Standard Deviation, $\bar{X}$ = Mean Value

3.3.2 Trend Analysis

Trend analysis (Time series analysis) is also one of the most useful statistical tools, which is used to study the forecasting. A widely and most commonly used method to describe the trend is "The method of least square."

The trend line is given by the following equation:

y = |ℑ+ ℘T

Where,

Y= Values of dependent variables.

α= y-intercept of trend line.

β= Slope of the trend line.

T=Value of independent variable (Time)

$\alpha = \frac{Y}{N}$, X $\frac{TY}{T^2}$ (Kothari, 1990).

3.34.3 t-test

The t-test is the significant test of the regression coefficient of the hypothesis which is used to test the hypothesis about any individual partial regression coefficient. The decision to accept or reject null hypothesis is made on the basis of the value of t i.e. calculated or tabulated value and,

$$t = \frac{\bar{d}}{\sqrt{s^2/n}} \sim t_{nZ1}$$ (Kothari, 1990).

3.4 Research Variables and Measurement

The variables that are used to analyze the study are as follows:

a. **Subsidy:** Subsidy indicates the subsidy amount provided by the government for biogas plant installation in different regions (Terai, Hilly and Remote) with different rate.
b. **Costs:** Cost indicates the total installation cost (money) required for biogas plants installation including people's donation and opportunity cost (time).
c. **Benefits:** Benefits includes the benefits received under biogas plant i.e. time savings, production, employment, investment, health benefits, bio-compost, production.
d. **Plants:** Plants indicate the total number of installed biogas plants under BSP/N at the end of August 2014, with different capacities i.e. $4m^3$, $6m^3$, $8m^3$, $10m^3$, $15m^3$ and $20m^3$ in size.

CHAPTER - IV

DATA PRESENTATION AND ANALYSIS

In this chapter the presentation and analysis of primary as well as secondary data has been conducted. Present status of biogas energy in Nepal, subsidy policy of government on biogas installation, trend of installation, soeio-economic status of biogas users and its economic benefits on them are the main headings and subheadings have been discussed and elaborated within the circumference of the objectives of this research.

4.1 Present Status of Biogas Energy in Nepal

The development trend of biogas energy in Nepal has completed more than three and half decades. Due to the multiple advantages, the development trend of installing biogas plants is rapidly increasing. During the beginning years 1973/74 to 1974/75 there was an increment from 4 to 199 plants. But till 1981/82 the trend decreased tremendously and finally reached 134 plants. 11,000 biogas plants were installed before the establishment of BSP/N. After the establishment of BSP/N in 1992/93 there was increment by 8.9percent. The total plants during the years 2001/02 was 15527 while the total plants reached 17663 in 2014/15 and the total cumulative plants was 241920 after the change of 5.2 percent in average covering 77 districts. In Nepal total potential production of biogas plants are 2.9 million out of which 57percent are in Terai region, 43percent are in Hills and mountain region. The table 4.1 describes the potential production of biogas energy in different regions of Nepal in 2016/17.

Table 4.1 Biogas Production Potential in Nepal (2014/15) Unit in 000 GJ

Development regions	Physical Regions (in %)			Total
	Hills	Mountains	Terai	
EDR	36.83	12.15	51.02	10755
CDR	49.37	10.47	40.16	10125
WDR	69.18	0.38	30.44	9177
MWDR	54.46	10.92	37.62	7312
FWDR	40.69	22.92	36.39	5504

Source: Water and Energy Commission Secretariat, 2017.

Total biogas production potential in the year 2016/17 is about 73 million GJ which is about to 11percent of total energy demanded of the same year. The availability factor of biogas production in Terai, Hills, and mountain regions is 100percent, 75percent and 50percent. Among the 2.65 millions of total estimated biogas plants only 2.475 million plants are economically viable. Since 2001/02 to the end of August 2017, 2.4192 millions biogas plants of varying capacities (4,6,8,10,15 and 20 m^3) has been installed (table 4.2). Due to the technical and financial support of AEPC, BSP/N and SNV/N the installation trend of biogas plants was increased and more than 90percent biogas plants are operating at present. The yearly installation trend of biogas plants since 2001/02 to 2016/17 is shown by the table 4.2 below:

Table 4.2: Yearly Installations of Biogas Plants by Capacity (Since 2001/02 to 2016/17)

Fiscal years	Districts coverage	Capacity (in cubic meter)						Total installation plants	Increased/ Decreased %
		4	6	8	10	15	20		
2001/02	58	123	1190	2460	3097	249	38	7157	-
2002/03	57	304	2004	3201	2686	175	17	8387	17.19
2003/04	56	265	2861	4264	2303	180	26	9869	17.67
2004/05	56	494	4268	4717	1451	109	13	11052	11.98
2005/06	58	1771	7850	2001	643			13265	20.02
2006/07	59	3225	11629	2616	287			17857	34.62
2007/08	57	2779	10597	1864	287			15527	-13.04
2008/09	57	3391	11105	1622	222			16340	5.24
2009/10	58	1859	8072	1191	137			11259	-31.09
2010/11	56	2467	13352	1804	180			17803	58.13
2011/12	55	2058	12184	1686	190			16118	-9.46
2012/13	60	2463	13486	1550	164			17663	9.59
2013/14	62	2224	11558	1099	3			14884	-15.74
2014/15	69	3420	14997	1062				19479	30.87
2015/16	75	4979	14265	829				21158	8.62
2016/17	75	5828	12482	727				20056	-5.21

Source: Bio-Gas Support Programme, Yearly Book, 2017.

The table 4.2 illustrates the present status of yearly installed, biogas plants. There is increasing trend on 4 m^3, $6m^3$ and $8m^3$ size of plants installation but decreased trend on $10m^3$, $15m^3$ and 20 m^3. The cumulative installation trend increased by 17.19 percent in 2002/03 and 34.62 percent in 2006/07 but in 2007/08 decreased by 13.04 percent. Similarly in 2010/11 the increasing trend was 58.13 percent but in 2012/13 and 2016/17 it decreased by 15.74 percent and 5.21 percent respectively.

4.1.1 Significance of Model Plant

The present study describes the significance of the model plant ($6m^3$) under the cost benefit analysis approach.

Table 4.3: Dung and Water Requirement for Different Size of Plant

Size of plant in (m^3)	Average cattle required	Invested Subsidy rate (in Rs.)	Required during (Kg/day)	Required water (ltr./day)	Dung required at kg	Total gas production at $0.032m^3$/Kg dung
4	2-3	13034	24	24	1450	46.4
6	3-4	13034	36	36	2170	69.6
8	4-6	12334	48	48	2900	92.8
10	6-9	NA	60	60	3500	112.0
15	9-14	NA	90	90	5500	176.0
20	14+	NA	120	120	7200	230.4

Source: Gobar Gas Company and BSP/N, 2017.

The table 4.3 reveals that required number of cattle and government subsidy amount for $4m^3$ and $6m^3$ biogas plants is similar but production level of gas in $6m^3$ is 50percent more than in $4m^3$. Similarly required cattle number and dung for $6m^3$ and $8m^3$ is similar but production level of gas in $6m^3$ is 25percent less then $8m^3$. The construction and management cost is more in $8m^3$ than in $6m^3$ but subsidy amount is more in $6m^3$. When 7.78percent more subsidy is provided for $6m^3$ size then in $8m^3$ the installation level increased by 27.58percent (table 4.3). The $6m^3$ size of plant can meet the requirement of gas for cooking $1.75m^3$ per day and lighting $1.5m^3$ per day (Biogas, 2017, pg.32). From the cost benefit analysis approach, the benefit cost ratio is greater than one in $6m^3$ then in $8m^3$ excluding other size. Hence more number of people are interested towards $6m^3$ plant installation (table 4.2) than in other size which signifies it as model plant.

4.2 Subsidy Policy of Government on Biogas Installation

The government subsidy policy can play the significant role in the development of biogas energy in Nepal. To solve the present energy crisis and environmental problems the government of Nepal has revised the subsidy policy on renewable energy development programme under the management of AEPC throughout all district development committees to benefit the people living in the rural and remote areas of the country.

4.2.1 General and Additional Subsidy Rate

The subsidy rate has been fixed on the geographical regions and accessibility of motorable roads according to the size of plants and furthermore additional subsidies are provided for the beneficiaries of low penetrated districts to encourage the small farmers and there is a provision to provide additional subsidy amount to poor, Dalit, Janajati, Utpidit and conflict affected people. There is a policy to provide additional subsidy amount for biogas plants installation program on police and military barracks, monastery orphanage home, schools, colleges including hospitals. The government has also fixed a policy to provide extra subsidy amount to encourage the biogas installation program at community level by managing cattle dung, variety of biodegradable materials, human and garbage waste and weeds. There is a policy to provide additional subsidy amount for biogas installation at community level. Besides this the biogas users, especially in remote areas that are not connected by motorabel roads, are liable to receive extra subsidy besides as transportation. The provided subsidy amount on various sectors is shown by the table 4.4.

Table 4.4: General and Additional Subsidy Rate on Biogas Installation

S.N	Location for disbursing subsidies districts	General Subsidy rate Rs/plant		Additional subsidy rate for			
		$8m^3$ plant	2,4,6m^3/p	Poor, Dalit, Janajati, Utpidit conflict effected people 4,6,8m^3	Institutional biogas plants 4,6,8	Community biogas installation at required size more than 15 m^3 or $3m^3$/p/HH	Transportation in remote and non motorable remote
1	20 Terai districts as fixed by GON	9000	9700	2000	8000	6000	0
2	40 Hills districts as fixed by GON	12000	12700	2500	12000	9000	
3	15 remote districts not connected by motorable road as fixed by GON	16000	16700	3500	16000	12000	2000(Only 12 remote Districts)
4	Additional subsidy for low penetration districts as fixed by GON	700	0		0	0	0
5	Additional subsidy to encourage small farmers (beneficiaries)	700	0		0	0	0

Source: Renewable Energy Subsidy Management, AEPC, 2074.

4.2.2 Uniformity of Current Subsidy Policy on Biogas Installation

The Subsidy amount provided by government in three different regions (20 Terai, 40 Hills and 15 Remote Districts) is playing significance role for biogas plant installation. But, there is vast different in amount for per plant installation in three different regions (Table 4.4.) The table bellow describes the uniformity and consistency of subsidy amount on biogas installation in different regions using coefficient of variation methods.

Table 4.5: Uniformity of Subsidy Amount on Biogas Installation

Year	One Terai District in average		One Hill District in average	
	Amount (X)	$(X-\overline{X})^2$	Amount (Y)	$(Y-\overline{Y})^2$
2007	3.6	12.96	3.1	9.61
2008	3.5	12.25	2.6	6.76
2009	3.4	11.56	2.7	7.46
2010	2.6	6.76	1.7	2.86
2011	4.7	22.09	2.3	5.29
2012	4.4	19.36	3.9	15.26
2013	4.6	21.16	2.1	4.41
2014	4.1	16.81	1.9	3.61
2015	4.9	24.01	2.7	7.29
2016	4.7	22.09	3.3	10.89
2017	4.2	17.64	3.4	11.56
N = 11	$\overline{X}$ = 4.06 |∃x = 0.70 C.V. = 17.27%		$\overline{Y}$ = 2.7 |∃y = 0.65 C.V. = 24.67%	

Source: Table 4.4 and BSP Yearly Book, 2017.

The table 4.5 reveals the uniformity and consistency of government subsidy amount on biogas plants installation in Terai and Hills district neglecting 15 remote districts. From the above table CV of Hill District is 24.67 percent and CV of Terai District is 17.27percent (In average) i.e. CV of 40 Hills District is greater than the 20 Terai District. So the distribution of government subsidy amount on 20 Terai District has greater variability than in Hill Districts. The Subsidy amount on biogas plant installation in Terai District is more uniformity and consistency than in Hills District because 17.27 percent < 24.67 percent.

4.3 Trend of Installed Biogas Plants

The table 4.6 describes the trend of total biogas plants installation in Nepal since 2001/02 to 2016/17. The trend value is calculated by using least square methods which provides more accurate trend of biogas installation in Nepal during the different years shown in the table 4.6.

Table 4.6: Trend Value of Total Installed Biogas Plants Using Least Square Method

Fiscal years	Total installed biogas plants (actual values)	Trend values
2001/02	7157	7120
2002/03	8387	8227
2003/04	9869	9334
2004/05	11052	10440
2005/06	13265	11547
2006/07	17857	12654
2007/08	15527	13760
2008/09	16340	14867
2009/10	11259	15974
2010/11	17803	17081
2011/12	16118	18187
2012/13	17663	19294
2013/14	14884	20401
2014/15	19479	21507
2015/16	21158	22614
2016/17	20056	23721

Source: Appendix-I.

Y = |ℑ+ ℘T

Y = 14867.21 + 1106.71 (T)

If T = 2018 (i.e. n = 10) then Y = 25934

If T = 2024 (i.e. n = 16) then Y = 32574 (Source: Appendix-I).

The trend line of biogas installation since 2001/02 to 2016/17 is given by the linear equation Y=14867.12+1106.71 (T). This line indicates that the installed biogas plants in Nepal increased approximately by 1106 per year. During the years 2001/02 to 2016/17 the trend value is increasing year after year by 14867. Using this technique we can predict the future trend of installation of biogas plants in Nepal. From the above table total installation biogas plants in 2018 and 2024 are expected to be 25934 and 32574 respectively.

The trend and actual value of total installed biogas plants in Nepal is shown by the following figure:

Figure 4.1: Trend and Actual Value of Total Installed Biogas Plants Since 2001/02-2016/17

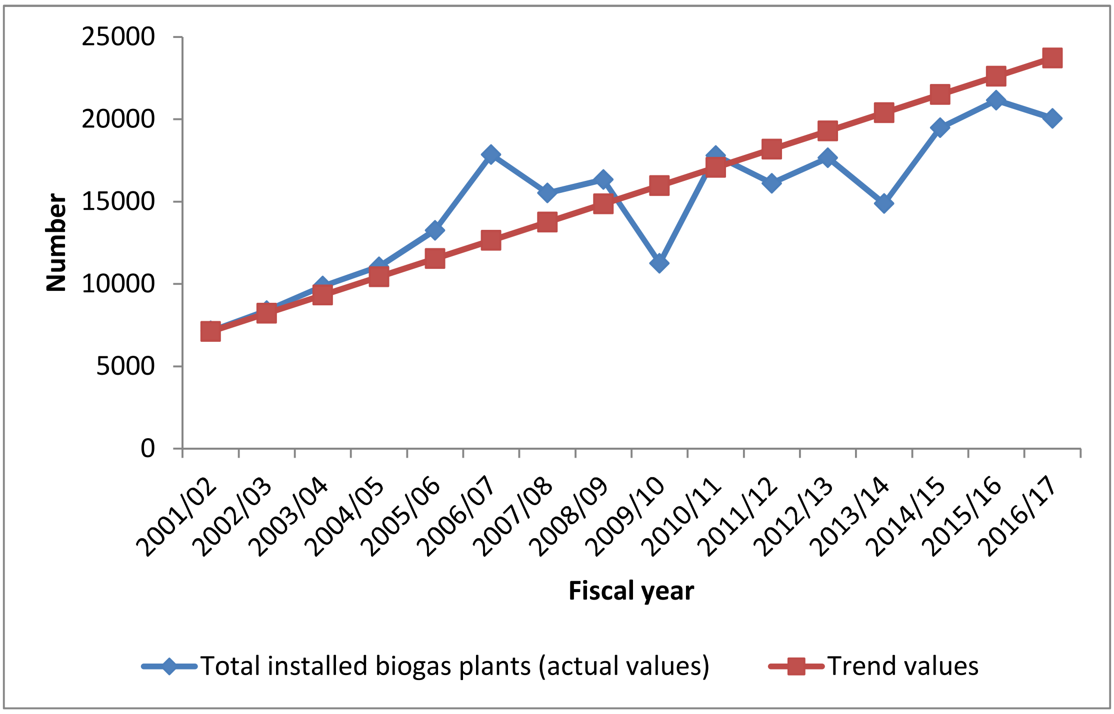

Figure 4.1 shows the actual and trend value of biogas plant since 2001//02 to 2016/17. However it is increased every year by 1106.71 but actual biogas plant installation is decreased in highly fluctuating trend. This shows the biogas plants installation is increased in cumulative trend. There may be at least three reasons: (a) modern form of energy sources like Lp gas, solar, micro-hydro have been developed (substitute effect), (b) construction cost related to biogas installation is increasing at the rate of about 11percent (NRB, 2017) subsidy amount is increasing at nominal rate (income effect) and (c) expansion of rural electrification program (selection variables).

4.4 Socio-Economic Status of Biogas Users

In Nepalese context the final beneficiaries group after using the biogas energy are farmers and women who works on the Smokey kitchen. Especially the farmers of agricultural country are more benefited after using the multi advantages from biogas and they can boost up their socio-economic conditions.

4.4.1 Biogas Users According to Ethnicity and Occupation

Form the beginning, different ethnic group of people and the people who are involved in the different types of occupation are also more positive for the installation of biogas plants in Nepal which is shown by the following table 4.7.

Table 4.7: Biogas Users According to Ethnicity and Occupation

S.N	Ethnic group	Total user (in%)	Professions	Total users (in %)
1	Bhramins	40.4	Agriculture	68.2
2	Chhetris	27.0	Employee/service holders	17.9
3	Newar	7.2	Businessmen	8.2
4	Tamang	4.4	Overseas employee	5.8
5	Tharu	4.2	Manufactures	0.8
6	Rai	3.4	-	-
7	Limbu	3.4	-	-
8	Dalits	10.0	-	-

Source: BSP Year Book, 2017.

According to table 4.7, Bhramins and Chhetris consists 47.4percent and 27percent on biogas plant installation while Newar ranks third by 7.2percent. Other ethnical users are Tamang (4.4%), Tharu (4.2%), Rai (3.4%), Limbu (3.4%), while marginalized groups and Dalits hold 10% of total installation plants. According to occupationwise distribution of biogas users, the people who are involved in agriculture sector are highest i.e. 68.2percent whereas least in manufacturing sector.

4.4.2 Biogas Users According to Literacy Status

In Nepal 83.1percent of people who have access towards formal education are involved in biogas installation. The literacy rate of the family members of biogas holders is shown in the following table 4.8.

Table 4.8: Literacy Status of Biogas Users

S.N	Literacy level	Male (%)	Female (%)	Both (%)
1	Illiterate	8.0	24.8	16.4
2	Literate (Class 1 to 10)	50.7	47.7	59.8
5	S.L.C.	29.0	22.7	25.9
6	Above S.L.C.	22.7	15.3	19.0

Source: BSP Year Book, 2017.

4.5 Economic Benefits of Biogas Energy: Findings from an opinion Survey

Socio-economic profile

4.5.1 Workload Reduction and Utilization of Save Time

Biogas is a promising technology and decentralized energy sources which can help to meet energy demand of rural and urban people. Women in rural areas of Nepal are confronted with a high workload. They not only work inside the house but also go far away to collect fuelwood and fodder. Besides carrying out almost all domestic works, they are also involved in the major part of agricultural activities in their field. Although women are involved from the very beginning in the extension program of biogas, they would be able to oversee all the consequences better. They are more familiar about the advantages and disadvantages of biogas use. The use of biogas in rural areas has reduced the work load and devoted time for such households activities. The field survey held on 2016/17 shows the time allocation before and after the biogas installation is shown by the table 4.9.

Table 4.9: Time Allocation Before and After Biogas Installation

(In minutes per day)

S.N	Activities	Before biogas use	After bio-gas use	Time saving
1	Livestock carrying	40	70	-30
2	Fetching water	50	70	-20
3	Plant feeding	20	50	-30
4	Firewood collection/Dung cake preparation	180	40	140
5	Fodder collection	30	50	-20
6	Cooking	120	40	80
7	Cleaning utensils	70	30	40
	Total time (minutes)	510	350	160

Source: Field Survey, 2016/17.

The table 4.9 reveals that people are able to save 160 minutes i.e. two hour 40 minutes per day after biogas installation. After the biogas installation, the allocation of time for livestock carrying, fetching water, plant feeding and fodder collection is increased but firewood collection, cooking and cleaning utensils is decreased. If we take the average value, we can conclude that nearly 2.5 hours per day is saved due to installation of bio-gas.

Biogas is a new energy production system which does not affect the traditional working patterns. It is time saving technology which does not automatically imply the workload reduction. However different activities are done by family members after the use of biogas who are involved on various sectors. The utilization of saved time on adult education 4.1percent, recreation 42.6percent, social work 22.4percent, income generating activities 26.8percent and others activities 32.1percent of total saved time 2.5 hours/day has positive economic impact on society. Besides these activities a new pattern of time utilization has also been developed among the rural women. After the use of biogas, they have more time to care their children (i.e. 51percent before but 94percent after) and elder people of the family use their time to maintain cleanliness (i.e. 94percent against 57.5percent before biogas use, field survey, 2016/17).

According to t-test hypothesis there is significant difference in the time saving before and after the biogas installation because calculated t-value 0.909 is smaller than tabulated t-value i.e. 2.179 in 0.05 level of significance, t-test suggested that time saving before and after biogas installation is significantly different (See appendix-II).

If the saved time is converted to the total employment sectors, a labour can earn Rs 25.84/per house/months (MOF, GON 2074) and total earning on total saved time is Rs 64.58/day and Rs 1937.50/months and Rs 23250/year/plant. The total earning under biogas installation and its percentage comparison to the total GDP of same years is shown by the following table 4.10.

Table 4.10: Total Earning Under Biogas Plant Installation (Since 2001/02 to 2016/17)

Fiscal years	Total installed biogas plants	Total earning (Rs in million)	Total GDP (Rs in million)	Earning as % of GDP
2001/02	7157	167	239388	0.070
2002/03	8387	195	269570	0.072
2003/04	9869	230	289798	0.079
2004/05	11052	257	330018	0.078
2005/06	13265	309	366251	0.084
2006/07	17857	415	441519	0.094
2007/08	15527	361	459443	0.078
2008/09	16340	380	492231	0.077
2009/10	11259	269	546749	0.050
2010/11	17803	414	589412	0.070
2011/12	16118	375	654084	0.057
2012/13	17663	411	727827	0.056
2013/14	14884	346	815658	0.042
2014/15	19479	453	988053	0.046
2015/16	21158	492	1171905	0.042
2016/17	20056	466	1346816	0.035

Source: BSP Yearly Book 2015, Economic Survey, 2014.

The table 4.10 reveals the average earning from biogas plants installation and its percentage relation to GDP in corresponding years. In the year 2001/02 the earning ratio form biogas to the GDP was 0.070percent but in the year 2006/07 it was 0.094percent. The earning ratio percentage decreased in 2008/09 and became 0.050 percent. After the year 2010/11 the ratio was deceased by 0.057percent and at the end of 2014/15 and 2016/17 it became 0.046percent and 0.035percent respectively. On the one hand, biogas plants installation has been increasing in fluctuation trend and on the other hand GDP has been increasing, this shows the reverse relationship between GDP and earning from bio-gas installation.

4.5.2 Contribution on Employment

Both skilled and unskilled labours are required for the construction of biogas. The contribution of female on biogas installation programme is more limited as unskilled labour, But to manage the plants both male and female are involved. At present 52.3percent male and 47.7percent female are directly or indirectly involved on the biogas plant construction activities.

The "BSP yearly book 2017" published by BSP/Nepal has found that, out of total installed 242989 biogas plants 13000 persons were employed directly or indirectly. The result shows nearly 0.054 persons (in average) are employed under per plant. The employee trend is directly increasing to the biogas plant installation. If the above result is compared to the total biogas plants installation in national level, the biogas generation programme is being increased by about 15percent in annual basis (WECS 2017). The total employment provided by biogas sectors and its increasing trend to the total number of employee on 12 governmental industrial status is shown by the table 4.11.

Table 4.11: Total Employment Provided by Biogas Energy (2007/08 to 2016/17)

Fiscal years	Total installed biogas plants	Total number of employee under biogas	Total number of employee on 12 industrial states	Employment provided by biogas in % comparison to 12 industrial states
2007/08	15527	838	14587	5.74
2008/09	16340	882	14273	6.18
2009/10	11259	608	14976	4.05
2010/11	17803	961	14122	6.80
2011/12	1611	870	14178	6.13
2012/13	17663	954	13537	7.04
2013/14	14884	804	13526	5.94
2014/15	19479	1052	13500	7.79
2015/16	21158	1143	12582	9.08
2016/17	20056	1083	13583	8.60

Source: BSP Yearly Book 2017, Economic Survey, 2016.

The table 4.11 describes the employment provided by biogas energy and 12 governmental industries. In the year 2007/08 the employment ratio provided by biogas energy to the comparison of industrial states was 5.74percent and in the year 2009/10 it was 4.05 percent. But in the year 2012/13 the employment percentage ratio was 7.04 percent and in the years 2015/16 and 2016/17 it was 9.08 percent and 8.60 percent respectively.

4.5.3 Contribution on Investment

Investment is the backbone of the economy which plays the significant role in economic development. The investment towards biogas energy installation is a major one which has been able to collect investment from the government (as subsidy amount), private and local sectors. At present the invested amount for a biogas plant installation is Rs 25000/plant (BSP, 2017). The result obtained after comparing the above fact with national economy can be expressed in detail with the help of following table. The table 4.12 describes the relationship between the total investment by government on twelve industrial states and biogas installation programme since the years 2007/08 to 2016/17.

Table 4.12: Investment Impact of Biogas Energy (Since 2007/08 to 2016/17)

Fiscal years	Total installation biogas plants	Total investment on biogas (Rs in million)	Total investment by government on 12 industrial states (Rs in million)	Investment % on biogas as compared to 12 industrial states
2007/08	15527	388	5917	6.55
2008/09	16340	409	7382	5.54
2009/10	11259	282	7674	3.67
2010/11	17803	445	8498	5.23
2011/12	16118	403	8495	4.74
2012/13	17663	442	8488	5.20
2013/14	14884	372	8483	4.38
2014/15	19479	487	10018	4.86
2015/16	21158	529	18310	2.88
2016/17	20056	502	18489	2.71

Source: BSP Yearly Book 2017, Economic Survey, 2016.

The table 4.12 describes the total investment on biogas sector and 12 governmental industrial states since 2007/08 to 2016/17. In the year 2007/08 the investment in biogas energy was 6.55percent of the total investment invested in 12 governmental industrial states. The percentage ratio decreased in 2009/10 and was 3.67percent similarly the investment ratio on biogas energy in the comparison of industrial states in 2014/15, 2015/16 and 2016/17 was 4.38 percent, 2.88 percent and 2.71 percent respectively.

4.5.4 Contribution on Production

Agriculture has multilateral linkage with household government, industry, livelihood and employment despite a primary sector. At present its contribution on GDP is 38percent, employment creation 76percent, food crops 80percent, cash crops 20percent, share in export 50percent and providing raw materials to industries 50percent. Although agriculture has various contributions to national economy, and fertilizer is its basic component and Nepalese people are dependent on other countries for its fulfillment. On that context the bio-compost produced from biogas may be the supplementary factors. Government of Nepal had conducted a preliminary field trial with wet biogas effluent in some crops and vegetables under ministry of agriculture, soil science and agriculture chemistry division department, to find the effect of bio-compost on production as compare to before. Following table 4.13 reveals the contribution of bio-slurry on growth of various crops and its economic contribution in the national economy.

Table 4.13: Average Contribution of Bio-Compost on Various Crops Production

Types of crops and vegetables	Crops & veg. Production (In %)		Increment in production (In %)
	Without bio-slurry	With bio-slurry	
Rice	2.7	3.0	10.0
Tomato	15.0	17.8	15.7
Cauliflower	4.6	5.6	17.8
French been	0.3	1.0	70.0
Maize	2.8	3.5	10
Mushroom	NA	NA	30
Other Green leaps vegetables	NA	NA	50

Source: Biogas Newsletter.

The table 4.13 describes the highly increment on the various agriculture products in which the increment on rice 10percent, tomato 15.7percent, cauliflower 17.8percent, and French been 70percent after the use of bio compost which can meet the demand of such product. Besides these products, the contribution of bio-compost on tea-production, coffee production and horticulture production is also remarkable.

4.5.5 Contribution on Various Resources Savings (LP Gas, Electricity, Kerosene, Fuel-wood, Chemical Fertilizer)

Biogas energy is one of the most important sources of renewable energy. Out of 401 million GJ energy consumed in the year 2014/15 the share of biogas energy was 0.64percent. The production of biogas is the supportive factors of Nepalese economy. It is used for cooking instead of fuelwood, animal dung, LP gas and kerosene. And used for lighting instead of electricity and kerosene. The bio-compost produced by biogas can be used on agriculture sector instead of chemical fertilizer. When the product of biogas is increased the demand of other forms of energy will decrease and vice-versa.

According to the survey held by AEPC, BSP and WECS in 2013/14 and 2016 the annual saving on various resources due to use of biogas energy is shown by the following table (in approximately) and the current price is listed.

Table 4.14: Average Contribution of Biogas and Current Price of Various Resources

S.N	Various resources	Average contribution by 6m^3 plants	Current cost/rate
1	Fuelwood	2 tons/ year	Rs 2/kg
2	Kerosene	25 l/ year	Rs 76/lt
3	LP gas	0.5 cylinder/ month	Rs 1325/cylinder
4	Electricity	4 unit/month	Rs 7.30/unit
5	Chemical fertilizer	31.5 kg/year	Rs 23.50/kg
6	Health cost reduction	Rs. 6000/year (see app. V)	

Source: BSP, WECS 2016, 2017, Field Survey, 2018.

The result obtained after comparing the above fact with national economy, can be expressed in detail with the help of following table 4.15.

Table 4.15: Economic Impact of Biogas Energy on Various Resources Saving

Fiscal years	Total installation plants	Saving (Rs. in million)							
		Fuel wood		Kerosene	LP Gas	Electricity	Chemical fertilizer	Health cost reduction	Total Saving
2001/02	7157	Rs.	28.68	13.6	56.9	2.51	5.3	42.94	149.88
		%	19.14	9.07	37.96	1.67	3.54	28.65	100
2002/03	8387	Rs.	33.54	15.94	66.68	2.94	6.2	50.32	175.62
		%	19.10	9.08	37.97	1.67	3.53	28.65	100
2003/04	9869	Rs.	39.48	18.75	78.44	3.46	7.3	59.21	206.64
		%	19.11	9.07	37.96	1.67	3.53	28.65	100
2004/05	11052	Rs.	44.21	21	87.86	3.87	8.18	66.31	232.06
		%	19.05	9.05	37.86	1.67	3.52	28.57	100
2005/06	13265	Rs.	53.06	25.2	105.46	4.65	9.82	79.59	277.78
		%	19.10	9.07	37.96	1.67	3.54	28.65	100
2006/07	17857	Rs.	71.43	33.93	141.96	6.26	13.23	107.12	373.93
		%	19.10	9.07	37.96	1.67	3.54	28.65	100
2007/08	15527	Rs.	62.11	29.5	123.44	5.44	11.49	93.16	325.14
		%	19.10	9.07	37.97	1.67	3.53	28.65	100
2008/09	16340	Rs.	65.36	31.05	129.9	5.73	12.09	98.04	342.17
		%	19.10	9.07	37.96	1.67	3.53	28.65	100
2009/10	11259	Rs.	45.04	21.39	89.5	3.95	8.34	67.55	235.77
		%	19.10	9.07	37.96	1.68	3.54	28.65	100
2010/11	17803	Rs.	71.21	33.83	141.54	6.29	13.18	106.82	372.87
		%	19.10	9.07	37.96	1.69	3.53	28.65	100
2011/12	16118	Rs.	64.48	30.62	128.19	5.65	11.93	96.7	337.57
		%	19.10	9.07	37.97	1.67	3.53	28.65	100
2012/13	17663	Rs.	70.65	33.56	140.42	6.19	13.07	105.98	369.87
		%	19.10	9.07	37.96	1.67	3.53	28.65	100
2013/14	14884	Rs.	59.54	28.28	118.32	5.22	11.02	89.3	311.68
		%	19.10	9.07	37.96	1.67	3.54	28.65	100
2014/15	19479	Rs.	77.92	37.01	154.86	6.83	14.42	116.87	407.9
		%	19.10	9.07	37.96	1.67	3.54	28.65	100
2015/16	21158	Rs.	84.63	40.2	168.2	7.42	15.66	126.94	443.05
		%	19.10	9.07	37.96	1.67	3.53	28.65	100
2016/17	20056	Rs.	80.25	37.17	159.45	7.03	14.84	120.34	420.08
		%	19.10	8.85	37.96	1.67	3.53	28.65	100

Source: Table No. 4.14 and BSP Year Book, 2017.

Table 4.15 shows the impact of biogas energy on resources (fuelwood, kerosene, LP gas, electricity chemical fertilizer, and health cost reduction) saving. All the resources have been saved in increasing trend i.e. fuelwood saving is Rs. 28.68 million in FY 2001/02 while it is increased to Rs. 80.25 million, kerosene is Rs. 26.68 million in FY 2002/03 while it is Rs. 37.17 million in FY 2016/17, LP gas saving is Rs. 56.9 million in FY 2001/02 while it is 159.45 million in FY 2016/17, electricity is Rs. 2.51 million in FY 2001/02 while it is Rs. 7.03 million in FY 2016/17. Likewise, chemical fertilizer is Rs. 5.3 million in FY 2001/02 while it is Rs. 14.84 million in FY 2016/17. Similarly, health cost reduction is Rs. 42.94 million in FY 2001/02 while it is Rs. 120.34 million in FY 2016/17. However, the cost saving on resources have been increasing in fluctuating trend. From the above table it can be said that LP gas saving is maximum among all the resources mentioned and chemical fertilizer is least.

4.5.6 Contribution on Health and Sanitation Sectors

Most important concern factors of the people are health and sanitation. In rural households the main cause of health problems is indoor air pollution which is produced from the use of fuel wood and kerosene. The other important factor of health problem is contamination due to unmanaged facials wastes that harbor various kinds of pathogenic germs leading to water borne diseases.

4.5.6.1 Status of Latrine Connection

After the connection of human excreta on biogas plants, the production level of gas is very high which motivates the owner to connect their toilet on biogas plants. The table 4.16 describes the installation of latrine before and after use of biogas.

Table 4.16: Status of Latrine Connection Before/After Use of Biogas

S.N	Activities	Households (in%)	
		With latrine	Without latrine
1	Before biogas use	58	42
2	After biogas use	97	3

Source: Field Survey, 2018.

The table 4.16 reveals that there is significant difference between the two study groups. Only 58percent households had latrine before biogas use and it increased to 97percent after the use of biogas. Similarly the households without latrine also decreased form 42percent to 3percent after biogas installation.

CHAPTER - V

SUMMARY, FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

Renewable energy is one of the most essential components for human development as well as rapid economic growth. Nepal has various sources of energy production but it has been facing problems of energy crisis from beginning. At present context, the development of biogas energy may be one of the fulfilling factors of energy problem and it may replace the dependency ratio on traditional and commercial energy sources. The present study shows that the per-capita income of people and energy access ratio are interdependent with each other i.e. lesser the per capital income less the energy access ratio and vice-versa.

The energy efficiency ratio of any country depends upon its GDP and total energy produced in the same year. The annual product of energy growth indicates the rapid growth of national income and employment as well as per capital income level. The structure of energy composition of Nepal indicates the combination of various energy sources, among which traditional energy sources play the dominant role. But the share of biogas energy was 0.81percent in total energy consumption which is increasing by 13.13percent in 2016/17 in comparison of 2015/16. In Nepalese society the cheap energy source is biogas which indicates the availability of local resources, labours and simple technology.

Biogas energy is used for cooking and lighting instead of LP gas, kerosene, electricity and fuel wood. It directly helps to decrease the high expenditure on fuels. The present scenario of expenditure towards kerosene and LP gas import is rapidly increasing in Nepal. So the biogas energy which can be used for cooking and lighting instead of kerosene and LP gas may be supplementary energy sources. It helps to reduce the dependency ratio on forest for traditional energy source and to conserve the forest resource.

The dung which is a raw material for biogas energy is easily available in our country. Although Bhramins and Chhetri have been playing the dominant role in biogas plants installation, the participation of other ethnic group on different sectors of the country is remarkable. In Terai region, the potentiality of biogas production is very high in comparison of Hills and mountain regions. There is high economic efficiency of establishing biogas plants which benefits the people of different ethnic group on different areas of the country. The subsidy policy on biogas production provided by government under AEPC has been playing important role for establishing biogas plants and have highly motivated the people of marginal level, mountain region and remote area towards the installation of biogas plants.

All types of people i.e. highly educated, partially educated and literate as well as illiterate are more interested towards the installation of biogas plants. The people holding different types of occupations such as farming, business, service and foreign employee are also interested towards its installation. This indicates that the concept of plants installation is increasing. The people who do not have their own land and capital are more interested towards its implementation. The role of women on conduct and management of biogas energy is also remarkable. Similarly due to increasement in use of biogas energy, the level of people suffering form various water borne diseases, smoke borne diseases and indoor air pollution is decreasing.

Fertilizer plays the significant role on increasing agriculture products. Nepal is fully depending on third country for its fulfillment of chemical fertilizer. But after the biogas installation, the bio-compost and slurry produced by biogas are the substitute factors of chemical fertilizer. In twenty first century the demand of organic product is highly increasing. The production levels of various crops are also increasing due to use of biog-compost.

The utilization of leisure time after the biogas installation is remarkable. The average saving time 2.5 hours daily is used on the various sectors such as education of child, reading newspapers, involving on entertainment and social works, income generating activities and the level of local employment has increasing . After the establishment of BSP/Nepal, the trend of installing biogas plants has tremendously increased. When the AEPC was established under the ministry of science and technology the subsidy management policy is more effective towards biogas plant installation. The additional subsidy policy has played significant role in establishing biogas plants on community based and remote areas of the country. Among the various size of biogas plants installation, the model size of plant is $6m^3$ and the trend of installation $4m^3$, $6m^3$ and $8m^3$ is increasing but $10m^3$, $15m^3$ and $20m^3$ are decreasing.

When toilets are connected on the biogas plants, the management of sanitary system of plant holders is increasing by 97percent and has decreasing its mismanagement. Due to various benefits of biogas energy, the people of urban and town are also interested on it. It also helps to increase quality of family and life of people.

In the beginning agriculture development bank was the main institution to provide loan on the establishment of biogas energy and the process is followed by the various financial institutions such as commercial banks, development banks, finance companies, co-operatives, INGOs and NGOs.

The systematic biogas plant installation was started after eighth five years plan and the trend of biogas plants installation on ninth, tenth and three years interim plan was positive. After 1992, the private companies were involved on biogas plant installation. At the end of August 2014, 95percent plants are economically benefited and they are producing energy equivalent to 443 MW electricity out of 241920 biogas plants. Among the total installed plants, it is found that 56.2percent HH are fully satisfied 36.6percent are moderate and 7.2percent are not satisfied. The above data shows that there is high satisfaction of people towards biogas energy consumption.

5.2 Findings

The main objectives of the present study is to detect the benefit of biogas energy on various sectors of the economy. In agriculture country like Nepal, the major finding of the study are as follows:

Energy efficiency is the ratio of total GDP and total energy produces in the same year. There is positive relation between the income growth level and energy consumption level. If there is positive incensement on GDP and energy consumption level, the energy efficiency level increase positively. In the year 2001/02 the energy efficiency of Nepal was 1.22percent and in the year 2005/06 it was 0.095percent. After the 10 years in 2011/12 it was 0.057percent which shows that energy produced was not accordant to the level of GDP produced. Similarly in the year 2013/14, 2014/15 and

2016/17 it was 0.047percent, 0.040percent and 0.031percent which show the decreasing trend of energy efficiency in Nepalese economy.

Energy consumption level determines the development level of any country. In Nepal, the growth level of energy produced increased by 3.55percent in the year 2007/08 and 2.60percent in the year 2006/07. But it was 3.12percent in the year 2014/15. In the year 2015/16 energy consumption level raised by 5.5percent as compared to 2014/15 but in the same year the GDP increased by 4.5percent. It shows that energy consumption level is higher than GDP growth level on the same period.

In the energy structure patterns of Nepal, the share of traditional, commercial and renewable energy is 83.percent, 15.6percent and 0.7percent respectively. The consumption level of such energy is increasing by 1.22percent, 6.32percent and 13.5percent. At present biogas energy is playing the significance role on renewable energy development process and the average developing trend of biogas energy is 20.13percent and solar energy is 33.34percent. The share of biogas energy on energy consumption was 0.141percent in 2001/02 but it was 0.58percent in 2011/12 and 0.81percent in 2016/17.

After the establishment of AEPC and BSP/N, the trend of biogas plants installation was increased by 17.19percent in the year 2002/03 in the comparison of previous years. In 2005/06 the trend increased by 34.62percent but in 2007/08 it decreased by 31.09percent. Similarly in the year 2009/10 installation trend increased by 58.13percent and in the year 2014/15 increased by 30.87percent. Although the trend increased by 8.62percent at the end of 2015/16 and it was decreased by 5.21percent in the year 2016/17. At the end of 2016/17 the total number of installed biogas were 240991 from 2001/02 and 241920 from its beginning.

The new subsidy policy on biogas energy development programme was managed under AEPC in 2014/15. The subsidy amount provided by government was 25percent less in Terai districts in the comparison of hills districts and 33.34percent more in remote districts which are not connected by moterable roads. The additional subsidy amount to encourage small farmers in Terai, hills and remote districts is more by 7.78percent, 5.83percent and 4.38percent in comparison to the total subsidy amount. Similarly the additional subsidy for poor, Dalit, Janajati, Utpidit and conflict affected people for Terai, hills and remote districts is more by 22.23percent, 20.84percent and 21.88percent respectively. The provided subsidy increases the rate of installing biogas plants by 30.87percent in comparison to previous years which shows the positive relation of subsidy amount as biogas plants installation.

Among the different ethnic group, Brhamins and Chhetries have been playing dominant role by covering 67percent in total plants installation programme. The share of other ethnic group indicates the less participation but they are also positive towards biogas installation. The occupational share of agricultural holders is 68.2percent and manufactures group is only 0.8 percent shows the high range between two groups. The role of illiterate female on plant installation is 16.8percent more in the comparison of male of same group. But 7.4percent more literate male are involved in plant installation compared to female of same group. The fully satisfied group are 19.6percent more than moderate group but not satisfied group are 29.4percent less than that group of people.

The time saving aspects of biogas users is positively related to the welfare economy. Utilization of saved time 2.5 hours daily contributes to the socio-economic earning in the society. The contribution of saved time on education is 4.1percent, reading newspapers is 46.1percent, social work is 22.4percent and income generating activities is 26.8percent shows the positive socio-economic activities on the society.

At present context of Nepal, the level of employment provided by biogas energy in the year 2002/03 was 18.27percent more than previous years. But level of employment provided by biogas energy decreased by 13.1percent in the year 2007/08 but on the same year the employment provided by biogas was 5.74percent less in the comparison of employment provided by 12 governmental industrial states. In the year 2009/10 it was 4.05percent and 7.04percent was in the year 2012/13, Comparison an employment provided by biogas and 12 governmental industrial states was 7.79percent, 9.08percent and 8.60percent in the years 2014/15, 2015/16 and 2016/17 respectively.

After saving health expenses Rs 6000/plant/HH/per year and 97percent household connected their toilets on the biogas plants, the status of health economic sectors are positively increased. Similarly various smoke borne diseases decreased by

31.7percent on women, men and children. The problems of respiratory diseases decreased on same group by 17.57percent in average. The decreased on incidence of cough and diarrhea episodes on the same group was 27.44percent and 5.64percent in average. The effects on dysentery and parasitic infection is also decreased by 4.44percent and 4.24percent in average The decreased results on headache and fire related accidents on the same group is 30.5percent and 8.9percent in average.

More biogas plants installation indicates more production of bio-compost which has positive relation on agriculture product and national savings. The increment on various agriculture product by 24.7percent (in average) indicates the more production on GDP. Similarly Rs 25000/plant investment indicates the large volume of investment on energy sectors which creates the employment and savings. The total investment by government on 12 industrial states and biogas energy was 6.55percent in the year 2007/08 and 4.74percent in the 2011/12. Similarly investment percent ratio on biogas to 12 industrial states was 2.88percent in the 2014/15 and 2.71percent in the year 2016/17.

There is negative relation between biogas installation and the use of various energy resources and increasing health cost. But due to negative effect of biogas on such sectors, high volume of national expenditure is saved. In the year 2001/02 the saving percent of such resources to GDP was 0.062percent but in the year 2007/08 it was 0.070percent similarly in the year 2010/11 it was 0.063percent and in the year 2013/14 was 0.038percent while in the year 2016/17 was 0.031percent.

Finally the main implementing agencies on the development of biogas energy are AEPC (govt. of Nepal), SNV (govt. of Netherlands), KFW (govt. of Germany), the World Bank, European Union including BSP/Nepal as principal implementing agency.

5.3 Conclusion

The study on economic benefit and trend of biogas energy since 2001/02 to 2016/17 shows that it is one of the most important renewable energy sources and the share of biogas in total energy consumption is in increasing trend. The development of biogas is the supplementary factor for poverty reduction, income generation, to increase employment level and investment, reduction on health problems and cost, including saving on various resources. During the beginning of biogas installation programme rapidly started and nearly 11,000 gas plants were installed before the establishment of BSP/N in 1993/94. In the year 1993/94 the installation programme increased by 8.9percent and in the year 2007/08 it decreased by 13.04percent due to various reasons. But in the year 2010/11 it increased by 58.13percent and in the year 2016/17 the programme decreased by 5.21percent in the comparison of previous years. According to WECS 2017, biogas production potential in hills of WDR was 69.18percent, mountain of FWDR 22.92percent and in terai of EDR was 51.02percent of total production. Similarly at the end of August 2017, 2.4192 millions of biogas plants with varying capacities have been installed and equivalent to annual production of total thermal power 443 MW. Due to more gas production in low level of cost as well as subsidy amount $6m^3$ size of plant is a model plant. At present the installed biogas plants increased by 1106 plants per year and the trend value is increasing year after year by 14,867 plants.

Different ethnic groups, literacy level of people and occupation holders are also involved towards biogas installation. Saving time i.e. 2.5 hours a day under different activities and the use of saving time on various sectors have positive economic impact on society. The contribution of biogas installation programme as employment, investment as well as agriculture production and various resources saving has positive impact. The average increased cost on various smoke-borne and water borne diseases by 2.5percent before plant installation decreased by 7.9percent on women, men and children of plant owner household saving Rs. 6000 per year. After saving 2,82,024 tons of fuelwood and (63-69)percent of total plants are connected with toilet, healthy environment is created.

At the end of August 2015, the total installed biogas plants 2,62,929 have contributed 0.81percent of total energy consumption of same years and the programme is being supplementary factors to fulfill the 15percent energy demand every years. The investment Rs. 25,000 per plant and employment generated 0.54 person per plant is also positive factor. It would be better to participate all when the rate of subsidy amount is increased sectors of people toward the installation programme. From the study, it seems that biogas energy has become necessary to broaden the Nepalese energy system which helps to meet the energy demand, increase healthy environment and reduce the poverty level by various methods and helps to change of burning dungs into bio-compost.

5.4 Recommendations

On the basis of finding of the present study the followings specific suggestions have been recommended for a source and effective development of biogas plants installation.

- Biogas development center should be established with the objective of biogas energy development and providing economical, technological, vocational, practical educational including administrative services.
- Priority should be given on productive animals husbandry for multi-purpose so that both bio-compost and extra income through various animals products can be generated which might be the essential factors to reduce the poverty level.
- A nominal rate of invested subsidy amount should be returned by authorized agency (government) and reinvest for the development of other biogas plants specially for marginal and privileged groups.

REFERENCES

Abeygunawardana, S.M. (2005). *National Biogas Programme,* Biogas for better Life, SNV/Sri Lanka.

ADB/N (2003). *Rural Finance in Nepal*. Kathmandu: Agricultural Development Bank of Nepal.

Adhikari, K.G. (2007). *A Study on Socio-Economic Impact of Biogas Technology: A Case Study of Bakalauri VDC, Sunsari District.* Central Department of Economics. Tribhuvan University, Kritipur, Nepal.

Adhikari, S.R. (2010). *Writing a Thesis in Economics: A Practical Approach*. Kathmandu: New Hira Enterprises.

AEPC (2006). *Subsidy for Renewable (Rural) Energ*y. Kathmandu: Alternative Energy Promotion Center, Ministry of Environment, Science and Technology, GON.

AEPC (2017). *Management Information System.* Kathmandu: Alternative Energy Promotion Center, Ministry of Environment, Science and Technology, GON.

Akther, A.K. (2003). *Final Report on the Technical Study of Biogas Plants Installed in Pakistan*. Kathmandu: SNV.

Bajracharya, P.(2001). *Subsidy Scheme for Biogas Plant Souvenir Silver Jubliee Issue.* Kathmandu: Gobar Gas Tatha Krishi Yantra Bikas (P.) Ltd.

Basnet, D. (2067). *Prabhat: A Annual Report.* Kathmandu: Nepal Oil Corporation.

Boitin, T. (2013). Biogas Technology and Market status in China. *BIT 3rd Annual World Congres of Bioenergy*. Nanjing.

BSP (2017). *Biogas, As Renewable Source of Energy in Nepal, Theory and Development.* Lalitpur: Biogas Slurry Project Nepal.

BSP (2017). *Final Reports 2016/17*. Kathmandu: Biogas Slurry Project Nepal.

BSP (2017). *Management Information System of Biogas*. Lalitpur, Biogas Slurry Project Nepal.

BSP Yearly Book (2017). Lalitpur: Biogas Slurry Project Nepal.

Center for Energy Studies (2001). *A Study Report on Efficiency of Measurement of Biogas, Kerosene and LPG Stoves*. Lalitpur: Biogas Slurry Project, Nepal.

CMS (2015/16/17). *Biogas Users Survey*. Kathmandu: Alternative Energy Promotion Center.

Desai, V.A (1992). *Use and Consumption of Biogas*: New Delhi: Prentice Hall of India.

Dhungel, K.R. (2004). *Reading in Nepalese Economy*, New Delhi: Prentice Hall of India.

East Consult (P.) Ltd. (2000). *Final Report of BSP, Biogas Users Survey 2001/02.* Lalitpur: Biogas Slurry Development Nepal.

Kanel, N.R. (1999). *An Evaluation of BSP Subsidy Scheme for Biogas Plants. Final Report.* Lalitpur: Biogas Slurry Development Nepal.

Kothari, C.R. (1990). *Research Methodology: Methods and Techniques*. New Delhi: Wishwa Prakashan.

Kumar, A. (2003). *Biogas Technology in India*. New Delhi: Prentice Hall of India.

Lamsal, P.R. (2001). *Souvenir, Silver Jubliee Gobas Gas Tatha Krishi Ynatra*. Kathmandu: Vikash (P.) Ltd.

Malla, M.B. (2013). *Revisiting the Need of Improved Stoves: Estimating Health, Time and Carbon Benefits,* SANDEE, Working Paper, No. 44-99.

MOF (2016/17). *Economic Survey*. Kathmandu: Ministry of Finance.

MoPE (2016). Renewable Energy Subsidy Policy- 2073BS. Kathmandu: Ministry of Population and Environment.

NBPG (2007). *Biogas Sector in Nepal: Highlighting Historical Heights and Present Status.* Kathmandu: Nature Palace Community Botanic Garden.

Panta, K.P. (2008). *Estimating Health Benefits When Behaviours are Endogenous: A Case of Indoor Air pollution in Rural Nepal,* SANDEE Working Paper, No. 34-80.

Pokhrel, R.K. (2007). *Application of Biogas Technology in Nepal: Problems and Prospects.* Lalitpur: International Center for Integrated Mountain Development.

Regmi, S.K. (2002). *Women's Empowerment Through Biogas: A Case Study of Vijaur VDC Puthan District*. Central Department of Economics. Tribhuvan University, Kritipur, Nepal.

Sathianathan, M.A. (1975). *Biogas Achievements and Challenges Association of Voluntary Agencies of Rural Development*. New Delhi: Prentice Hall of India.

Shrestha, M. (2003). *Role of Women in Implementation of Biogas in Nepal, Conference Secretariat of RETRUD*, 2003, Institution of Engineering, T.U.

SNV/BSP (2002). *An Integrated Environment Impact Assessment*. Kathmandu: Netherlands Development Organization.

Tripathi, A.K. (1993). *Biogas Slurry: A Boon for Agriculture Crops.* New Delhi: Biogas Slurry Utilization.

Vannes, W. J. (2008). *Brief Report on Asia Biogas Programme Progress*. New Delhi: Prentice Hall of India.

VanNes, W. J. (2008). *National Domestic Biogas and Manure Progrmame in Srilanka*. Kolombo: Raja Publication.

WECS (2017). *Energy Sector Synopsis Report 2017.* Kathmandu: Water and Energy Commission Secretariat.

YSD (2005). *Pathological Test of Bio-Slurry from Latrine Attached and Non-Attached Biogas Plants*. Kathmandu: Biogas Slurry Project.

APPENDICES

APPENDIX-I

TREND ANALYSIS OF TOTAL INSTALLED BIOGAS PLANT

Calculation of the trend of total installed biogas plant since 2001/02 to 2016/17

Year (T)	Total installed biogas plants (Y)	X=(T-2008)	X^2	XY	Y=|ℑ+℘T
2001/02	7157	-7	49	-50099	7120
2002/03	8587	-6	36	-50322	8227
2003/04	9869	-5	25	-49345	9334
2004/05	11052	-4	16	-44208	10440
2005/06	13265	-3	9	-39795	11547
2006/07	17857	-2	4	-35714	12654
2007/08	15527	-1	1	-15527	13760
2008/09	16340	0	0	0	14867
2009/10	11259	1	1	1125	15974
2010/11	17803	2	4	35606	17081
2011/12	16118	3	9	48354	18187
2012/13	17663	4	16	70652	19294
2013/14	14884	5	25	74420	20401
2014/15	19479	6	36	166874	21507
2015/16	21158	7	49	148106	22614
2016/17	20056	8	64	160448	23721
Total	ϕY=237874	ϕX=8	$\phi X^2=344$	ϕXY=380709	

Note: X represents the deviation of the year taken form 2001/02 and Y represents the annual installed biogas plants.

We have, the trend of straight line is given by the following formula.

Y=ℑ+℘T____________(i)

Where,

Y=Values of total installed biogas plants

ℑ=Constant

℘=Rate of change of total installed biogas plants

T=Years

n=Number of years

Now ~ X$\frac{\phi Y}{N} = \frac{237874}{16}$ = 14867.12

$\wp = \frac{\phi XY}{\phi X^{2}} = \frac{380709}{344}$ = 1106.71

Substituting the value of |ℑ and ℘on equation

(i) then,

Y = 14867.21 + 1106.71 (T)

If T = 2018 (i.e. n = 10) then Y = 25934

If T = 2024 (i.e. n = 16) then Y = 32574

Appendix-II

Hypothesis Testing

H_0: |⇑x = ⇑y, i.e. there is significant different difference in time saving before and after the use of biogas.

H_1: ⇑x ≠ ⇑y, i.e. there is no significant difference in time saving before and after the use of biogas.

Level of significance: 5percent

Test of statistics: Applying t-test as n = 7 < 30.

Computation: Since the samples are dependent are apply paired t-test as:

$$t = \frac{\bar{d}}{\sqrt{s^2/n}} \sim t_{nZ1} \text{ X} t_6$$

Calculation table

Activities	Before (x)	After (y)	d = (x-y)	d^2
1	40	70	-30	900
2	50	70	-20	400
3	20	50	-30	900
4	180	40	140	19600
5	30	50	-20	400
6	120	40	80	6400
7	70	30	40	1600
n = 7			ϕd = 160	ϕd^2 = 30200

$$\bar{d} \text{ X} \frac{\phi d}{n} \text{ X} \frac{160}{7} \text{ X} 22.85$$

$$S^2 = \frac{1}{n \text{ Z} 1} \left(\phi d^2 \text{ Z} n(\bar{d})^2\right)$$

$$= \frac{1}{6}\left(30200 \text{ Z} 7(22.85)^2\right)$$

$$= 4424$$

$$\text{Now, } t = \frac{\bar{d}}{\sqrt{s^2/n}} \text{ X} \frac{22.85}{\sqrt{4424/7}} = 0.909$$

Critical value of t for 6 degrees of freedom at 5percent level of significance is 2.179.

Decision: Since calculated t (0.909) is smaller than tabulated t (2.179), null hypothesis is accepted. Thus there is significant difference in time saving before and after the use of biogas energy.

Appendix-III

Questionnaire

1. In whose name is the biogas plant registered?

   a. Husband b. Wife c. others

2. Since when have you used biogas plant?

   …………. years.

3. Have you taken any loans for the installment of biogas plant?

   a. yes b. no

4. is your toilet connected to the biogas plant?

   a. yes b. no

5. Do you boil your drinking water in the gas?

   a. yes b. no

6. Do you have idea diseases which transmit from polluted water?

   a. yes b. no

6.a. If yes, what is the total expense for the cure of the diseases?

Expenses

Gender and children	Diarrhoea			Dysentery			Worm and parasitic infection			Fire relation accident		
	I	D	N	I	D	N	I	D	N	I	D	N
Women												
Men												
Children												

7. Do you have idea of the diseases which transmit through air?

   a. yes b. no

7.a. If yes, what is the total expense for the cure of the disease? (After the use of biogas)

Expenses

Gender and children	Eye-infection			Headache			Respiratory disease			Cough		
	I	D	N	I	D	N	I	D	N	I	D	N
Women												
Men												
Children												

8. Which type of energy do you use while cooking?

a. Biogas b. Fuel wood c. Kerosene

d. Electricity e. Others

9. Which source do you use for lighting?

a. Biogas b. Kerosene c. Electricity

d. Solar e. L.P gas f. Others

10. Which fertilizer do you use in agriculture?

a. Bio compost b. Chemical fertilizer c. Others

11. Do you know about some incidents of fire?

a. yes b. No

11.a.If yes, is there increase in fire after the installment of the biogas plant?

a,. yes b. No

12. Is your time saved after Biogas has started to be used in many fields?

a. yes b. no

13. In which field is your time being saved after the installment of Biogas plant?

	time consuming	time saving
a. Cattle rearing		
b. Water management		
c. Feeding biogas plant		
d. Collecting timber		
e. Collecting fodder		
f. Cooking food		
g. Cleaning utensils		

14. If time is saved, in which sectors have you used the saved time?

- Informal education
- Entertaining works (watching TV, listening to radio, reading newspapers, reading magazines)
- Getting involved in social activities
- Involvement in income related works
- Others (Child care, caring of elderly people, cleaning of surrounding)