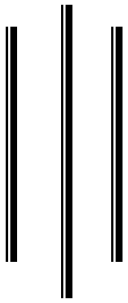
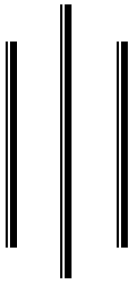
THE ROLE OF BIOGAS FOR SUSTAINABLE DEVELOPMENT IN NEPAL: A CASE STUDY OF NIGLIHAWA VDC OF KAPILVASTU DISTRICT



A Dissertation submitted to the Central Department of Sociology/Anthropology, TU, Kirtipur in partial fulfillment of the requirements for Master of Arts (MA) in Sociology



By:

Maheshwar Prasad Yadav

Roll No. 94-066/67

TU Registration No. 27815-93

Central Department of Sociology/Anthropology

Faculty of Humanities and Social Sciences

Tribhuvan University

Kirtipur, Kathmandu

February 2014

Tribhuvan University

Faculty of Humanities and Social Sciences

Central Department of Sociology/Anthropology

Kirtipur, Kathmandu, Nepal

LETTER TO RECOMMENDATION

This is to certify that **Mr. Maheshwar Prasad Yadav** has completed his dissertation entitled "**The Role of Biogas for Sustainable Development in Nepal: A Case Study of Niglihawa VDC of Kapilvastu District"** under my guidance and supervision. I recommend this dissertation for final approval and acceptance.

……

Bhanu Timseena

Associate Professor

Central Department of Sociology/Anthropology

Tribhuvan University

Kirtipur, Kathmandu, Nepal

Date:

Tribhuvan University

Faculty of Humanities and Social Sciences

Central Department of Sociology/Anthropology

Kirtipur, Kathmandu, Nepal

ACCEPTANCE CERTIFICATE

This dissertation entitled **"The Role of Biogas for Sustainable Development in Nepal: A Case Study of Niglihawa VDC of Kapilvastu District"** prepared by **Mr. Maheshwar Prasad Yadav** has been accepted as the partial fulfillment of the requirements for the Master of Arts (MA) in Sociology.

Expert Committee:

1) Prof. Dr. Om Gurung .....

Head of the Central Department of Sociology/Anthropology,
Tribhuvan University, Kirtipur, Kathmandu, Nepal

2) Mr. Surendra Mishra (External Expert) .....

Associate Professor
Central Department of Sociology/Anthropology,
Tribhuvan University, Kirtipur, Kathmandu, Nepal

3) Mr. Bhanu Timseena (Dissertation Supervisor) .....

Associate Professor
Central Department of Sociology/Anthropology,
Tribhuvan University, Kirtipur, Kathmandu, Nepal

Date: 13th April 2014

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Needless to say, I alone am responsible for any deficiencies that may have remained in this work.

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(Maheshwar Prasad Yadav)

Assistant Director, BSP-Nepal**,** Thapathali, Kathmandu, Nepal

Email: mpyadav2006@gmail.com, **Website:** www.bspnepal.org.np

ABSTRACT

Development is the process of developing or being developed. It means that positive changes are regarded as development. Sustainable development is a pattern of resources use in such a way that present needs can be met without destroying the ability for the future generations to meet their needs. Hence, sustainable development comprises of environmental sustainability, economic sustainability and social sustainability. Furthermore, energy is an essential ingredient of socio-economic development. Renewable energy is energy that comes from resources which are continually replenished such as sunlight, wind, rain, tides, waves and geothermal heat. Reliable and sustainable supply of energy is the basic needs of the people for meaningful life including cooking, lighting and economic activities. Furthermore, renewable energy technologies (RETs) such as biogas, solar and micro-hydro are widely promoted in Nepal and biogas only considered for this study. The major objective of this study is to examine role of biogas for sustainable development in Nepal based on a case study of Niglihawa VDC of Kapilvastu district. Its specific objectives are: 1) to analyze the role of biogas for quality of life through livelihood enhancement by improving health & hygiene and developing micro-enterprises; 2) to examine the role of biogas for protecting environment through forest conservation and pollution reduction; and 3) to evaluate the role of biogas for cultural development in the context of Nepal.

In order to conduct this study, descriptive cum analytical research design has been employed. This study has based on both primary and secondary data. This study has used cross-sectional secondary data at National level of Nepalese biogas sector for the period of 1992/93 to 2012/13. Likewise, the primary data have collected by using structured questionnaire to get opinion of biogas users. Sixteen household out of twenty two users have been selected randomly for the study at Niglihawa-6 of Kapilvastu district. The data has edited, tabulated and analyzed through applied statistics using IBM SPSS Statistics 20 which facilitates the process of data analysis in a more precise and appropriate way. Moreover, the simple statistical techniques of analysis such as table, percentage, graphs, and correlation coefficient (r) have been employed to a number of cases in this study.

Likewise, White's formula has used in this study to assess the role of biogas for cultural development.

The study suggests existence of the role of biogas for sustainable development by determining its role for quality of life, protecting environment, and cultural development. Based on the analysis of the primary and secondary data, the results revealed these three conclusions. *First,* biogas plays important role for quality of life through improving health and sanitation, creating enterprises and employment, utilizing bio-slurry as feed and fertilizer. *Second,* biogas contributes for protecting environment in relation to forest conservation and reduction of pollution. *Finally,* biogas plays important role for social and cultural development. The results have shown that the biogas plays positive role for cultural changes in *cooking practices, use of toilet, and the role of women in social activities.* Based on White's model using national data, the results show that cultural development moves in the same direction with total plants installed over the year as the correlation coefficient (r) between two is 0.81. There is very high degree of positive correlation between these two variables. It means if total plants increase then the degree of cultural development also increases and vice versa. Hence, biogas plays an essential role for the economic and social development as well as protecting environment that contributes for sustainable development in one way or another.

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LIST OF ABBREVIATIONS AND SYMBOLS

AD	=	Anno Domini
ADBL	=	Agriculture Development Bank Limited
AEPC	=	Alternative Energy Promotion Centre
BSP	=	Biogas Support Program
BSP-Nepal	=	Biogas Sector Partnership Nepal
CDM	=	Clean Development Mechanism
CH_4	=	Methane
CO_2	=	Carbon Dioxide
E	=	the measure of energy consumed per capita per year
e.g.	=	For example
et al.	=	And others
etc.	=	Excreta
FY	=	Fiscal Year
GE	=	Green Economy
GGC	=	Gobar Gas and Agricultural Equipment Development Company
GoN	=	Government of Nepal
HH	=	Household
LPG	=	Liquid Petroleum Gas
Ltd.	=	Limited
M^3	=	Meter cube
MJ	=	Mega Julie
MW	=	Mega watt
NGO	=	Non Governmental Organization
NPK	=	Nitrogen, Phosphorous, Potassium
P	=	the degree of cultural development in terms of product produced
RETs	=	Renewable Energy Technologies
RETS	=	Renewable Energy Testing Station
SNV/N	=	Netherlands Development Organization, Nepal
T	=	the measure of efficiency in utilizing energy harnessed.
TU	=	Tribhuvan University
UNCED	=	United Nations Commission for Economic Development
VDC	=	Village Development Committee
WECS	=	Water and Energy Commission Secretariat

CHAPTER-I: INTRODUCTION

1.1. General Background

Development is the process of developing or being developed (www.google.com.np: 14 Jan 2014). It is also known as evolution, growth, maturing, expansion, enlargement, spread, build out, progress, success, blossoming, blooming, burgeoning, headway. It means that positive changes are regarded as development. Moreover, development consists of the process of economic and social transformation that is based on complex cultural and environmental factors and their interactions. Development is the act of improving quality of life and making sure everyone has the preference in what that life looks like. These choices are widened through the combined effort of local people, international bodies, governments and a variety of civil society organizations such as NGOs, community organizations and religious groups.

Sustainable development is a pattern of resources use that aims to meet human needs while preserving the environment (Wikipedia: 14 Jan 2014). The use of resources in such a way that present needs can be met without destroying the ability of future generations to meet their needs is known as sustainable development.

Moreover, the sustainable development recognizes that growth must be both inclusive and environmentally sound to reduce poverty and build shared prosperity for today's population and to continue to meet the needs of future generations (World Bank: 14 Jan 2014). It is efficient with resources and carefully planned to deliver both immediate and long-term benefits for people, planet, and prosperity. The sustainable development ties together concern for the carrying capacity of natural systems with the social and economic challenges faced by humanity.

As early as 1970s, 'sustainability' was employed to describe an economy "in equilibrium with basic ecological support systems. The term 'sustainable development' rose to significance after it was used by the Brundtland Commission in its 1987 report *Our Common Future* (World Bank: 14 Jan 2014). In

the report, the commission coined what has become the most often-quoted definition of sustainable development: "development meets the needs of the present without compromising the ability of the future generations to meet their own needs." It is development that meets the needs of the present without compromising the ability of the future generations to meet their own needs.

The concept of sustainable development has in the past most often been broken out into three constituent domains: *environmental sustainability, economic sustainability and social sustainability*. The three pillars of sustainable development - economic growth, environmental stewardship, and social inclusion - carry across all sectors of development, from cities facing rapid urbanization to agriculture, infrastructure, energy development and use, water availability, and transportation. Cities are embracing low-carbon growth and public transportation. Farmers are picking up the practices of climate-smart agriculture. Countries are recognizing the value of their natural resources, and industries are realizing how much they can save through energy and supply chain efficiency.

However, many other possible ways to delineate the concept have been suggested. For example, the Circles of Sustainability approach distinguishes the four domains of economic, ecological, political and cultural sustainability. These accords with the United Cities and local governments are specifying of culture as the fourth domain of sustainability. The other important sources refer to the fourth domain as 'institutional' or as 'good governance.'

On the other hand, the United Nations 2005 World Summit Outcome Document refers to the "interdependent and mutually reinforcing pillars" of sustainable development as economic development, social development, and environmental protection (Wikipedia: 14 Jan 2014). This study has based on these three pillars.

Sustainability consists of information, integration, and participation as key building blocks to help countries achieve development that recognizes these interdependent pillars. It emphasizes that in sustainable development everyone is a user and provider of information. It stresses the need to change from old sector-centered ways of doing business to new approaches that involve cross-sector co-ordination and the integration of environmental and social concerns into all

development processes. Furthermore, environmental sustainability is the process of making sure current processes of interaction with the environment are pursued with the idea of keeping the environment as pristine as naturally possible based on ideal-seeking behavior. Thus, environmental sustainability demands that society designs activities to meet human needs while indefinitely preserving the life support systems of the planet. This, for example, entails using water sustainably, only utilizing renewable energy, and sustainable material supplies (e.g. harvesting wood from forests at a rate that maintains the biomass and biodiversity).

Energy is necessary for daily survival (World Commission on Environment and Development, 1987). Energy is an essential ingredient of socio economic development and economic growth (Goldemberg, 1996). Renewable energy is energy that comes from resources which are continually replenished such as sunlight, wind, rain, tides, waves and geothermal heat (Wikipedia: 28 Feb 2013). About 16 percent of global energy consumption comes from renewable resources, with 10 percent of all energy from traditional biomass, mainly used for heating, and 3.4 percent from hydroelectricity. New renewable energy (small hydro, modern biomass, wind, solar, geothermal, and bio-fuels) accounted for another 3 percent and are growing very rapidly. The share of renewable energy in electricity is around 19 percent, with 16 percent of electricity coming from hydroelectricity and 3 percent from new renewable (Wikipedia: 28 Feb 2013). Reliable and sustainable supply of energy is the basic needs of the people for meaningful life including cooking, lighting and economic activities.

Moreover, fuel crisis exists also in the supply of traditional sources of energy (firewood). Beside, increasing population pressures means that fuel wood from forest, in most part of the country is now being used faster than it can be replenished by natural growth or re-plantation. This demand for wood, coupled with commercial exploitation of trees for construction, pulping and other uses, mean that the forests are being destroyed at an alarming high rate. As a result, it is as usual that people lose out in two ways: not only cannot they develop, because of high cost of petroleum fuel, but also their traditional life-style is threatened as fuel wood is becoming less available day by day.

To cope up with the increasing pace of population growth in Nepal, production of food grains need to be increased. For that, more land needed to be used for agriculture. More fertilizers must be used to maintain fertility of soil and enhance the agricultural productivity. These demands make the fuel problem even worse, as new agricultural land must come from the forests. As wood becomes less available, people turn to other fuels, such as dried cattle dung and agricultural residues, which could be used for organic fertilizer.

In such circumstances, Nepal has very high potential to exploit the renewable energy; however, it has not been exploited to the fullest. The energy sector of Nepal is characterized by a very heavy reliance on traditional resources that contribute to more than 85 percent of the total energy consumption (AEPC, 2012, p. 1). Renewable energy is energy that comes from resources which are continually replenished such as sunlight, wind, rain, tides, waves and geothermal heat (Wikipedia: 28 Feb 2013). Renewable energy technologies such as biogas, solar and micro-hydro are widely promoted in Nepal and biogas only considered for this study. Whereas non-renewable energy is energy that comes from resources which are not continually replenished such as coal, petroleum fuels and fuel wood etc. Those non-renewable sources of energy are also taken as traditional sources of energy. The use of renewable energy can reduce the dependency on traditional sources of energy.

On the other hand, electricity from the national grid is not feasible in some of the places and it is too expensive as well (AEPC, 2012). The big projects need a huge investment which can be the economic burden for the country like Nepal. The high potentiality of the renewable energy resources available in the country is the most appropriate option to electrify these remote areas. It also helps to reduce the dependency on the traditional biomass energy resources and fossil fuels and to manage the energy crisis of the nation. This ultimately helps to minimize the degradation of the environment. The use of Renewable Energy Technologies (RETs) can reduce the dependency on traditional energy and help to protect the environment and reduction of emission of greenhouse gases, contribute sustainable development, regional balance and increases the economic activities. It ultimately contributes to improve the health and educational status of the

population as well (AEPC, 2012, p. 1). Nepal has enormous potential for different kinds of renewable energy resources, however, mini/micro hydro power up to 10 MW, solar energy, biogas, wind energy and biomass energy are promoted as renewable energies in Nepal. View in this perspective, the potential of domestic biogas is over 1.2 million plants based on livestock population (AEPC, 2012).

Among others, biogas is the mixture of different gases produced by methanogenic bacteria feeding on bio-degradable materials in anaerobic (without oxygen) conditions. Biogas is 50-70 percent methane and 30-40 percent carbon dioxide (BSP-Nepal). It also contains small amount of other gases. Biogas is about 20 percent lighter than air. It is odorless and colorless and burns with a clear blue flame similar to that of LPG. Its calorific value is about 20 MJ per m^3 and it burns with 60 percent efficiency in a conventional biogas stove. Moreover, Biogas technology is a modern, ecology-oriented form of appropriate technology based on the decomposition of organic materials by putrefactive bacteria at suitable and stable temperatures. A combustible mixture of methane and carbon dioxide, commonly referred to as biogas, develops under oxygen exclusion in the digester. Biogas is produced by bacteria during digestion or fermentation of organic matter under airless condition (anaerobic process). The gas consists mainly of methane (CH_4) and carbon dioxide (CO_2). That is why; biogas can be useful for cooking and lighting.

Active anaerobic treatment has been used for centuries by various societies (Karki, Shrestha, Bajgain, & Sharma, 2009). To ensure continuous gas production, the biogas plant must be fed daily with an ample supply of substrate, preferably in liquid and chopped or crushed form. The slurry is fed into the digester by way of the mixing pit. If possible, the mixing pit should be directly connected to the livestock housing by a manure gutter. Suitable substrates including the feeding from dung of cattle, pigs, chickens, green plants and plant waste, agro-industrial waste and wastewater, etc. A continuous biogas plant is charged and discharged regularly, e.g., every day. A normal farmer's biogas plant is a continuous plant with automatic discharge at the overflow.

Biogas contributes for economic sustainability, environmental sustainability and social sustainability. It plays role for cultural development, health and sanitation,

reduction of greenhouse gas emission, forest conservation, and production of slurry & compost fertilizer. It improves in health and sanitation through providing clean energy and smokeless kitchen that directly associated with children and women's health and environment. Health and environment along with friendly surroundings contribute for better enterprise integration. It saves time in each household that improved people's livelihood through starting agro & forest based micro enterprises such as: cash crops, cattle farming, fish farming, etc. These enterprises contribute for quality of life through livelihood enhancement. Likewise, the slurry & compost fertilizer produce from biogas that contribute for ago-based enterprise integration. Moreover, it also reduces greenhouse gas emission as per new Clean Development Mechanism (CDM) methodology. Likewise, trees protected after installation of biogas that enhance greenery and protect environment. As a whole, all these factors contribute for sustainable development in one way or another that play vital role for quality of life.

Nepal has over a half century history of promoting domestic biogas. The history of biogas in Nepal goes back to 1955 AD in which the biogas technology was first introduced at St. Xavier School, Godawari, Lalitpur by late father B.R. Saubolle. Thereafter, Government of Nepal (GoN) started biogas program mainly as the technology for high quality organic manure production and with potential to reduce fire wood consumption in Fiscal Year (FY) 1974/75. More and more development oriented agencies started getting involved in this technology. In 1977 a private company called Gobar Gas and Agricultural Development Company (GGC) started its program in close cooperation with Agricultural Development Bank Ltd. (ADBL) mobilized resources from various donor agencies for building awareness and technical capability in the country. To meet the ever growing demand for biogas plants and services, GGC also worked with Non Government Organizations (NGOs), and Community Based Organization (CBOs). In order to expedite the progress rate towards achieving the biogas potential of Nepal, Biogas Support Program (BSP) was launched in 1992, in collaboration with ADB/N and GGC with the grant support from Netherlands Development Organization (SNV/Nepal). The biogas program came under the umbrella of Alternative Energy Promotion Center (AEPC) in 1996. As the result, biogas plant

installation was rapidly increased after the end of nineties. The biogas program developed and resisted as the first CDM project in Nepal.

In this perspective, this study aims at determining role of biogas for sustainable development in Nepal. The first focus of this study is to examine the role of biogas for quality of life through livelihood enhancement by improving health & hygiene and developing micro-enterprises. The second focus of this study is to examine the role of biogas for protecting environment through forest conservation and reducing greenhouse gas emission. The third focus of this study is to assess the role of biogas for cultural development.

1.2. Statement of the Problem

Development is the process of developing or being developed. It means that positive changes are regarded as development. Sustainable development is the pattern of resources use to meet human needs while preserving the environment. The use of resources in such a way that present needs can be met without destroying the ability of the future generations to meet their needs is known as sustainable development. The concept of sustainable development has been divided into three constituent domains: *environmental sustainability, economic sustainability and social sustainability*. Biogas contributes the vital role for sustainable development through providing environment-friendly solutions, supporting for income generating activities and social development.

Nepal has very high potential to exploit the renewable energy resources. However, the potential has not been exploited to the fullest. The energy sector of Nepal is characterized by a very heavy reliance on traditional resources that contribute to more than 85 percent of the total energy consumption (AEPC, 2012). The use of Renewable Energy Technologies (RETs) can reduce the dependency on traditional sources of energy, and help to protect the environment by reducing the emission of greenhouse gases which in turn can contribute to sustainable development, regional balance and economic activities. It ultimately contributes to the improvement in the health and education of the population as well.

Moreover, development is sustainable when it meets the needs of the present

generations without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987)**.** Likewise, sustainable construction means that the principles of sustainable development are applied to the comprehensive construction cycle from the extraction and collection of raw materials, through planning, design and construction of buildings and infrastructures, until their final deconstruction and management of the resultant waste. It is a holistic process aiming to restore and maintain harmony between the natural and built environment, while creating settlements that affirm human dignity and economic equity (UNCED, 1992).

Broadly, the sustainable development is about creating a better quality of life for everyone, now and generations to come. It means that our economy, environment and social well-being are interdependent. The maintenance of the structures is the challenges of the developmental activities. The design of the structures should be friendly to the local construction materials and environment. The sustainable infrastructure is new building and refurbishment that promotes environmental, social and economic gains now and for the future (Shelbourne, 2006).

Furthermore, biogas increases awareness in this technology as a forest saver. The biogas reduces women's workload, improves cooking environment and saves time. New Era (1995) found that one of the main attractions towards the biogas plants of easy availability of gas for cooking and the crop production was increased. The study comprised of the problem of eye disease and respiratory diseases was reduced and the users felt some relief. Mathew & Wim (1999) have discussed the benefits of biogas which includes gender benefits, environmental benefits and health benefits. In addition, the benefits of biogas plants to its owner was the cooking and lightning facilities that saved a considerable amount of money reduce family workload. However, Winrock (2000) has shown biogas as the way for sustainable development. Biogas produces bio-fertilizer that saved the amount of money spending on chemical fertilizer. It represents economic benefits and organic crops/vegetable production that play the vital role for health and hygiene. Likewise, White (2005) concluded that biogas as an alternative energy help in developing China’s agriculture oriented rural economy.

Furthermore, Bhattarai (2009) showed biogas has positive impact on economic, environmental, social, educational and healthy aspects to them. View in this perspective, the main reason behind the installation of biogas plant was easy and smokeless cooking, time saving and improves health and sanitation. Women are utilizing their saved time for productive activities. Similarly, women had experienced much improvement in their health status after the installation of biogas plants than men.

In addition, Arthur, Baidoo, & Antwi (2011) found that the associated harmful environmental, health and social effects with the use of traditional biomass and fossil fuel have enhanced the growing interest in the search for alternate cleaner source of energy globally. Likewise, Yadav (2012a) revealed the significant role of biogas for sustainable development in Nepal. The study also concluded that the vital role of biogas to mitigate climate change and for quality of life. Another study by Adhikary (2012) dealt with green economy in pursuance of sustainable development and nature for an improved and sustained quality of life.

There are several studies conducted in Nepal and abroad reveal the fact that role of biogas is vital for sustainable development including environmental protection and other benefits. The studies conducted in Nepal either focus on technical aspects or environment aspects of biogas. The applicability of these facts is yet to be seen in the context of Nepal. In this context, a sociological study of biogas is considerable to investigate. The study then concentrates its attention to assess the role of biogas for sustainable development. Consequently, the first focus of this study is the examination of the study has analyzed the role of biogas for quality of life through livelihood enhancement by improving health & hygiene and developing micro-enterprises. The study has also analyzed the role of biogas for protecting environment through forest conservation and reducing greenhouse gas emission etc. Finally, the relationship of biogas with cultural development has assessed to achieve another objective of the study. The research questions of the study are as follows:

a) Does biogas play vital role for quality of life through livelihood enhancement? Is biogas contributed for improving health & hygiene of the

rural people of Nepal? Are there any relationship of biogas with sanitation, clean energy and smokeless kitchen?

b) Does biogas play role for improving people's livelihood through starting micro enterprises such as: cash crops, cattle farming and fish farming? Is biogas reduced dependency on chemical fertilizer through replacing with compost fertilizer?
c) Does biogas contribute in protecting environment in Nepal? Does biogas play significant role for reducing greenhouse gas emission? Does biogas protect tree and enhance greenery?
d) Does biogas play vital role for cultural development in the context of Nepal? Are there any relationship between biogas and cultural development? Is there positive relationship of biogas with cultural development?

1.3. Objectives of the Study

The major objective of this study is to examine the role of biogas for sustainable development in Nepal. The specific objectives are:

1) To analyze the role of biogas for quality of life through livelihood enhancement by improving health & hygiene and developing micro-enterprises.
2) To examine the role of biogas for protecting environment through forest conservation and reducing greenhouse gas emission.
3) To evaluate the role of biogas for cultural development in the context of Nepal.

1.4. Scope and Significance of the Study

The scope of the study is to analyze role of biogas for sustainable development in Nepal. It has examined the role of biogas for quality of life through livelihood enhancement by improving health & hygiene, developing micro-enterprises and protecting environment through reducing greenhouse gas emission forest conservation. It has also analyzed role of biogas for cultural development in Nepal. The study consists of survey of users' opinion towards biogas through questionnaire that has compared with analysis of secondary data.

In other words, this study is related with the benefits of biogas that contribute for the sustainable development. The study aims at determining improved in health and sanitation through providing clean energy, smokeless kitchen in rural household that directly associated with children and women's health and environment. It has also focused on time saving daily in each household and its effect on improvement of people's livelihood through starting agro & forest based micro enterprises such as: cash crops, cattle farming, fish farming, etc. Likewise, the study assessed slurry & compost fertilizer production annually per household that enhance independency through reduction of dependency on chemical fertilizer. Moreover, the study focused on analyzing reduction of greenhouse gas emission annually per household as per new Clean Development Mechanism (CDM) methodology. The forest conservation has been analyzed that enhance greenery and protect environment. Lastly, the study evaluated the role of biogas for the culture development in Nepal. The study is a new undertaking for biogas sector.

It is most likely to be useful for the biogas sector, researchers, academician and policy makers. The study will be useful for biogas sector to grow it through better understanding of the sector. It will also be useful for development actors of the renewable energy sector for more commercialization of the sector. Likewise, this study will be useful for academia and researchers by acquiring new knowledge in the literature of study area and recommendation for future research. Finally, the study will be useful for policy makers. It will be guide map to formulate biogas-friendly policies to facilitate the sector.

1.5. Conceptual Framework

Development is the process of developing or being developed that means positive changes. Sustainable development is a pattern of resources use that aims to meet human needs while preserving the environment. The concept of sustainable development has in the past most often been broken out into three constituent domains: *environmental sustainability, economic sustainability and social sustainability*.

Biogas contributes the vital role for sustainable development through providing environment-friendly solutions, supporting for income generating activities and social development. View in this perspective, green economy framework is a critical stepping in leading to sustainable development (Adhikary, 2012, p. 77). Sustainable development comprises economic, environmental, and social sustainabililty.

The major focus of the study is to assess the role of biogas for sustainable development. Moreover, the first focus of this study is the examination of the role of biogas for quality of life through livelihood enhancement by improving health & hygiene and developing micro-enterprises while the second focus of this study is the examination of the role of biogas for protecting environment through forest conservation and reducing greenhouse gas emission etc. Finally, the relationship of biogas with cultural development has assessed to achieve the third objective of the study.

The variables are introduced in this study are related with the benefits of biogas that contribute for the sustainable development. Leslie Alvin White's model has been employed in this study to assess the role of biogas for cultural development. White introduced a model: **P = ET;** Where, P represents the degree of cultural development in terms of product produced; E is a measure of energy consumed per capita per year; and T is the measure of efficiency in utilizing energy harnessed.

In order to accomplish the objectives of this study, three aspects have been conceptualized. They are: 1) the role of biogas for quality of life, 2) the role of biogas for protecting environment, and 3) the role of biogas for cultural development. This conceptual framework has been shown in Table 1.1.

This study analyzes the role of biogas for quality of life through livelihood enhancement by improving health & hygiene, developing micro-enterprises, reducing chemical fertilizer, and saving time. This study also analyzes the role of biogas for protecting environment by reducing deforestation and reducing green house gas emission.

Table 1.1

Conceptual Framework for the Role of Biogas for Sustainable Development

Basis	Components of Sustainability	Conceptualization of Sustainability for this Study	Components of Sustainability
Role of Biogas for Sustainable Development	Economic Sustainability	Biogas for quality of life	Enhance livelihood through improving health & hygiene
			Enhance livelihood through developing micro-enterprises
	Environmental Sustainability	Biogas for protecting environment	Protecting environment through reducing deforestation
			Protecting environment through reducing green house gas emission
	Social Sustainability	Biogas for social and cultural development	Degree of cultural development in terms of product produced (P)
			Measure of energy consumed per capita per year (E)
			Measure of efficiency in utilizing energy harnessed (T)
			Cultural changes

Likewise, the role of biogas for cultural development by analyzing degree of cultural development in terms of product produced (P), measure of energy consumed per capita per year (E); and measure of efficiency in utilizing energy harnessed (T) and its relationship. Cultural changes in the selected area have been analyzed in this study in order to accomplish the objectives of the study.

1.6. Limitations of the Study

Limitations are those elements over which the researcher has no control. They are the shortcomings, conditions or influences that cannot be controlled by the researcher that place restrictions on the methodology and conclusions. Among others, this study limits to attempt to examine the role of biogas for sustainable development in Nepal. Furthermore, the area sampling will be done based on multi-stage cluster sampling. The area of the study was Jaralahiya cluster of Niglihawa VDC of Kapilvastu. Moreover, the study has covered only 16 biogas

users (76.19 percent) out of 21 through random sampling. The study has also limitations that come due to the limitations of the used tools and techniques. Thus, the results can be varied in other area and/or sector of Nepal and beyond.

1.7. Organization of the Study

The study has been organized into five chapters, each devoted to some aspects of the study of the role of biogas for sustainable development in Nepal. The first chapter consists of introduction while second chapter deals with review of literature. Research method has discussed in chapter three whereas chapter four comprised of role of biogas for sustainable development. Last but not least, chapter five contains of summary, conclusions and recommendations.

The rationale behind this kind of organization is to follow a simple research methodology approach. The contents of each of the chapters of this study are briefly mentioned here.

Chapter One contains the introductory part of the study. This chapter describes the major issues to be investigated along with the general background and objectives of the study. The limitations, scope and significance of the study are also included in this chapter.

Chapter Two includes a discussion on the theoretical framework and review of the major empirical works. The theoretical analysis and review of related literature conducted in this chapter provide a framework with the help of which this study has been accomplished.

Chapter Three describes the research method employed in the study. This chapter deals with research design, nature and sources of data, method of analysis, and definition of key terms.

Chapter Four consisting of four sections is devoted to the empirical analysis of the study. Section 1 consists of study area while the role of biogas for quality of life has been discussed in section 2. The role of biogas for protecting environment has comprised in section 3 whereas finally section 4 has analyzed the role of biogas for cultural development in Nepal.

Lastly, Chapter Five state summary and conclusions of the study. This chapter presents the major findings and compares them with theory and other empirical evidence to the extent possible. *Chapter Six also* offers recommendations and several avenues for future research.

CHAPTER-II: REVIEW OF LITERATURE

The review of literature has been described in three sections. Section 1 presents a discussion on the theoretical framework. The review of empirical works on the role of biogas for sustainable development in Nepal has been presented in Section 2 while section 3 has been devoted to concluding remarks.

2.1. Theoretical Framework

The theoretical framework of this study comprised of Leslie Alvin White's Model and the general benefits of biogas for quality of life of people as given in the following pages.

The primary function of culture and the one that determines its level of advancement is its ability to ***"harness and control energy"***. White's law states that the measure by which to judge the relative degree of evolvedness of culture was the amount of energy it could capture (energy consumption). White differentiates between five stages of human development as: At first, people use the ***energy*** of their ***own muscles***. Second, they use the ***energy*** of ***domesticated animals***. Third, they use the ***energy*** of ***plants*** (so White refers to ***agricultural revolution*** here). Fourth, they learn to use the ***energy*** of ***natural resources***: coal, oil, **gas**. Fifth, they harness ***nuclear energy***.

In this perspective, White introduced a formula (White L. , 2010): **P = ET**

Where, P represents the degree of cultural development in terms of product produced; E is a measure of energy consumed per capita per year; and T is the measure of efficiency in utilizing energy harnessed. In his own words: "the basic law of cultural evolution" was "culture evolves as the amount of energy harnessed per capita per year is increased, or as the efficiency of the instrumental means of putting the energy to work is increased".

This model shows the relationship of technology and energy with the cultural development. In this study, the relationship of biogas technology and energy from it with cultural development has been analyzed through using this model.

2.2. Review of Empirical Works

This section has been comprised review of major empirical studies in the area of biogas in relation to sustainable development in Nepal and beyond.

Sigdel and Das (1990) surveyed 13 biogas plants from Lekhnath village near Pokhara. It was found that there was a growing awareness in this technology as a forest saver. People have felt that it would be more applicable in a semi urban area where people were richer. Since the villager suffered from problems of finding capital to repay loans and installation cost was found to be high, realization of temperature constraint and the strong need for government subsidy could be observed.

Karmacharya (1992) conducted comparative analysis of installation of biogas plant in the hill and teraian perspective. Dadhikot village of Bhaktapur district for Hill site and Phoolbari village of Chitwan district for Terai site were chosen for the study. A total of 30 samples were chosen thus each site consisting of 15 samples the study takes economic approach and analysis is focused on the various types of benefits obtained and saving made through the installation of biogas plants. No significant differences of impact were noticed between Hill and Terai. However, some differences noticed as: lamps uses patterns were zero in Terai but 27 percent in the Hill; gas production was less in Hill; use of slurry as fertilizer was low in Hill. The study has shown concise overview of studies specifically designed to measure the effects of biogas on women's workload in different geographical setting of Nepal.

Keizer (1993) carried out a research entitled effect of biogas on the workload of women in Nuwakot District. The research was conducted with the help of structured questionnaire. In order to obtain relevant information, interviews were conducted with female users of 50 biogas plants. All biogas plants in his research were fixed concrete dome plants constructed by GGC. Most of them (80 percent) had a size of $10m^3$ on the average, the plants were three years old.

Regarding division of labour tasked related to biogas, women carried out 56 percent work while men were responsible only for 11 percent of task. Other family

members and servants did the remaining 33 percent task. The research revealed that the biogas influences women's workload positively. The quality of the work got improved activities as cooking cleaning the cooking pots became easier and it was held very pleasant to cook in clean environment.

The physical condition of women using biogas got improved because cooking as biogas did not cause headache, lung disease and eye problems. Interestingly, even old asthmatic women not able to cook on wood anymore were able to cook again on biogas. Women work many hours in a day. Saving time is regarded as workload reduction. The results showed that biogas reduced the time spent on daily activities with approximately 2.5 hours per household per day.

Furthermore, Sigdel and Das (1990) show the forest conservation and economic benefits from the biogas while Karmacharya (1992) indicates the social development. Likewise, Keier (1993) study consists of economic benefits, social development, improvement in health and sanitation, and protecting environment.

Britt (1994) has shown concise overview of studies specifically designed to measure the effects of biogas on women’s workloads in different geographical setting of Nepal and the studies were done in Rolpa, Rupandehi, Nuwakot and Chitwan districts. The result stated that given the overwhelming workloads for women in most part of Nepal the saving in time in the majority of instances is quite significant.

But, it remarks that the introduction of biogas doesn’t appear to fundamentally alter the position of women. So called traditional or unequal patterns in the division of labours are sustained, with working women for long hours simply substituting one labour activity for another. The research design used were district based and village based workloads effects were calibrated in terms of before and after installation of the biogas plant.

It was found that, estimated time saving for women in Rupandehi was 4 hours and 30 minutes (on average) and 2 hours and 35 minutes (on average) in Nuwakot. However, in a village based research, the estimated time saving was found to be 1 hour and 55 minutes in Madan Pokhara, 3 hours and 14 minutes in Pithuva and 15 minutes in Hathilet village.

New Era (1995) in its study "Biogas Plant in Nepal" has revealed that one of the main attraction towards the biogas plants of easy availability of gas for cooking. Almost all of the users used gas for cooking purposes and more than half of the owners used gas for lighting purpose as well.

The main reason behind not using biogas for lighting was the availability of electricity and breakage during the use of gas. Lamp and mantle and insufficient gas particularly in winter were found however most of the users reported that they were satisfied with the use of gas for cooking. The reason behind this satisfaction were mainly due to the less time for cooking no black shoot on cooking pot smokeless kitchen etc. Regarding the users of slurry only 44 percent of the users reported that the crop production was increased. The study has also revealed that the problem of eye disease and respiratory disease were reduced and the users felt some relief.

Adhikari (1996) in his report entitled "Effects of Biogas on Family Health, Sanitation and Nutrition" has concentrated on the impact study in the fields of health, sanitation and nutrition. Both positive and negative impacts have been evaluated. The study has employed methodology consisted of household opinion survey, women focus group discussion, key informants interview, field observation and pathological test of digested slurry. The study showed that most significant positive impacts on health, reduction in eye disease, headache, coughing and throat ache. However, the negative impacts were increased prevalence of mosquito and loss of warmth in house in winter.

Likewise, Britt (1994) finds social and cultural changes, and economic benefits while Livelihood enhancement through micro enterprises, health and sanitation benefits have comprised in New Era (1995) Study. Adhikari (1996) mentions improvement in quality of life through health and sanitation and reduction of workload of women. These studies support to analyze quality of life, environment protection and changes through using biogas.

Mathew & Wim (1999) in their article entitled "Elements of success in rural household supply" has discussed the benefits of biogas which includes gender benefits, environmental benefits and health benefits. It presents financial and

economic assessment of the BSP, which illustrate economical attractiveness of the programme. The paper depicts the energy consumption pattern in Nepal. Petroleum and coal are entirely imported requiring 35 percent of Nepalese export earning but meeting only 8 percent of the total energy demand. Wood is used mostly 72 percent in the residential sector to meet energy demand. The technical potential of biogas in Nepal is 1.5 million units. The biogas plants till July 1998 are estimated to displace the use of 1,00,000 tons of firewood and 1.27 liters of kerosene annually.

Ghimire (1999) has tried to document the benefits of biogas produce by harvesting. The more popular and appropriate renewable energy resource cattle dung and assessed the immediate impact of biogas on respective users. The outcome of the study revealed that the main benefits of biogas plants to its owner was the cooking and lightning facilities that saved a considerable amount of money.

Economic analysis, which is not done in this case, this study, has only dealt with the general impact of the biogas plant on the users. In general, biogas plants are found to have very positive impact on the users which is well appreciated by them. The total saving of 1.22 hours/days/family on an average from the installation of biogas plants suggests that it has been successful to lower the family workload.

Winrock (2000) comprised the experience of Gram Vikas in promoting rural enterprise and the subsequent progress of turnkey entrepreneurs in Orissa has been very positive and has major lessons to be considered for the process of rural development in India. This is especially relevant in the context of structural changes taking place in the national economy. Efficient resource use and environmental sustainability will be key factor to development in this scenario of globalization. Enterprise development through efficient development and the use of local human capabilities and resources could be key factor in this scenario. In the context of rural Orissa, the biogas entrepreneurs and Gram Vikas have shown the way for sustainable development.

Moreover, Mathew & Wim (1999) Study consists of economic benefits through reducing petroleum goods and environment protection from forest conservation by

installation of biogas. Similarly, Ghimire (1999) finds economic benefits from cooking and lighting, lowering workload and social changes are the major benefits of biogas. Winrock (2000) concludes biogas play vital role for environmental protection, improving quality of life through micro enterprises. These findings are quit consistent with this study.

Nepal (2001) conducted study on optional biogas plant size daily consumption pattern and conventional fuel saving. He carried out the study of the impact of biogas on users and also taken non-biogas households for the study in Syngja, Nuwakot, Chitwan and Morang districts. The study areas were taken as the study area representing high hills, mid hills and tarai region of the country.

The study has found that the whole quantity of dung produced is not collected by the biogas users and collected amount is also not entirely fed into the plant which reduced the plant efficiency. However, the plant efficiency was found to be increased with the latrine attachment. This study has also shown the comparatively greater benefits to biogas users than non-biogas HHs with regarded to cooking food because of time saved. Similarly, the total saving of kerosene was significant (2.7 litres per year per HHs). However, the study showed that no specific correlation between average use of firewood and kerosene and the family size.

Karki, Karki, & Khadka (2002) conducted a study entitled "A study of Renewable Energy Technology with Focus on Income Generating Activities" in Dhading district. The study was mainly focused on the adoption of renewable energy technology (RET) and its impact on income generating activities. The outcome of this study showed that three among the five of biogas users reported an increase in crop production by 5 to 10 percent due to the application of bio-slurry. However the user of other types of renewable energy technology (RET) did not report an increase in crop production as experienced by the biogas users. The biogas user' main income generating activities are agricultural based like vegetable, butter (Ghee) and local wine (Rakshi) production. Fertilizer required for vegetable production has reduced and so the amount of money spending on chemical fertilizer saved.

A study by White (2005) concluded that commercial energy consumption by rural Chinese is disproportionably lower than urban Chinese. As a result, traditional biomass fuels such as crop stalks, animal dung, fuel wood, and straw continue to be the dominant source of rural household energy. Reliance on traditional energy sources limits economic and social development due to lacking many economic applications, promoting the degradation of natural resources, and causing serious health problems. However, expanding commercial energy supply too much of rural China is not currently feasible due to various geographic and economic constraints. As a result, the Chinese government has begun promoting renewable energy technologies as an alternative means to provide cleaner and more efficient energy to China's rural population. This paper looked into the capability of biogas as an alternative energy to help develop China's agriculture oriented rural economy.

Additionally, Nepal (2001) finds the vital role of biogas for increment in sanitation and saved time that improves quality life as well as protecting environment through forest conservation. Karki, Karki, & Khadka (2002) conclude increase in crop production and reduction of chemical fertilizer by using biogas. Similarly, White (2005) Study consists of the role of biogas as cleaner and efficient energy for agriculture development that consistent with this study for analyzing quality of life through starting micro enterprises.

Ghimire (2006) studied on socio-economic impact of biogas plant in rural setting: a case study of Shukranagar VDC, Chitwan, Nepal. This study is basically based on both primary and secondary sources of data. Like an island between Narayani and Rapti rivers Shukranagar VDC is situated in the west-southern part of Chitwan. In this VDC, there were 1,436 households. In the study area there were 506 households (in selected wards-1 and 2). About 30 households have been taken as sampled households out of 506 households. Sampled households were those who had installed biogas plant. Simple random sampling technique has been used to select sample. In this study data were collected from field survey by applying household survey questionnaire and observation method.

This study found that majority of the households (50 percent) out of total interviewed reported that they had adopted agriculture as a main occupation.

Average family size of the sampled household was 5.6 per household. About 86.6 percent plant owners out of total interviewed were literate whereas only 13.4 percent were illiterate. Average landholding size is 17 katthas per household. About 53.3 percent were from Brahmin caste.

Out of total sampled biogas plant owners, majority of the households (83.3 percent) had taken loan from financial institutions. About 80 percent households reported that the main reason behind the installation of biogas plant was easy and smokeless cooking. Around 86.7 percent plant owners had attached toilet with the biogas plant. Average livestock population size of sampled household was 4.3 per household. Average dung production was 24.4 kg per household. Majority of the respondents (73.3 percent) reported that the agricultural production had been increased. Total average time saving was 2.5 hours per day per household. Average saving amount of money was Rs.600/- per month per household.

It was found that from the study, majority of the respondents (43.3 percent) has used saved time on farm activities. This study also revealed that improvement was found in health and sanitation situation. About Rs.310/- per year was saved on health treatment by each household. Majority of the respondents (86.7 percent) out of total interviewed reported that their social status was raised. It was also found that women were highly benefited by the biogas plant (63.3 percent). About 50 percent households out of total interviewed accepted that the overall energy, environmental and economic condition had been improved.

Subedi (2006) conducted a study on socio-economic impact of biogas plant: a case study of Dhikurpokhari VDC of Kaski District. Raising concern over firewood and kerosene as a fuel has led to the installation of biogas in the study area, Nepal is heavily based on agriculture and it is suffering from the low productivity. So, its productivity has to be maintained for overall development. An immediate solution of their problem is to maintain the soil fertility which is possible by the application of bio-slurry on the farm instead of chemical fertilizer. As biogas technology does not require procurement of raw material from outside and the rural people can set up it utilizing their and keep clean environment as well, biogas is seen as the major effective technology to uplift the energy economy. Due to higher productivity, less workload for women reduced, pressure on the

traditional fuel resources, this technology may maintain ecological balance in the study area as well as in the nation as whole.

This study discusses the benefits of the biogas technology which accrue the level of individual family. Biogas is making significant contribution in meeting the cooking energy requirement in the study area. Higher standard of living, higher productivity and reduces pressure on traditional natural fuel resources are the main benefit of biogas. Out of the total of 120 biogas households, 30 households (25 percent) have been taken as the sample households using simple random sampling. Primary as well as secondary data have been used in this study. The household survey threw interview, field observation has been taken as a method of data collection and collected data has been analyzed using simple statistical tool such as, average, percentage table. Biogas seems to have succeeded in substituting traditional biomass and fossil fuels. However, it has not completely substituted the traditional energy. The users of biogas has brought the significant improvement in the quality of life of the family members and reduction on the work load of women who are the sole manager in kitchen and take the responsibility of household cooking.

Timsina (2008) studied on socio-economic impact of biogas plant in rural Nepal: a case study of Phidim VDC of Panchthar District. The purposive sampling of 32 HHs was done to gather the necessary information required. From the research, it is known that the dominant position is of Bramahans followed by other castes. The main occupations of the local people are agriculture 46.88 percent and services 25 percent. More than 65 percent people in sampled households are literate. On an average, the each plant owners has 4 heads of livestock. The most popular biogas plant of the study area is $6m^3$. The main reasons behind the installation of biogas plant are easy and smokeless cooking, get rid of firewood collation and time saving.

On an average, time saving after installation is 2 hours per day from firewood collection, cooking activities and washing utensils. Saving of time which is spent collecting firewood and its reduction of consumption is equal to Rs. 400 per months. Most of the people use Bio-slurry in their farms in composted form. According to them, the use of slurry has increased the production especially

maize, paddy and vegetables. The use of chemical fertilizer has been reduced which has helped in saving money.

In addition, Ghimire (2006) concludes improvement in health and sanitation situation and their social status was raised. It was also found that women were highly benefited by the biogas plant that the overall energy, environmental and economic condition had been improved. Subedi (2006) finds the users of biogas have brought the significant improvement in the quality of life and reduction on the work load of women. Timsina (2008) comprises time saving after installation of biogas from firewood collection, cooking activities and washing utensils. The use of slurry has increased the production especially maize, paddy and vegetables and the use of chemical fertilizer has been reduced which has helped in saving money. These study reveals that the role of biogas for quality of life, protecting environment and cultural development on one way or another.

Nepal (2008) study comprised socio-economic impact of biogas energy on rural women: a case study of Chandragadi VDC in Jhapa district. While talking about the impacts of biogas to rural women, one counts a number of benefits like it minimises the workloads and time of fetching firewood, motivates male to help in kitchen works and kitchen gardening and also make marginalised community inclusive to the livelihood programme for the betterment. Further to the social impact, it also has economic impacts like saving money of firewood, minimisation of health costs due to health improvements, women participation in economic works and slurry use for increasing the productivity of farms. The number of impacts goes even more when environmentalists explain them. However, using the concept of social structure of gender and following the field study with structured questionnaires and focus group discussion the study found that the effect of biogas is general in nature. It has made the work easier within the social construction of gender, but it has no effect to increase women participation in income generating activities outside the farm. After installation of biogas plant women left to go to jungle for collecting firewood or they are saving money by not buying firewood anymore. Social activities of women are mostly religious, which are also parts of the social construction. Besides these observations the study found that biogas program in Jhapa is not able to benefit Dalits and minorities as

they are not included in the program significantly. The other weakness is that it is also not able to demonstrate the benefits of biogas for lighting and thus, is limited to cooking and slurry use for kitchen gardening and farms. However, biogas program, in general, has positive effects to reduce the workload and improve health situation of women.

Bhattarai (2009) studied on socio-economic impact of biogas technology in Nepal: a case study of Ghorahi Municipality of Dang District. This study is mainly based on the primary information and the data were collected using the techniques of field survey with the help of questionnaire, field visit, observation, and focus group discussions. In this study, the energy consumptions pattern for cooking is 17.55 percent were used biogas and 60 percent were dependent on fuel wood. Majority of the households, 63 percent, have 6 members in their family whereas the number of households engaged in agriculture and service sector are 63 percent and 20 percent respectively.

During the study, it was found that Brahmins (50 percent) were the main beneficiaries of the biogas technology. The economic condition of the biogas user households was found good and most of the biogas plants (86.67 percent) were toilet connected. Even though the plants were found underfed, the gas production was sufficient in summer but it was much less in the winter biogas energy was used only for cooking purposes.

The 63 percent people had annual income Rs. 20,000-60,000 of total population in this study area. The land holding size on this study areas population have 11-20 Ropanies which is the 40 percent of the total population the people of this study area most rear cow study as the more source of raw material for biggest production economic support.

All the surveyed biogas plants were in good condition and well functioning. Biogas user households were satisfied with the performance of biogas plants because it had positive impact on economic, environmental, social, educational and health aspects for them. Both male and female were found benefits from biogas. But comparatively, women had experienced much improvement in their health status after the installation of biogas plants than men. People's perceptions about the

biogas plant were found positive. Thus, both male and female were equally pleased with biogas technology.

Wagle (2010) conducted study entitled "Socio-economic Status of Bio Gas Users: A Case study of Tanahunsur Village Development Committee of Tanahun District" dealt with the socio economic status of biogas energy for biogas users. The general objective of the study is to find out the socio economic status of bio gas users: a case study of Tanahunsur VDC of Tanahun District. The specific objectives are to assess the socio-economic characteristics, analyze the operational status, and impact of the biogas on women status. For the study, the extensive field visit was conducted in Tanahunsur VDC of Tanahun district. Both primary as well as secondary data have been used in this study.

In this VDC, there are 712 households. 145 HHs have installed the biogas plants. About 40 households have been taken as sampled households. Out of 145 households, sampled households were those who had installed biogas plant. Simple random sampling technique has been used to select sample. In this study, data were collected from field survey using household survey questionnaire and observation method.

This study found that majority of the households 45 percent out of total interviewed reported that they had adopted agriculture as a main occupation. Average family size of the sampled household was 4.5 per household. About 77.5 percent plant owners out of total interviewed were literate whereas only 22.5 percent were illiterate. Average landholding size is 14.5 Ropani per household. About 42.5 percent out of total interviewed were from Brahmin caste.

Out of total sampled biogas plant owners, majority of the households 52.5 percent had taken loan from financial institutions. About 47.5 percent households reported that the main reason behind the installation of biogas plant was easy and smokeless cooking. Around 72.5 percent plant owners had attached toilet with the biogas plant. Average livestock population size of sampled household was 3.22 per household. Total average time saving was 3 hrs per day per household. Average saving amount of money was Rs.5,928/- per year per household.72.5 percent households has been mosquito increased. This study also revealed that

improvement was found in health and sanitation situation. Majority of the respondents 77.5 percent out of total interviewed reported that their social status has increased. It was also found that 82.5 percent women were highly benefited by the biogas plant. This study also revealed that 47.5 percent women are utilizing their saved time for productive activities.

Sharma (2010) studied on prospects and problems of biogas plant in rural Nepal: a case study of Devdaha VDC, Rupandehi district. The specific objectives of the study are: to study the biogas plant as an appropriate alternative source of energy, to study the impact of biogas in relation to the workload; improvement in health and sanitation; time and money saving; overall energy, environment and economic benefits, to study the potential benefits of biogas plant installation in relation to use of digested slurry as fertilizer, to find out the problems faced by the biogas installers and its prospects and to make recommendations and suggestions to promote biogas plant installation situation and solve the problem. This study is basically based on both primary and secondary sources of data.

The total number of household owing biogas plants in nine wards of this VDC is 234. About 46 households have been taken as sampled households out of 234 households who have installed biogas plant. Also 20 HHs having livestock and non-biogas plant installers were interviewed to find out the prospect of the plant in the VDC. Simple random sampling technique has been used to select the both sample. In this study data were collected from field survey by applying household survey questionnaire, checklist and observation method.

This study found that majority of the households (67 percent) had adopted agriculture as a main occupation. Average family size of the sampled household was 5.6 per household. Average landholding size is 15.21 katthas per household. About 47.83 percent out of total interviewed reported that they were from Brahmin caste. About 40 percent households reported that the main reason behind the installation of biogas plant was for easy and smokeless cooking whereas 60 percent installed it to get relief from firewood scarcity. Around 71.74 percent plant owners had attached toilet with the biogas plant. Average livestock population size of sampled household was 4 per household. Majority of the respondents (63.04 percent) reported that the agricultural production had been increased. Total

average time saving was 6.16 hours per day per household. Average saving amount of money was Rs.1344/- per month per household.

It was found that from the study, majority of the respondents (60.87 percent) has used saved time on farm activities. This study also revealed that improvement was found in health and sanitation situation. It was also found that women were highly benefited by the biogas plant. About 50 percent households accepted that the overall energy, environmental and economic condition had been improved.

Besides, Nepal (2008) Study shows social development, economic impacts like saving money of firewood, minimisation of health costs due to health improvements, women participation in economic works and slurry use for increasing the productivity of farms. The number of impacts goes even more when environmental protection. Bhattarai (2009) Study consists of the economic benefits and improvement in health and sanitation by using biogas. It also shows the role of biogas for livelihood enhancement. Improvement of health and sanitation from biogas and reduces women workload that contributes for cultural changes in positive way concluded by Wagle (2010) Study. Sharma (2010) comprises the agricultural production had been increased after installation of biogas plants. This study also revealed that improvement was found in health and sanitation situation and women were highly benefited by the biogas plant that the overall energy, environmental and economic condition had been improved. These studies show role of biogas for quality of life, protection of environment and cultural development consistent with this study as well.

Bhandari (2010) conducted study entitled "Socio-economic Impact of Biogas Plants (A Case Study of Bungkot VDC of Gorkha District). The objectives are: 1) to study the biogas plant as an alternative of forest resource, 2) To assess socio-economic benefit of the users from the biogas, 3) To suggest measure for suitable policy formulation.

This study is mainly based on the primary information and the data were collected using the techniques of field survey with the help of structured questionnaire, field visit, observation, unstructured interviews. Majority of the households 61.76 percent have 5 to 7 members in their family whereas the number of households

engaged in agriculture and service sector are 70.59 percent and 20.59 percent respectively.

The study found that Newars (50 percent) were main beneficiaries of the biogas plants. The economic condition of the biogas users' household was found good and most of the biogas plants (91.18 percent) were toilet connected. Even though the plants were found underfed, the gas production was sufficient in summer but it was much less in the winter. Biogas energy was used only for cooking purposes.

The landholding size on this study area population has 21 ropanies or above which is the 60 percent of total population. The people of this study area are mostly rearing buffaloes. Hence, the reliable source of feeding is cattle dung for providing biogas. All the surveyed biogas plants were in good condition and well functioning. Biogas user households were satisfied with the performance of biogas plants because it had positive impact on social, economic, environmental, educational, and health aspects and many other benefits for them. Comparatively, women had experienced much improvement in their health status after the installation of biogas plants then men.

People perceptions about biogas plants were found positive. Biogas has made easy for cooking and maintaining clean environment. The biogas plant made the provision of toilet and also reduced the workload of people. Also biogas plants raised the having started and social prestige to them. Both male and female are happy with biogas plants.

Arthur, Baidoo, & Antwi (2011) found that the associated harmful environmental, health and social effects with the use of traditional biomass and fossil fuel has enhanced the growing interest in the search for alternate cleaner source of energy globally. Ghana, a developing country depends heavy on wood fuel as a source of fuel contributing about 72 percent of the primary energy supply with crude oil and hydro making up the rest. Biogas generation has simply been seen as a by-product of anaerobic digestion of organic waste. Having proven to be a practicable and promising technology, it has been very successful and a very reliable and clean source of energy when proper management programs are followed. There are many vast biomass resources including organic waste in Ghana that have the

potential for the use as feedstock for biogas production to reduce the over reliance of wood fuel and fossil fuel that would reduce greenhouse gas emission. This paper presents the energy situation and the status of the biogas technology and utilization in Ghana. It also presents the potential benefits, prospects and challenges of the biogas technology.

A study by Yadav (2012a) dealt with the role of biogas for sustainable development in Nepal. The results have been estimated by using data for the period of Fiscal Year 1992/93 to 2010/11. The study revealed the significant role of biogas for sustainable development in Nepal. The study also concluded that the vital role of biogas to mitigate the climate change and for quality of life in Nepal.

Adhikary (2012) dealt with green economy in pursuance of sustainable development in Nepal. He explored that development should not be pursued in isolation but should best be interfaced with nature for an improved and sustained quality of life. The pursuit of green economy requires a considerable change in our approach to development wherein the greening of the sectors needs to be planned at the very outset of the process. This study has conceptualized, and discusses strategic thrust, sector integration, management dynamism and institutional and policy regime as a basic embodiment in a green economic framework. It may involve mobilization of additional resources but is worth an investment for all smiles in near future. Green Economy Framework is a critical stepping in leading to sustainable development which is indeed an ability to transform from one phase of the timeline to the other phase.

As a final point, Bhandari (2010) finds positive impact of biogas on social, economic, environmental, educational, and health aspects and many other benefits for the users. Comparatively, women had experienced much improvement in their health status after the installation of biogas plants then men. Biogas has made easy for cooking and maintaining clean environment and increase social prestige. Arthur, Baidoo, & Antwi (2011) Study consists of a very successful and a very reliable and clean source of energy when proper management of biogas programs that help reduce greenhouse gas emissions which may be affecting climate change. A study by Yadav (2012a) dealt with the role of biogas for sustainable development that concluded that the vital role of

biogas to mitigate climate change and for quality of life in Nepal. Likewise, Adhikary (2012) deals with green economy in pursuance of sustainable development in Nepal that very much similar to this study.

2.3. Concluding Remarks

There are several studies conducted in the area of biogas and sustainable development as discussed in the following pages. Sigdel and Das (1990) show the forest conservation and economic benefits from the biogas while Karmacharya (1992) indicates the social development. Likewise, Keier (1993) study consists of economic benefits, social development, improvement in health and sanitation, and protecting environment.

Likewise, Britt (1994) finds social and cultural changes, and economic benefits while livelihood enhancement through micro enterprises, health and sanitation benefits have comprised in New Era (1995) Study. Adhikari (1996) mentions improvement in quality of life through health and sanitation and reduction of workload of women. These studies support to analyze quality of life, environment protection and changes through using biogas.

Additionally, Nepal (2001) finds the vital role of biogas for increment in sanitation and saved time that improves quality life as well as protecting environment through forest conservation. Karki, Karki, & Khadka (2002) conclude the increase in crop production and reduction of chemical fertilizer by using biogas. Similarly, White (2005) Study consists of the role of biogas as cleaner and efficient energy for agriculture development that consistent with this study for analyzing quality of life through starting micro enterprises.

In addition, Ghimire (2006) concludes improvement in health and sanitation situation and their social status was raised. It was also found that women were highly benefited by the biogas plant that the overall energy, environmental and economic condition had been improved. Subedi (2006) finds the users of biogas have brought the significant improvement in the quality of life and reduction on the work load of women. Timsina (2008) Study comprises time saving after installation of biogas from firewood collection, cooking activities and washing utensils. The

use of slurry has increased the production especially maize, paddy and vegetables and the use of chemical fertilizer has been reduced which has helped in saving money. These study reveals that the role of biogas for quality of life, protecting environment and cultural development on one way or another.

Besides, Nepal (2008) shows social development, economic impacts like saving money of firewood, minimisation of health costs due to health improvements, women participation in the economic works and slurry use for increasing the productivity of farms. The number of impacts goes even more when environmental protection. Bhattarai (2009) Study consists of the economic benefits and improvement in health and sanitation by using biogas. It also shows the role of biogas for livelihood enhancement. Improvement of health and sanitation from biogas and reduces women workload that contributes for cultural changes in positive way concluded by Wagle (2010) Study. Sharma (2010) comprises the agricultural production had been increased after installation of biogas plants. This study also revealed that improvement was found in health and sanitation situation and women were highly benefited by the biogas plant that the overall energy, environmental and economic condition had been improved. These studies show the role of biogas for quality of life, protection of environment and cultural development consistent with this study as well.

As a final point, Bhandari (2010) finds positive impact of biogas on social, economic, environmental, educational, and health aspects and many other benefits for the users. Comparatively, women had experienced much improvement in their health status after the installation of biogas plants than men. Biogas has made easy for cooking and maintaining clean environment and increase social prestige. Arthur, Baidoo, & Antwi (2011) Study consists of a very successful and a very reliable and clean source of energy when proper management of biogas programs that help reduce greenhouse gas emissions which may be affecting climate change. A study by Yadav (2012a) deals with the role of biogas for sustainable development that concluded that the vital role of biogas to mitigate climate change and for quality of life in Nepal. Likewise, Adhikary (2012) deals with green economy in pursuance of sustainable development in Nepal that very much similar to this study.

Several studies have been conducted in Nepal and abroad reveal the fact that the role of biogas seems vital for sustainable development including environmental protection, cultural development and other benefits. The studies conducted in Nepal either focus on technical aspects or environmental aspects of biogas and less on sociological aspects. The applicability of these facts is yet to be seen in the context of Nepal. In this context, a sociological study of biogas is considerable to investigate. The study then concentrates its attention to assess role of biogas for sustainable development. Thus, the study on the role of biogas for sustainable development may be very rewarding.

CHAPTER-III: RESEARCH METHOD

This chapter has been divided into six sections. Section 1 presents the research design of the study while section 2 deals with the nature and sources of data. Section 3 consists of population and sample whereas section 4 explains the tools of data collection employed in the study. Similarly, the method of analysis and definition of key terms are provided in the Sections 5 and 6 respectively.

3.1. Research Design

Research design is the plan, structure and strategy of investigation conceived so as to obtain answers to the questions and to control variance (Kerlinger, 1986). The research design refers to the entire process of planning and carrying out a research study (Wolff & Pant, 2005). It describes the general framework for collecting, analyzing and evaluating data after identifying: (i) what the researcher wants to know, and (ii) what has to be dealt with in order to obtain required information. In order to achieve the objectives of this study, descriptive cum analytical research design has been adopted.

Descriptive research design has been utilized mainly for conceptualization of the problem. In descriptive approach, to conceptualize the different aspects of education, religion, size of family, involvement in decision-making; spend earning, land ownership, housing facilities, family income & expenditure. On the other hand, analytical research design has been followed mainly to analyze the results comes from analysis. In analytical approach, results on the role of biogas for quality of life, protecting environment, and cultural development were analyzed to furnish the study.

3.2. Nature and Sources of Data

The study has comprised of both qualitative and quantitative data as well as both primary and secondary data. The necessary data collected from various sources. The data related with the literatures will be collected through literature survey. In order to achieve the objectives of the study, the other secondary data have been collected from the database of Biogas Sector partnership-Nepal (BSP-Nepal)

based on check list. This study has used cross-sectional data of Nepalese biogas sector for the period of 1992/93 to 2012/13. The primary data collected by using structured questionnaire to get opinion of biogas users as mentioned in Appendix-1. All relevant research issues translated into question for field survey. The survey conducted at Ward Number 6 of Niglihawa VDC, Kapilvastu district of Nepal. Sixteen biogas users out of twenty two users have been selected randomly for the study.

3.3. Population and Sample

The study has employed multi-stage sampling to determine sample. The Kapilvastu District and Ward number 6 of Niglihawa VDC have selected based on judgmental sampling. The primary rational behind the selection of this study area is proximity with the forest that makes easier to get genuine information on reduction of deforestation. The secondary rational is uses of both dung cake and firewood before installation of biogas plants by the biogas plant owners. However, the simple random sampling (SRS) method has employed to determine study unit for the study. The plant owner is the study unit for this study. There are 22 biogas plants constructed at Ward Number 6 of Niglihawa VDC, Kapilvastu district of Nepal. Sixteen biogas users out of twenty two users have been selected randomly for the study by applying lottery method. Under which, the name slip of all 22 biogas plants owner was prepared and put together in a box and then pick 16 from them as the sample for the study. The list of respondents is mentioned in Appendix-2. The primary data have been collected by using sample method to get opinion of biogas users. All relevant research issues have translated into question for field survey 2013. The sample of the study has given in Table 3.1.

Table 3.1: Selection of Sample for the Study

Total number of household with biogas plats in Niglihawa-6, Kapilvastu	Number of household with biogas plats selected for the study	Number of sampled household with biogas plats (%)	Remarks
22	16	72.73%	

Source: The database of BSP-Nepal and field survey 2013

The sample of the study has selected randomly. There is 72.73 percent household with biogas plants selected for this study which represents the population of household with plants constructed at Niglihawa-6 of Kapilvastu district.

3.4. Tools of Data Collection

The study unit is biogas users at Number 6 of Niglihawa VDC, Kapilvastu district of Nepal. The tools of data collection divided into two sections as given below:

3.4.1. Questionnaire

Data design is a plan of what data to gather, from whom, how and when to collect data and how to analyze it. For direct measurement of factors, each research question was translated into a question to capture participant's perception through field survey 2013. Each question included in the questionnaire of this study is based on the insight learnt from literature review, researcher's experience and questions used in similar studies in the past. The questions used in this study developed and customized in the context of study area.

The questionnaire is the prime instrument for this study. There are seven sections of questionnaire used in this study. Demographic information and information on biogas plant have comprised in section 1 and 2 respectively. Section 3 consists of biogas in relation to health and sanitation while biogas in relation to income generation has included in section 4. Biogas in relation to environment and cultural development has mentioned in section 5 and 6 respectively. Section 7 has devoted with some other points related with biogas. With this information, this study has determined the role of biogas for sustainable development.

3.5. Data Analysis

Analysis is the careful study of available facts so that one can understand and draw conclusions from them on the basis of established principles and sound logic (Cottle, 1988). The annual data obtained from the database of BSP-Nepal and questionnaire has edited, tabulated and analyzed through applied statistics using IBM SPSS Statistics 20 which facilitate the process of data analysis in a more precise and appropriate way. Moreover, the simple statistical techniques of

analysis such as table, percentage, graphs, and correlation coefficient (r) have employed to a number of cases in this study. Likewise, White's formula has used in this study to assess the role of biogas for cultural development. The role of biogas for sustainable development has determined through analyzing of biogas in relation to quality of life, protecting environment, and social and cultural development.

3.6. Definition of Key Terms

The terms used in this study have different meanings as per context and perspective. It is, therefore, desirable to define some key terms so as to avoid misunderstanding.

Renewable Energy: Renewable energy is energy that comes from resources which are continually replenished such as sunlight, wind, rain, tides, waves and geothermal heat (Wikipedia: 28 Feb 2013). Renewable energy technologies such as biogas, solar and micro-hydro are widely promoted in Nepal and biogas only considered for this study.

Renewable Energy Sector: All the enterprises involved in construction and consulting services for renewable energy technologies (RETs) under AEPC are regarded as renewable energy industry. Moreover, the industry is taken as renewable energy sector.

Biogas: Biogas is the mixture of different gases produced by methanogenic bacteria feeding on bio-degradable materials in anaerobic (oxygen-less) conditions. Biogas contains 50 to 70 percent methane and 30 to 40 percent carbon dioxide with other gases (AEPC, 2012).

CHAPTER-IV: THE ROLE OF BIOGAS FOR SUSTAINABLE DEVELOPMENT

This chapter has been divided into four sections. Section 1 has incorporated study area while the role of biogas for quality of life has analyzed in section 2. Section 3 comprises the role of biogas for protecting environment. Finally, section 4 discusses the role of biogas for social and cultural development.

4.1. Study Area

This study is confined to only Jaralahiya village of Niglihawa VDC of Kapilvastu district where the main sources of income are crops farming, vegetable farming and cattle rearing. It is expensive for the people of the area to use other commercial sources of energy such as kerosene and LPG while use of firewood and other traditional biomass fuels for cooking are more time consuming and not environment friendly.

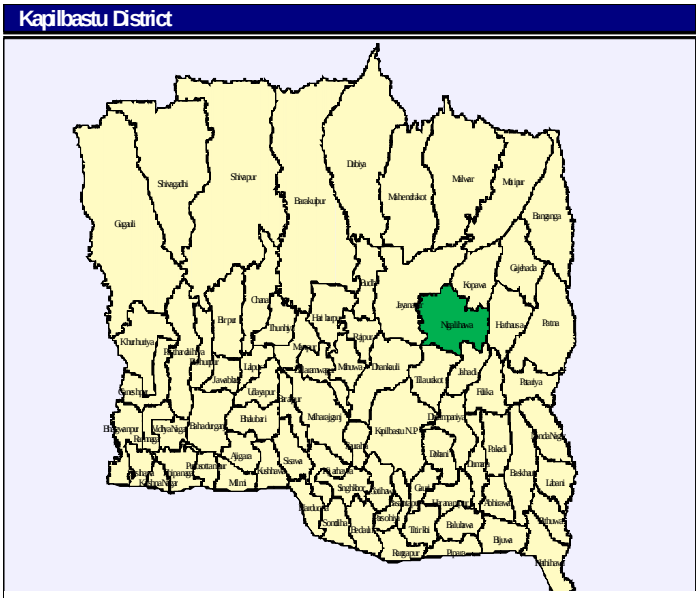


***Figure 4.1*:** Map of Kapilvastu indicating study area

There are 9 wards in the Niglihawa VDC. The Jaralahiya village lies in ward No. 6 of Niglihawa Village Development Committee (VDC). Nigalihawa is a VDC of Kapilvastu District in the Lumbini Zone of southern Nepal. The Kapilvastu district, with Taulihawa as its district headquarters, covers an area of 1,738 km^2 and has a population of 481,976 in 2001 and 571,936 in 2011. The district has 15 Ilakas, 77 VDCs, 1 Municipality and 5 constitutional assembly divisions. Among others, there is a popular tourist place Tilaurakot, the Shakya kingdom of Buddha's regime.

Additionally, the study area is about 9 kilometers north of Kapilvastu Municipality. There is Banaganga River to the west, Kopawa VDC to the north, Jahadi VDC to the east and Tilaurakot VDC to the south of this VDC. Niglihawa VDC has 11,235 populations including 5,435 males and 5,800 females. Likewise, Jaralahiya has 121 households and 788 populations including 392 males and 396 females. In the study cluster, there are four settlements and some households are scattered. Two small temple called Kalimai temple and Samaymai temple are in this village. There are some necessary facilities such as electricity, gravel roads, ground water for drinking, cannel for irrigation in the village. However, school, Sub-health Post and PCO are in neighboring Ward. Besides that, there is a big reservoir named Jagadishpur Tal. In the west of the village, there is a big Jungle. Sometimes, people see tiger, deer, fox, rabbit and other wild animals. Moreover, the people can see mountain from the village in the north. There is very hot in summer while very cold during winter. The major occupation of the people of the village is farming. Most of the people of the village speak Bhojpuri language as mother tongue and some speak Awadhi and Nepali. All the people of the village follow Hindu religion. They celebrate Dashain, Tihar, Holi etc. Similarly, smoke pollution can cause serious damage to health especially that of women who directly involves in cooking. The biogas plant which reduces the emission of smoke can therefore significantly contribute towards improving the quality of life of the people in this area.

Furthermore the study has collected biogas users' opinion through field survey 2013. The study has taken 16 households with biogas plants as sample of the study as mentioned in Annex-2. The respondents mix is given in Table 4.1.

Table 4.1: Respondents Mix

Basis	Data					
Gender	**Male**	**Female**	**Total**	**Remarks**		
	14	2	16			
Occupation	**Farmer**	**Student**	**Trader**	**Politician**	**Cook**	**Total**
	8	4	2	1	1	16
Education	**10+2**	**SLC**	**Barely Literate**	**Illiterate**	**Total**	**Remarks**
	4	6	4	2	16	

Source: Field survey 2013

The respondents' age are ranged between 22 to 55 years old. The average family size of the respondents is 9.06. Fourteen out of 16 respondents have 6 m3 biogas plants while one has 8 m3 and rest another one has 4 m3 biogas plant.

In addition, 15 plants out of 16 selected plants are 5 years old while one plant is more than 10 years old. The respondents consist of 14 male and 2 female. The respondents' occupations have been comprised of 50 percent farmer, 25 percent student and 12.5 percent trader whereas 6.25 percent politician and 6.25 percent cook. The education mix of the respondents include: 25 percent are 10+2, 37.50 percent are SLC, 25 percent are barely literate and rest 12.50 percent are illiterate.

4.2. The Role of Biogas for Quality of Life

The term quality of life is used to evaluate the general well-being of individuals and societies. The term is used in a wide range of contexts, including the fields of business, industries, development, healthcare, and politics. Quality of life should not be confused with the concept of standard of living, which is based primarily on income. Instead, standard indicators of the quality of life include not only wealth and employment, but also the built environment, physical and mental health, education, recreation and leisure time, and social belonging. Diverse "objective" and "subjective" indicators within a range of disciplines, scales and the psychology of happiness have encouraged renewed interest in quality of life. Among others, the quality of life comes up with quality product and service by creating happiness, professional quality of life or quality of work life. Consequently, the role of biogas for quality of life in case of Nepal has determining through examining in relation to health and sanitation, enterprise and employment, feed and fertilizer as discussed in the following pages.

4.2.1. Biogas in Relation to Health and Sanitation

Health and sanitation is one of the most important aspects for quality of life. Indoor air pollution resulting from fuel wood use is one of the major causes of health and hygiene dilemma in rural Nepal. Another important factor is the contamination from unmanaged wastes and germs leading to waterborne diseases.

The results of analysis of primary data show the role of biogas in relation to health and sanitation as given in Table 4.2. Eleven out of 16 respondents have experienced decrease in the frequency of visits to hospital/health post/clinic for checkup after the installation of biogas plant. However, 5 out of 16 respondents believed that the frequency remained the same. All the respondents think that there are changes in the general cleanness of the surrounding after the installation of biogas plants.

Table 4.2

Frequency of Visits to Hospital for Checkup after the Installation of Biogas Plant

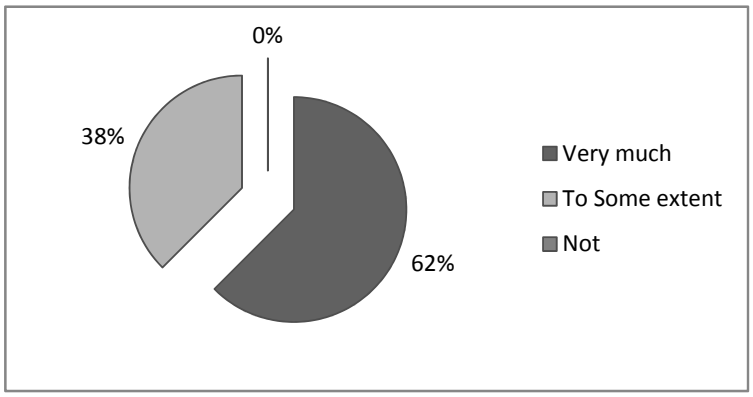
SN	Particulars	Responses		Remarks
		Number	*Percentage*	
1	Decrease	11	68.75	
2	Remained same	5	31.25	
Total		**16**	**100**	

Source: Field survey 2013

Additionally, 15 out of 16 respondents think biogas does not generate bad smell in the kitchen while rest one has expressed it generates bad smell. On the other hand, all respondents have toilet. Fifteen out of sixteen toilets constructed together with biogas and only one constructed beforehand. Likewise, fifteen out of sixteen toilets connected with biogas plants. The owner of a biogas plant that is not connected with toilet had believed cooking with the gas produced from human waste is not safe and hygienic. However the owner has agreed that it can be connected now. It means that biogas plays role to improve health and sanitation by enforcing to build toilet and also connect with biogas plants. Similarly, 10 and 6 out of 16 respondents have felt the decrease in the indoor smoke very much and to some extent respectively after biogas plant installation as shown in Figure 4.2.

Figure 4.2

Responses on Decrease in the Indoor Smoke



Source: Field survey 2013

Thus, the biogas reduces indoor and outdoor pollutions and improves health and sanitation.

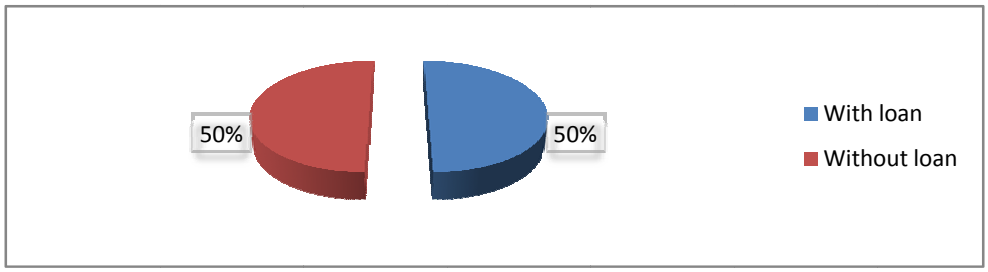
Furthermore, there are 290,902 biogas plants have been installed in Nepal during Fiscal Year 1992/93 to 2012/13 (BSP-Nepal). There are 95% plants are operational as per Biogas User Survey. Accordingly, 276,357 households have accessed to clean renewable energy. The result revealed that biogas has played a great role to improve health and hygiene providing clean energy, smokeless kitchen and toilet connection in 167,356 households that directly associated with children and women's health and hygiene. Biogas in relation to health and sanitation provides basis for quality of life that leads to economic and social changes that contributes for sustainable development in one way or another.

4.2.2. Biogas in Relation to Enterprises and Employment

Biogas is important in relation to enterprises and employment through economic empowerment, saving time, and creating agro-based micro enterprises. Fifty percent of respondents were taken loan to construct the plant and paid their loan from sales of crops/animals/vegetable as shown in Figure 4.3.

Figure 4.3

Biogas Constructed with Loan and without Loan



Source: Field survey 2013

It empowers them to get loan and mobilize it properly along with payment. In addition to this, it also develops saving habits to pay loan after saving for future.

Moreover, 9 out of 16 respondents believed that biogas is not more costly than other sources of energy while 5 respondents think it is the same. One respondent feel it is costly to others and rest one respondent does not express. Biogas saves time of the rural men and women including children in one way or another. The people of the study area saved 1.844 hours daily from fuel manage of dung cake and firewood while they saved 0.491 hours from cooking. They also saved 0.456 hours from washing utensils daily after construction of biogas. The average time saved per day in aggregate is 2.791 hours after installation of biogas which is slightly lower than the national average time saved daily in each household of 3 hours as per Biogas User Survey. The brief description of saving of time is given in Table 4.3.

Table 4.3

Saving Time after Installation of Biogas Plant

SN	Works	Average time saved per day (in hours)	Saving by:		
			Male	*Female*	***Both***
1	Fuel manage (dung cake or firewood)	1.844	1	3	**12**
2	Cooking	0.491		14	**2**
3	Washing utensils	0.456		16	
Total average time saved per day (hours)		**2.791**			

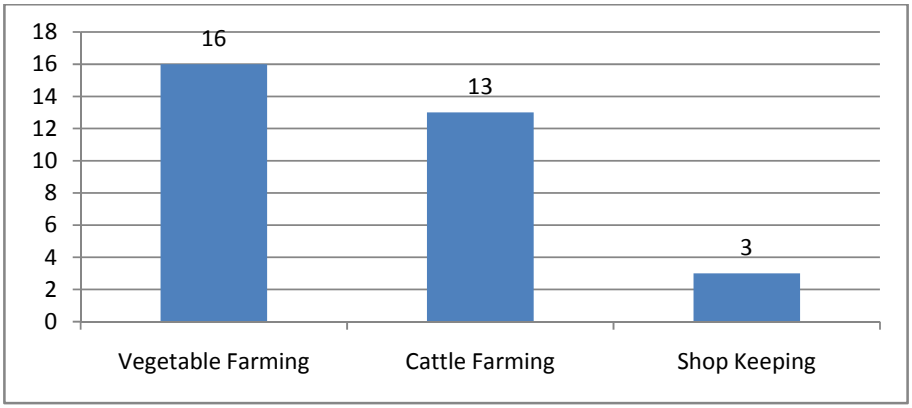
Source: Field survey 2013

The saving of time is most often by female as shown in Table 4.3. It means it reduces workload of women than that of men. View in this perspective, both male and female are involved in fuel manage at great extent but only females are involved in cooking and washing utensils at larger extent.

The biogas users utilize their saved time for both productive purposes and social work. The people of the study area before installation of biogas plants were also involved in farming however; they spent more time farming after installation of plants. They use their saved time for vegetable farming, cattle farming and shop keeping as shown in Figure 4.4.

Figure 4.4

Utilization of Saved Time by the Respondents



Source: Field survey 2013

All respondents use their saved time for vegetable farming while 13 respondents also use it for cattle farming. Only 3 respondents use their saved time in shop keeping after installation of biogas plant.

Among others, there are some other points in relation to biogas that contribute for quality of life. Biogas is also important in relation to gender role. Women specifically in rural areas of Nepal are confronted with a high workload. They not only work inside the house but also go away to collect fuel wood and fodder. In deforested areas, women spend significant time collecting fuel wood. Besides carrying out almost all domestic works, they are also involved in major part of the agricultural activities in the field. Both men and women are benefited by biogas

installation. The benefits are more for women as compared to their workload in household chores. Thus, biogas is an important technology in order to improve social condition of women in rural areas of Nepal. Furthermore, biogas also saved fuel for the sources of energy that saved money at the end in one way or another. Table 4.4 shows weekly saving amounts.

Table 4.4

Saving from Consumption of Fuel after Installation Biogas Plants

SN	Sources of energy	Weekly saved amount (Rs)	Remarks
1	Firewood	375.00	
2	Dung cake	184.38	
Total saved amounts (NRs.)		**559.38**	

Source: Field survey 2013

The average amounts saved in aggregate in NRs. 559.38 weekly per house consisting of NRs. 375 from firewood and NRs. 184.38 from dung cake. Likewise, the monthly and annual amounts saved have been NRs. 2,237.52 and NRs. 26,850.24 respectively. Thus, it also generates income for the rural people.

Moreover, biogas also plays a great role in reduction in brain drain & muscle drain and in reduction in migration from rural to urban and beyond. It also provides better rural life through available of basic services and improved urban life by managing of urban waste. Biogas contributes for sustainable economic growth by creating enterprises within country and reducing dependency on remittance as well as address energy crisis at larger extent.

View in this perspective, Biogas Construction Company has been involving in plants construction throughout 75 districts of Nepal (BSP-Nepal, 2012). There 107 private Biogas Companies have been strengthened and 17 Biogas appliances manufacturing workshops are developed. Likewise, 264 micro finance institutes got wholesale loan from AEPC's credit fund. Around 13,000 persons have gotten employment directly, indirectly in this sector (BSP-Nepal, 2012). In addition, there are many NGOs, consulting firms, entrepreneur that are involved in promotion of biogas technology. As the demand for biogas is increasing, employment of skilled and unskilled labour has been increasing every year. Thus, biogas contributes to

create enterprises and employment. It improves biogas user's livelihood through starting agro & forest based micro enterprises by utilizing saved time and bio-slurry such as: cash crops, cattle farming, fish farming, etc.

4.2.3. Bio-Slurry as Feed and Fertilizer

Bio-slurry, as one of the outputs of anaerobic digestion system, can profitably be returned to the agricultural system. The close relation between biogas and agriculture can be taken as an indicator of "eco-friendly" nature of the technology. Bio-slurry can be used not only as organic fertilizer or pesticide for crops, but it can also be used as feed for animals like pig, fish, etc.

Figure 4.5: Vegetable Farming Using Bio-fertilizer

Photo by: MP Yadav

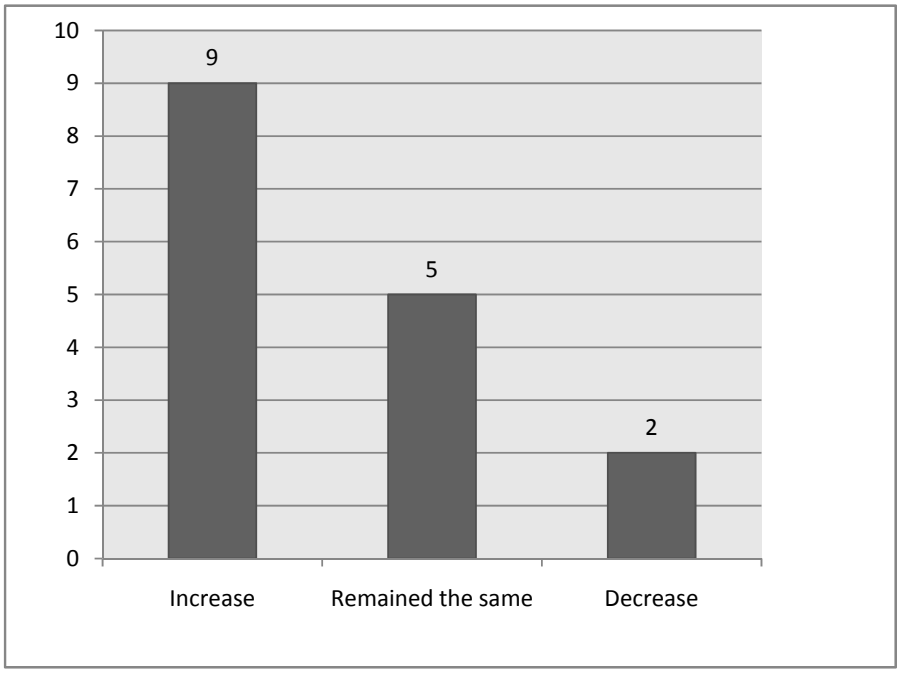
Bio-slurry has proved to be high quality organic manure rich in humus. It plays an important role in supplying plant nutrients, improving soils, and increase water holding capacity. It is also stabilizing its humid content and preventing the leaching of nutrients. The bio-fertilizers are used to improve the fertility of the land using biological wastes. They are extremely beneficial in enriching the soil with those micro-organisms, which produce organic nutrients for the soil and help combat diseases. The farm produce does not contain traces of hazardous and poisonous materials. Thus those products are accepted across the world as organic ones. Bio-slurry can use as bio-fertilizer after *bio-composting* while other agro-residuals utilize as bi-fertilizer after processing through *bio-char stove*.

View in this perspective, the analysis of the primary data shows all the respondents use bio-slurry as bio-fertilizer and one respondent also uses it as fish meal. The utilization of bio-slurry in farming is higher as all the respondents are belonging to farming. On the other hand, 10 out of 16 respondents use bio-slurry after composting while rest six respondents use it directly. It means that all the

respondents are not fully aware about proper composting of the bio-slurry. The bio-fertilizer has positive role on the production of crops as shown in Figure 4.6.

Figure 4.6

Status of Production after Installation of Biogas Plants



Source: Field survey 2013

Nine out of sixteen respondents believed that production increased by using bio-slurry while five respondents believed production remained the same. Two respondents think the production decreased somewhat. They believe the nutrients of bio-fertilizer decreased after digested in biogas plants. However, this logic contradicts with the general propositions. On the other hand, the larger number of respondents has expressed that vegetable and paddy increase after using bio-slurry. Ten and eight out of sixteen respondents think production of vegetable and paddy respectively increases by utilizing bio-slurry. One respondent think it increases production of all crops whereas one believes only production of fruits increases by utilizing bio-slurry. In addition to this, there are mix responses on advantages of slurry over dung. Five out of sixteen respondents think it is more effective than dung while four respondents think it is the same as composing of

dung. Three respondents think it do not have advantages while the rest four respondents do not like to say in this regard.

There are 276,357 plants functioning assuming 95 percent plants that are operational as per Biogas User Survey (BSP-Nepal). View in this perspective, there are 1.75 tons slurry & compost fertilizer annually per household (BSP-Nepal, 2012). In total, there is production of 483,623 tons slurry & compost fertilizer per year that enhances independency through reduction of chemical fertilizer and fish meal.

4.3. The Role of Biogas for Protecting Environment

The role of biogas for protecting environment in the case of Nepal has determining through examining in relation to forest conservation and reduction of Pollution.

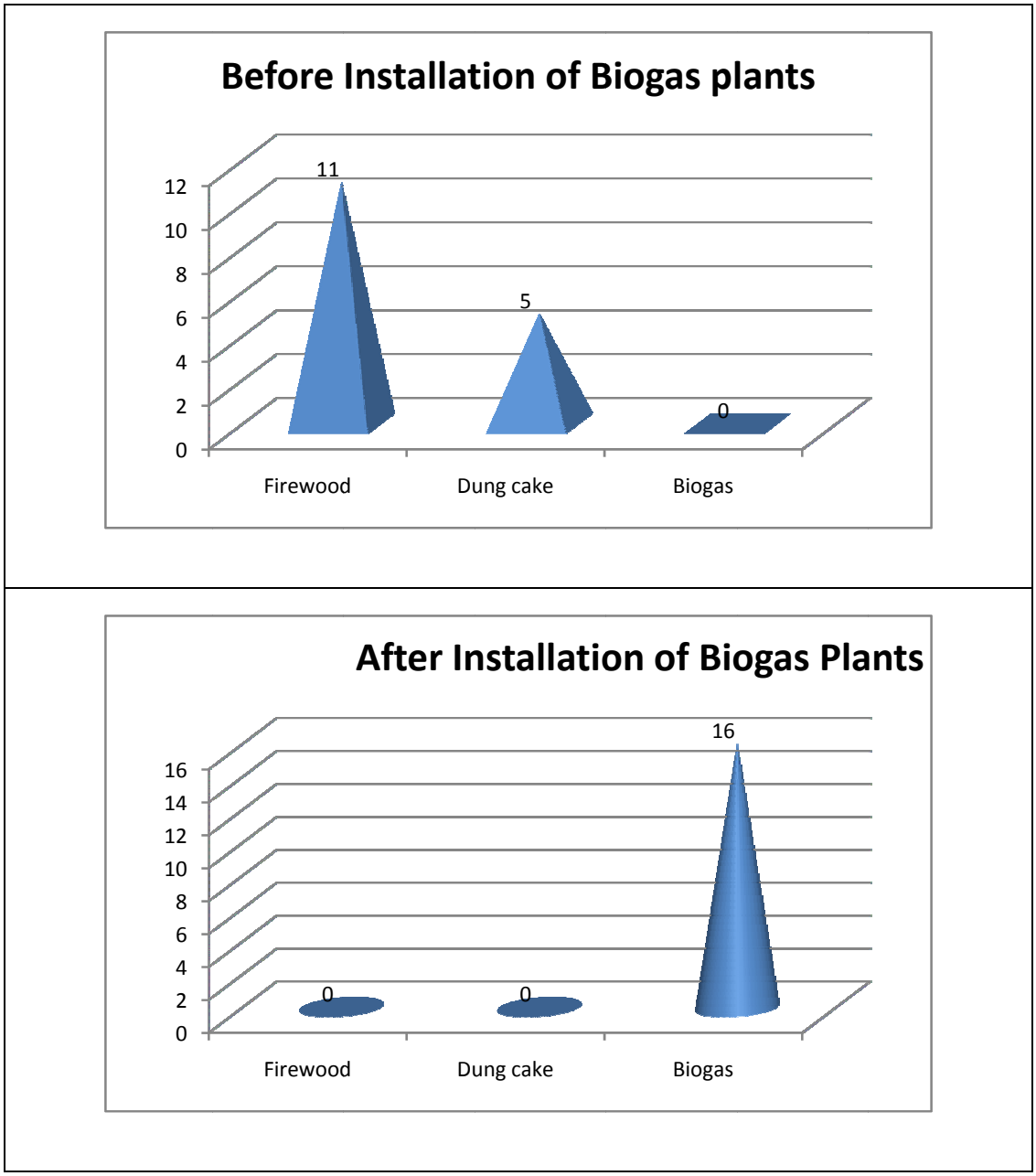
4.3.1. Biogas in Relation to Forest Conservation

Biogas is an important medium in relation to forest conservation. The forest conservation is an important factor for protecting environment. The decrease in fuel wood consumption due to its substitution by biogas stoves has threshold benefits. *Firstly*, at individual level it incurs financial gains to the households as they can save some money which would otherwise be spent in purchasing the fuel wood or spending time for the same. Similarly, the substitution of fuel wood by biogas also saves time and effort required on fuel wood collection, which in some cases could even be many hours of daily work. *Secondly*, at national level the decrease in the use of fuel wood contributes to some extent in reducing the prevailing high rate of deforestation of the country.

The primary survey shows that all respondents use biogas for cooking and one respondent has also used for lighting. The respondents were used either firewood or dung cake for cooking before installation of biogas plant as given in Figure 4.7. Eleven out of sixteen respondents used firewood for cooking while five respondents had used dung cake for cooking ***before*** installation of biogas.

Figure 4.7

Status of Cooking Fuel before and after Installation of Biogas Plants



Source: Field survey 2013

In addition to this, all respondents think that the installation of biogas plant has saved the other fossil fuel. It contributes to reduce deforestation ***after*** installation of biogas.

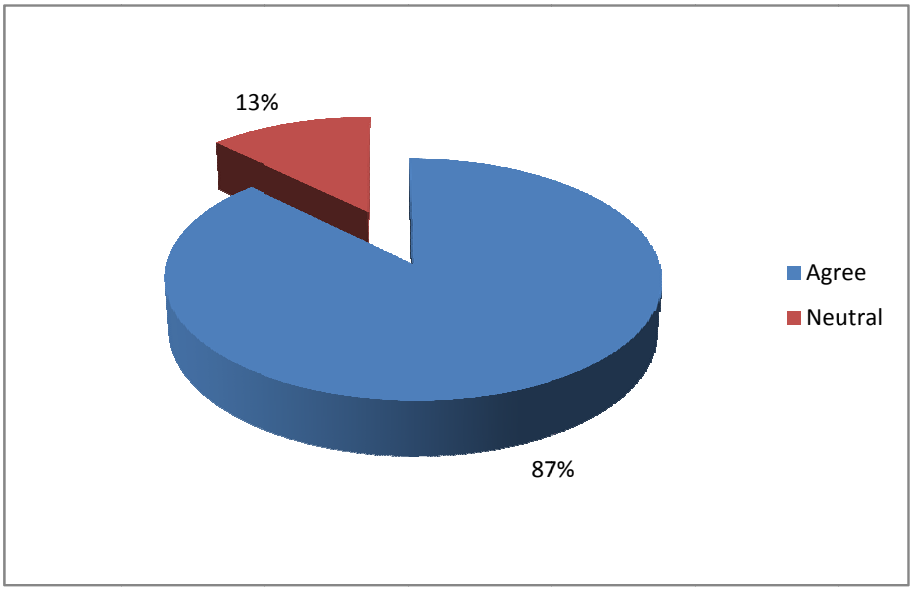
The amount of gas produced from biogas is sufficient during summer as all the respondents agree on. Likewise, twelve respondents agree that gas is sufficient in

winner while four respondents express their views that gas is insufficient during winter. The insufficient of energy has been managed from firewood and/or dung cake.

Furthermore, 14 out of 16 respondents agree that deforestation affects environment negatively while the rest two respondents are neutral in this regard as indicated in Figure 4.8.

Figure 4.8

Responses on Deforestation Affects Environment



Source: Field survey 2013

There are 87 percent respondents agree that deforestation affects environment negatively while the rest 13 percent respondents are neutral in this regard. Biogas plays a great role to reduce deforestation by reducing fuel wood. Hence, biogas contributes for protecting environment through forest conservation. As for national average, there are 1.25 trees protected per year per plant as per Biogas User Survey (BSP-Nepal, 2012). In total, 345,446 trees protected per year that enhance greenery and protect environment as well.

4.3.2. Biogas in Relation to Reduce Pollution

Energy plays indispensable role in running the wheels of the economy of any country and more importantly in the lives and livelihoods of its people. Moreover, greenhouse gas emission reduced from the decrease in the use of fuel wood, agriculture residues, dung cake and kerosene consumption.

Based on the results of primary survey, biogas helps reduce the both indoor and outdoor pollution through reducing smokes in kitchen and outdoor. *Fifteen* out of sixteen respondents believes that it reduce both pollution while only one respondent think that it does not reduce them.

Moreover, UN Summit on global warming termed as the Earth Summit took place in Rio de Janerio, Brazil in 1992 (UN Department of Public Information , 1997). The Summit formulated and adopted the UN Framework Convention on Climate Change (UNFCCC), which established principles and objectives but there was no specific target or obligations. Nepal ratified the Convention in 1995 as a party of the UNFCCC. In the follow up, the Conference of the Parties (CoP) of the UNFCCC that was held in Kyoto, Japan in 1997, drafted and adopted Kyoto Protocol. This treaty of UNFCCC sets specific targets and actions for the Annex I and Non-Annex I parties (UN Department of Public Information , 1997). The Kyoto Protocol in 1997 had the following 3 streams to meet the targets and legal obligations:

- Joint Implementation (JI) of Projects in an Annex I Country,
- Emission Trading among Annex I Parties, and
- Clean Development Mechanism (CDM).

Under the Clean Development Mechanism (CDM), the reduction of emission from projects in developing countries can be traded with Annex I countries to meet their targets. Nepal signed the instrument of accession to the Protocol and a party in September 2005.

In this perspective, biogas project has been registered with the CDM board as the ***first*** project of Nepal. There is 2.4 tons reduction of greenhouse gas emission

annually per household as per CDM methodology (BSP-Nepal, 2012). 59,968 plants have registered with CDM board till the end of FY 2012/13 (BSP-Nepal, 2012). Thus, biogas plays role for protecting environment through forest conservation, reduction in pollution and green house gas emission that leads to sustainable development.

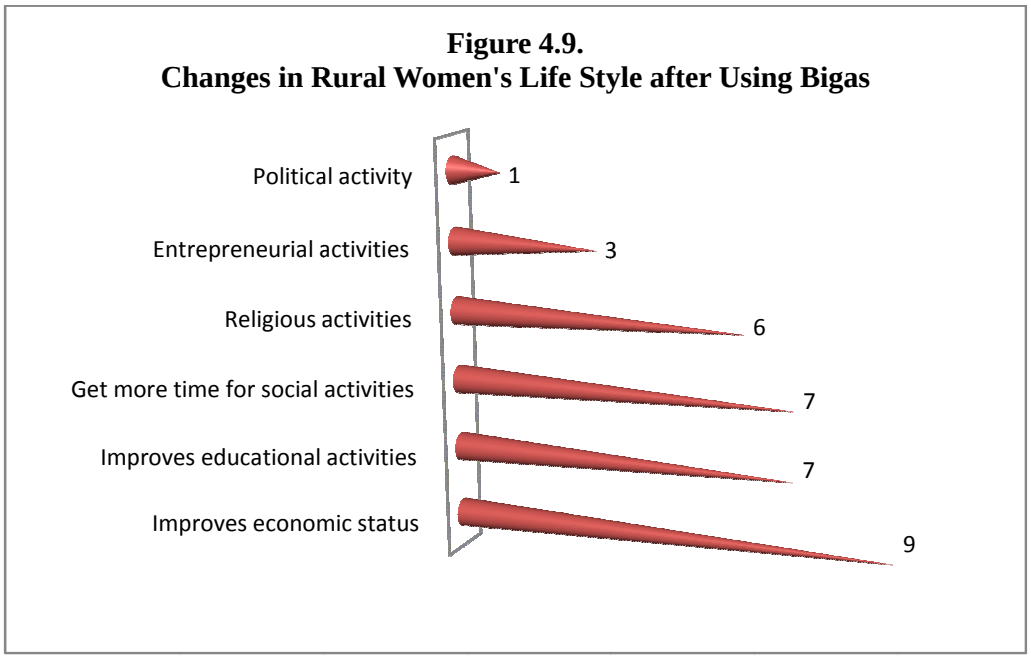
4.4. The Role of Biogas for Social and Cultural Development

Biogas in relation to cultural development has studied analyzing primary and secondary data. The primary data consists of responses of 16 respondents from Niglihawa-6 of Kapilvastu district. The result shows that 15 out of 16 respondents believe that biogas plays positive role for cultural changes and rest one is neutral in this regard. This means that biogas plays role for cultural development. The cultural changes the cooking practices, the use of saved time in social functions that lead to the social development.

It is further found that 10 out of 16 respondents have expressed biogas contributes positive changes of the role of women in social activities while the rest are neutral. The positive cultural changes are as: ***cooking practices using gas rather than firewood, use of toilet than open defecation, more time for participation in women's group meeting***. The rural women's life styles have been changed after using biogas. The major results are: 1) it improved their economic status (9 responses out of 16); 2) It helped improve educational activities (7 responses out of 16); 3) they get more time for social activities (7 responses out of 16), religious activities (6 responses out of 16), entrepreneurial activities (3 responses out of 16) and political activity (1 response out of 16). These results are also shown in Figure 4.9.

Moreover, fifteen out of sixteen respondents has connected toilet with biogas nowadays. All respondents think that human waste can be used for biogas plants.

Figure 4.9.
Changes in Rural Women's Life Style after Using Bigas



Source: Field survey 2013

Thus, these results show that biogas plays an important role for the social and cultural development through many ways.

Among others, the children use 1.66 hours daily before biogas installation while 2.28 hours after installation. The children use 0.62 hours more in average for study per day. The incremental time per day for the study is 37.35 percent. Thus, biogas plays an important role for social development through education and contributes for cultural development. The time utilization for study before and after installation of biogas is given in Table 4.5.

Table 4.5

Time Uses for Study before and after Installation of Biogas Plant

SN	Particulars	Hours per day	Remarks
1	Before Biogas installation	1.66	
2	After Biogas installation	2.28	
3	Increase in study time daily	0.62	
4	% increase in study time daily	37.35%	

Source: Field survey 2013

All the respondents are satisfied with the increase in study time of their children after biogas plant installation. It is due to time saved from firewood collection, cooking, and washing utensils. Likewise, all respondents have expressed that the female members were consulted for the decision of biogas plant.

Moreover, fifteen out of sixteen respondents are satisfied with the performance of biogas plant while one respondent is not satisfied due to biogas is not in operation. It is due to shifting of cattle shed far away from the plant. Similarly, 15 out of 16 respondents know that they get subsidy for biogas construction while one respondent has expressed no for this question means that not getting subsidy. It is due to indirect modality of subsidy flow to the biogas owner.

Furthermore, the results from analysis of primary data have also supported by the analysis of secondary data in the following pages. The secondary data have analyzed by applying *White's formula* in this study. White understood the world to be divided into cultural, biological, and physical levels of phenomenon. Among others, White comprised culture as an entity that was unique and could be explained only in terms of itself. White spoke of ***culture*** as a general human phenomenon, and claimed not to speak of 'cultures' in the plural. He believed that culture-meaning the total of all human cultural activity on the planet-was evolving. White differentiated three components of culture: **technological, sociological, and ideological**. He argued that it was the technological component which plays a primary role or is the primary determining factor responsible for the cultural evolution. His materialist approach is evident in the following quote: "man as an animal species, and consequently culture as a whole, is dependent upon the material, mechanical means of adjustment to the natural environment". This technological component can be described as material, mechanical, physical, and chemical instruments, as well as the way people use these techniques. White's argument on the importance of technology goes as follows: Technology is an attempt to solve the problems of survival.

- This attempt ultimately means **capturing enough *energy* and diverting it for human needs.**

- Societies that ***capture more energy and use it more efficiently*** have an advantage over other societies.
- Therefore, these ***different societies are more*** advanced in an ***evolutionary sense***.

Furthermore, the primary function of culture and the one that determines its level of advancement is its ability to ***"harness and control energy"***. White's law states that the measure by which to judge the relative degree of evolvedness of culture was the amount of energy it could capture (energy consumption).

White differentiates between five stages of human development as: At first, people use the ***energy*** of their ***own muscles***. Second, they use the ***energy*** of ***domesticated animals***. Third, they use the ***energy*** of ***plants*** (so White refers to ***agricultural revolution*** here). Fourth, they learn to use the ***energy*** of ***natural resources***: coal, oil, **gas**. Fifth, they harness ***nuclear energy***.

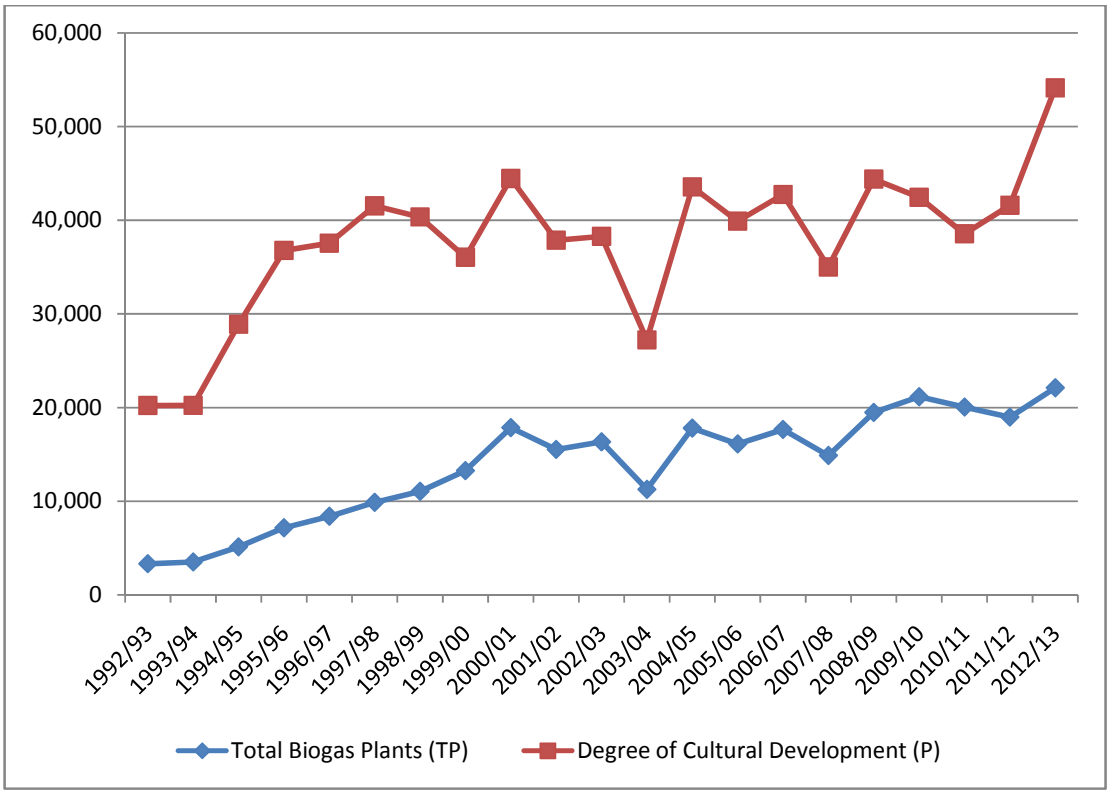
In his own words: "*the basic law of cultural evolution*" was "*culture evolves as the amount of energy harnessed per capita per year is increased, or as the efficiency of the instrumental means of putting the energy to work is increased*". Therefore, this conclude that progress and development are caused by the improvement of the mechanical means with which energy is harnessed and put to work as well as by increasing the amounts of energy employed.

Based on White's formula, Figure 4.10 shows that the degree of cultural development in relation to biogas. It shows that cultural development moves in the same direction with total plants installed over the year.

The upper line of Figure 4.10 shows the trend of degree of cultural development while the lower line shows the trend of construction of biogas plants. The both lines show increasing trend over the year. Moreover, the correlation coefficient (r) between total biogas plants (TP) and degree of cultural development (P) is 0.81. There is very high degree of positive correlation between these two variables. It means total plants and degree of cultural development move in the same direction. If total plants increase then the degree of cultural development also increases and vice versa.

Figure 4.10

Trend of Biogas Plants in Relation to Cultural Development



Source: The database of BSP-Nepal

It means there are positive relation between biogas and cultural development that contribute in the sustainable development. This result supports the result of analysis of the primary data. The results of primary data show that there are positive cultural changes in *cooking practices, use of toilet, and participation in women's group meeting* which are also verified from the analysis of secondary data.

CHAPTER-V: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary

Development is the process of developing or being developed. It means that positive changes are regarded as development. Moreover, sustainable development is the pattern of resources use in such a way that present needs can be met without destroying the ability for future generations to meet their needs. The concept of sustainable development has in the past most often been broken out into three constituent domains: *environmental sustainability, economic sustainability and social sustainability*. The three pillars of sustainable development - economic growth, environmental stewardship, and social inclusion - carry across all sectors of development, from cities facing rapid urbanization to agriculture, infrastructure, energy development and use, water availability, and transportation.

Furthermore, energy is an essential ingredient of socio economic development and economic growth. Renewable energy is energy that comes from resources which are continually replenished such as sunlight, wind, rain, tides, waves and geothermal heat. Reliable and sustainable supply of energy is the basic needs of the people for meaningful life including cooking, lighting and economic activities. Furthermore, renewable energy technologies (RETs) such as biogas, solar and micro-hydro are widely promoted in Nepal and biogas only considered for this study. This ultimately helps to minimize the degradation of the environment. The use of RETs can reduce the dependency on traditional energy and help protect the environment and reduction of pollution that contribute sustainable development, and increases the economic activities. It is expensive for the people of the study area to use other commercial sources of energy while the use of firewood and other traditional biomass fuels for cooking are more time consuming and not environment friendly. Similarly, smoke pollution can cause serious damage to health especially that of women who directly involves in cooking. The biogas plant which reduces the emission of smoke can therefore

significantly contribute towards improving the quality of life of the people in the area.

The major objective of this study is to examine the role of biogas for sustainable development in Nepal. Its specific objectives are: 1) to analyze the role of biogas for quality of life through livelihood enhancement by improving health & hygiene and developing micro-enterprises; 2) to examine the role of biogas for protecting environment through forest conservation and reducing pollution; and 3) to evaluate the role of biogas for cultural development in the context of Nepal.

In order to conduct this study, descriptive cum analytical research design has been employed. Descriptive research design has been utilized mainly for conceptualization of the problem. Analytical research design has been followed mainly to analyze the results. This study has based on both primary and secondary data. In order to achieve the objectives of the study, the other secondary data have collected from the database of BSP-Nepal based on check list. This study has used cross-sectional data of Nepalese biogas sector for the period of 1992/93 to 2012/13. The primary data have collected by using structured questionnaire to get opinion of biogas users. Sixteen households out of twenty two users have been selected randomly for the study. There is 72.73 percent biogas plants selected for this study which represents the population of plants constructed at Niglihawa-6 of Kapilvastu district. This study is confined to Niglihawa VDC of Kapilvastu district for primary data while Nepal as whole for secondary data.

The annual data obtained from the database of BSP-Nepal and questionnaire has edited, tabulated and analyzed through applied statistics using IBM SPSS Statistics 20 which facilitates the process of data analysis in a more precise and appropriate way. Moreover, the simple statistical techniques of analysis such as table, percentage, graphs, and correlation coefficient (r) have employed to a number of cases in this study. Likewise, White's formula has used in this study to assess the role of biogas for cultural development.

Major Findings

The major findings from the study of the role of biogas for quality of life in relation to health and sanitation, enterprises and employment, and bio-slurry as feed and fertilizer are stated as under:

1) Biogas plays important role for the quality of life through improving health and sanitation. The results of analysis of primary data show 11 out of 16 respondents have experienced decrease in the frequency of visits to hospital/health post/clinic for checkup after the installation of biogas plant. All the respondents think that there are changes in the general cleanness of the surrounding after the installation of biogas plants. Likewise, 15 out of 16 toilets connected with biogas plants. Thus, the biogas reduces indoor and outdoor pollutions and improves health and sanitation. At national level, 276,357 households accessed to clean renewable energy assuming 95% plants are operational as per Biogas User Survey. The result also revealed that biogas has played a role to improve health and hygiene through providing clean energy, smokeless kitchen and toilet connection in 167,356 households that directly associated with children and women's health and hygiene.
2) Biogas is an important factor in relation to enterprises and employment through saving time and creating agro-based micro enterprises. The average time saved per day per household in aggregate is 2.791 hours after installation of biogas which is slightly lower than the national average time saved daily in each household of 3 hours as per Biogas User Survey. They utilize their saved time for vegetable farming, cattle rearing and shop keeping. Biogas also saved fuel for sources of energy that saved money at the end in one way or another. The average amounts saved in aggregate in NRs. 559.38 weekly per house from firewood and dung cake. On the other hand, around 13,000 persons have gotten employment directly, indirectly in this sector including biogas companies, NGOs, and micro financing institutions throughout Nepal. It improves biogas user’s livelihood through starting agro & forest based micro enterprises.
3) Bio-slurry, as one of the outputs of anaerobic digestion system, can profitably be returned to the agricultural system as feed and fertilizer. View in this

perspective, the results show all the respondents use bio-slurry as bio-fertilizer while only one respondent also uses it as feed for fish. The utilization of bio-slurry in farming rather than other area is high because all the respondents are belonging to farming in one way or another. The digested slurry has positive impact on the production of crops. Nine out of sixteen respondents believed that production increased by using bio-slurry while five respondents believed production remained the same. The larger number of respondents has expressed that vegetable and paddy increase after using bio-slurry. On the other hand, there are 1.75 tons slurry & compost fertilizer annually per household as for national average. In total, there is production of 483,623 tons slurry & compost fertilizer per year that enhances independency through reduction of chemical fertilizer and fish meal.

The major findings from the study of the role of biogas for protecting environment in relation to forest conservation and reduction of pollution are stated as under:

I. Forest conservation is an important factor for protecting environment. The results show that all respondents use biogas for cooking and one for lighting. The respondents had used either firewood or dung cake for cooking beforehand. In addition to this, all respondents think that the installation of biogas plant has saved the other fossil fuel. It contributes to reduce deforestation after installation of biogas. Furthermore, 14 out of 16 respondents agree that deforestation affects environment negatively while rest two respondents are neutral in this regard. As for national average, there are 1.25 trees protected per year per plant as per Biogas User Survey. In total, 345,446 trees are protected per year that enhance greenery and protect environment as well.
II. Among others, biogas plays an important role for reducing pollution. The results show biogas help reduce the both indoor and outdoor pollution. Fifteen out of sixteen respondents believe that it reduces both pollutions while only one respondent think that it does not. In this perspective, biogas project has been registered with the CDM board as the first project of Nepal. There is 2.4 tons reduction of greenhouse gas emission annually per household as per CDM methodology. There are 59,968 plants have registered with CDM board till the end of FY 2012/013. Thus, biogas plays a role for protecting environment

through forest conservation, reduction in pollution and green house gas emission.

Finally, the major findings from the study of the role of biogas for cultural development are stated as under:

a) Biogas plays an important role for cultural development. The result shows that 15 out of 16 respondents believe biogas plays positive role for cultural changes in *cooking practices using gas rather than firewood, use of toilet than open defecation, more time for participation in women's group meeting* and rest one is neutral in this regard. It is further found that 10 out of 16 respondents have expressed that biogas contributes positive changes of the role of women in social activities while the rest are neutral. The rural women's life styles have been changed after using biogas in relation to economic status, educational and social activities. Moreover, all respondents think that human waste can be used for biogas plants that shows changing perceptions towards the use of toilet connections with biogas. Thus, biogas plays an important role for social and cultural development through many ways.
b) Based on White's model using national data, the results show that cultural development moves in the same direction with total plants installed over the year. Moreover, the correlation coefficient (r) between total biogas plants (TP) and degree of cultural development (P) is 0.81. There is very high degree of positive correlation between these two variables. It means if total plants increases then the degree of cultural development also increases and vice versa. This result supports the result of analysis of the primary data. The results of primary data show that there

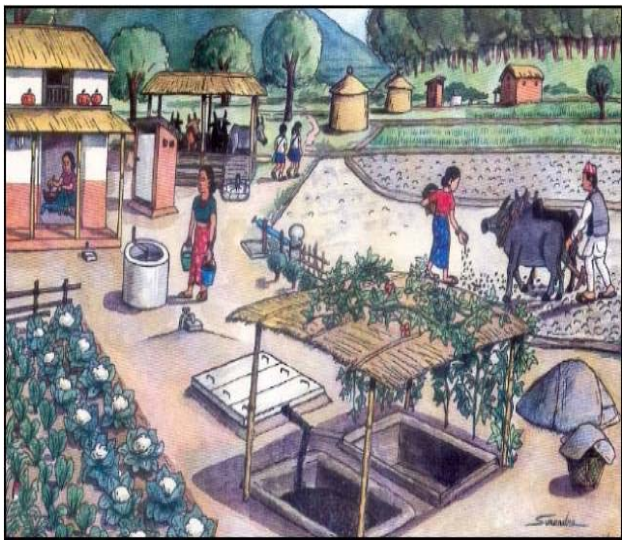


Figure 5.1: A Model House with Biogas

Source: BSP-Nepal

are positive cultural changes in *cooking practices, use of toilet, and participation in women's group meeting* which are also verified from the analysis of secondary data.

5.2. Conclusions

The study suggests existence of the role of biogas for sustainable development by determining its role for quality of life, protecting environment, and cultural development. Based on the analysis of the primary and secondary data, the results revealed that three conclusions. At *first*, biogas plays an important role for quality of life through improving health and sanitation, creating enterprises and employment, utilizing bio-slurry as feed and fertilizer. *Second*, biogas contributes for protecting environment in relation to forest conservation and reduction of pollution. *Finally*, biogas plays important role for social and cultural development. The results have revealed that biogas plays positive role for cultural changes in *cooking practices, use of toilet, and participation in women's group meeting* and positive changes of the role of women in social activities. Based on White's model using national data, the results show that cultural development moves in the same direction with total plants installed over the year as the correlation coefficient (r) between two is 0.81. There is very high degree of positive correlation between these two variables. It means if total plants increase then the degree of cultural development also increases and vice versa. Hence, biogas plays the role for economic and social development as well as protecting environment that contributes for sustainable development in one way or another.

5.3. Recommendations

Based on major findings and conclusions, the recommendations are offered as follows:

1. There is about 24.24 percent of total technically potential number of biogas plants constructed. Therefore, it is recommended to construct more plants that contribute for sustainable development in Nepal.

2. It is found that all the plant owners have used the gas for cooking purposes. Thus it is necessary to provide training to the users on uses of gas to other income generating activities.
3. The use of bio-slurry and its advantages must be made known to the installers. The relevant training, seminars and workshop should be implemented for this. The 37.5 percent respondents are not aware to use bio-slurry after composting. It is recommended to aware them for proper using of bio-slurry.
4. Encouragement should be given to utilize the saved time in a more productive activities.
5. Insufficient gas in winter has been an issue for the biogas users. So, proper way to use of biogas plant by hemp composting or jacketing of the biogas plant that produce comparatively more gas during winter as well.
6. Women should be encouraged in the productive works rather than social works for utilizing saved time. This would help towards gender balance issue. The time and money of households has been saved after installation of biogas. Therefore, women members should have chance to work in income generation activities. Concerned authorities should pay attention to this.
7. Concerned biogas companies should carry out training on proper utilization of bio-slurry and other uses of gas and bio-slurry than using for cooking and fertilizer more precisely.
8. Dissemination of information should be done massively through the media like newspaper, radio, television etc. As few owners are not fully aware about subsidy.
9. A consistent policy should be formulated and implemented to include the disadvantaged groups of the society that create balance development in the country.
10. Concerned agencies should conduct social awareness program among rural people to maximize the adaptation of biogas.

5.4. Avenues for Future Research

There are several avenues for future research in the area of the role of biogas for sustainable development. *First* extension of the present study is to use a combination of qualitative and quantitative information extracted from primary and secondary sources of data. A *second* avenue of research is to conduct a case study by taking a benchmark before installation of biogas and changes after installation biogas to get possibly more concrete results. A *third* research avenue is to make study by adding additional variables that are correlated with sustainable development to get greater insight into the results. A *fourth* research avenue is the comparative study of two areas on the role of biogas for sustainable development. A *final* avenue of research is to survey the opinions of stakeholders other than biogas users on the role of biogas for sustainable development in Nepal.

BIBLIOGRAPHY

Adhikari, P. (1996). *Effects of Biogas Plants on Family Health, Sanitation and Nutrition .* Kathmandu.

Adhikary, D. K. (2012, August). Green Economy: In Pursuance of Sustainable Development. *Administrative and Management Review, 24*(2), 77-89.

AEPC. (2012). *Annual Progress Report 2010/11.* Kathmandu: Alternative Energy Promotion Center, Ministry of Environment, Science and Technology.

Arthur, R., Baidoo, M. F., & Antwi, E. (2011). Biogas as a potential renewable energy source: A Ghanaian case study. (A. A. Sayigh, Ed.) *Renewable Energy, 36*(5), 1510-1516.

Barfield, T. (1997). *The dictionary of anthropology .* Wiley-Blackwell: Google Print.

Bhandari, K. (2010). *Socio-economic Impact of Biogas Plants: A Case Study of Bungkot VDC of Gorkha District.* A Master's Degree Thesis, Tribhuvan, Central Department of Rural Development, Kathmandu.

Bhattarai, M. (2009). *Socio-economic Impact of Biogas Technology in Nepal: A Case Study of Ghorahi Municipality of Dang District.* Central Department of Rural Development, Tribhuvan University , Kirtipur, Kathmandu.

Britt, C. (1994). *The effect of biogas on women's workloads in Nepal.* Lalitpur, Nepal.

BSP-Nepal. (n.d.). Retrieved February 27, 2013, from Biogas Sector Partnership-Nepal (BSP-Nepal) Web site: http://www.bspnepal.org.np

BSP-Nepal. (2012). *BSP Year Book 2011/12.* Kathmandu: BSP-Nepal.

Cottle, S. (1988). *Grahman and Dodd's Security Analysis.* New York: McGraw Hill Book Company.

Creswell, J. W. (2012). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (Third ed.). New Delhi, India: SAGE Publications India Pvt. Ltd.

Dahal, N. (2012). Key elements of green economy in the context of climate change and development in Nepal. *Paper presented on Training Course*. Kathmandu, Nepal: Nepal Administrative Staff College.

Ghimire, P. (2001). *Biogas in relation to other Disciples (Environment, Ecology, Agriculture and Health): Training materials in advanced Biogas technology for the teachers of the Institute of Engineering (IOE).* lalitpur: Institute of Engineering (IOE), Centre for Energy Studies (CES), Pulchowk.

Ghimire, T. (2006). *Socio-Economic Impact of Biogas Plant in Rural Setting: A Case Study of Shukranagar VDC, Chitwan District, Nepal .* Central Department of Rural Development, Tribhuvan University, Kirtipur, Kathmandu .

Goldemberg, J. (1996). *Energy, Environment and Development.* U.K.: Earthscan.

Gupta, D. R. (1991). Bio-Fertilizer from Biogas Plants. *Changing Villages, 10*(1).

Hagen, E. E. (1968). *On the Theory of Social Change: How Economic Growth Begins.* London: Tavistock Publications.

Halsall, P. (1997). *Modern History Sourcebook: Summary of Wallerstein on World System Theory.*

Hertin, J., Berkhout, F., Moll, S., & Schepelmann, P. (2001). *Indicators for Monitoring Integration of Environment and Sustainable Development in Enterprise Policy.* University of Sussex. Brighton, UK: SPRU - Science and Technology Policy Research.

Kar, D. P. (2010). The Lowest Cost Electricity for A Poor Rural Village in India: Rural Grid or Off-Grid SPV? . Golden, Colorado: Division of Economics and Business, Faculty and Board of Trustees of the Colorado School of Mines .

Karki, A. B., Shrestha, J. N., Bajgain, S., & Sharma, I. (2009). *Biogas as Renewable Source of Energy in Nepal: Theory and Development.* Kathmandu: BSP-Nepal.

Karki, B. B., Karki, A. B., & Khadka, A. (2002). *A Study of Renewable Energy Technology with Focus an Income Generating Activities.* Final Report , Alternative Energy Promotion Centre (AEPC), Lalitpur, Nepal.

Karmacharya, R. (1992). *An Analysis of the Socio Economics Impact of Biogas Plant in Nepal.* A Master's Thesis , Central Department of Socilogy/Anthropology, Tribhuvan University, Kirtipur, Kathmandu.

Keier, C. (1993). *Effect of Biogas on the Workload of Women from a Gender Perspective.* Biogas Support Programme, Kathmandu, Nepal .

Kerlinger, F. (1986). *Foundation of Behavioural Research.* New York: Holt, Rinehart, and Winston.

Kothari, C. R. (1999). *Research Methodology: Method and Techniques.* New Delhi: Vishwa Prakashan.

Kunkel, J. (1970). *Society and Economic Growth: A Behavioural Perspective of Social Change.* London: Oxford University Press.

Mark, D. G., & Jill, K. (2004). The Socio-economic determinants of innovation, an empirical examination. *The International Journal of Entrepreneurship & Innovation, 9*(4), 231-240.

Mathew, S. M., & Wim, J. V. (1999). *The Nepal Biogas Support Programme: Element of Success in Rural Household Energy Supply.* Biogas Suport Programme (BSP), Lalitpur, Nepal.

McClelland, D. (1961). *The Achieving Society.* NJ: Van Nostrand, Princeton.

Nepal, D. (2001). *Research Study on Optional Biogas Plant Size, Daily Consumption Pattern and Conventional fuel saving.* Kathmandu: Biogas Support Programme (BSP).

Nepal, P. (2008). *Socio-economic impact of biogas energy on rural women : a case studay of Chandragadi VDC in Jhapa District .* Central Department of Rural Development, Tribhuwan University, Kirtipur, Kathmandu.

New Era. (1995). *Biogas Plants in Nepal.* Kathmandu.

Pokharel, G. R. (2006). *Promoting Sustainable Development by Creating Enterprises on Renewable Energy Technologies in Nepal: Case Studies Based on Micro Hydropower Projects .* Germany: Institut für Politik und Wirtschaft und Ihre Didaktik.

Raman, R. (2004). *Motivating Factor of Educated Self Employed in Kerala: A Case Study of Mulanthuruthy Block Ernakulum.* Discussion Paper No. 90, Kerala Research Programme on Local Development Center for Development Studies.

Reynolds, P. (1991). Sociology and entrepreneurship: concepts and contributions. *Entrepreneurship: Theory & Practice, 16*(2), 47-70.

Sharma, S. (2010). *Prospects and Problems of Biogas Plant in Rural Nepal: A Case Study of Devdaha VDC, Rupandehi District, Nepal.* Central Department of Rural Development, Tribhuvan University, Kirtipur, Kathmandu.

Shelbourne, M. A. (2006). Managing Knowledge in the Context of Sustainable Construction. *ITcon*.

Subedi, B. R. (2006). *Socio-economic impact of biogas plant: a case study of Dhikurpokhari VDC, Kaski District .* Kirtipur, Kathmandu: Central Department of Rural Development, Tribhuvan University.

Timsina, D. (2008). *Socio-Economic Impact of Biogas Plant in Rural Nepal : A Case Study of Phidim VDC of Panchthar District.* Central Department of Rural Development, Tribhuvan University, Kirtipur, Kathmandu.

UN Department of Public Information . (1997, Copyright United Nations 23 May 1997 | Department of Public Information | Revised 23 May 1997). United Nations Conference on Environment and Development (UNCED), Rio de Janeiro, 3-14 June 1992. *The Earth Summit .* Brazil: United Nations Department of Public Information . Retrieved United Nations Conference on Environment and Development (UNCED), Rio de Janeiro, 3-14 June 1992

UNCED. (1992). *The Rio Declaration on Environment and Development: Agenda 21.* Rio : UNCED.

Wagle, B. (2010). *Socio-economic Status of Bio Gas Users: A Case study of Tanahunsur Village Development Committee of Tanahun District.* Central Department of Rural Development, Tribhuvan University, Kirtipur, Kathmandu.

White, L. (2010). *Mnsu.edu. http://www.mnsu.edu/emuseum/cultural/anthropology/White.html.* Retrieved May 14, 2010

White, R. A. (2005). *The Role of Biogas in Rural Development and Resource Protection in China: A Case Study of Lijiang Municipality.* Yunnan: National Science Foundation and Michigan State University.

Wikipedia: 14 Jan 2014. (n.d.). *wikipedia.* Retrieved January 14, 2014, from http://en.wikipedia.org/wiki/Sustainable_development

Wikipedia: 14 Jan 2014. (n.d.). *Wikipedia.* Retrieved January 14, 2014, from Wikipedia: http://en.wikipedia.org/wiki/Development

Wikipedia: 28 Feb 2013. (n.d.). Retrieved February 28, 2013, from Wikipedia Web site: http://en.wikipedia.org

Wolff, H., & Pant, P. (2005). *Social Science Research and Thesis Writing .* Kathmandu: Buddha Academic Enterprises Private Limited.

World Bank: 14 Jan 2014. (n.d.). *worldbank.* Retrieved January 14, 2014, from http://www.worldbank.org/en/topic/sustainabledevelopment/overview

World Commission on Environment and Development. (1987). *Our Common Future.* U.K.: Oxford University Press.

www.google.com.np: 14 Jan 2014. (n.d.). *Google.* Retrieved January 14, 2014, from www.google.com.np

Yadav, M. P. (2011, Oct-Dec). Role of Key Factors for Biogas Development: A Case of Nepal. *The Economic Journal of Nepal, 34*(136), 310-318.

Yadav, M. P. (2012a). Role of Biogas for Sustainable Development: A Case of Nepal. *Proceeding of International Conference on Operation Research for Sustainable Development.* Kathmandu: Operation Research Society of Nepal.

Yadav, M. P. (2012b). Role of Biogas for Quality of Life: The Nepalese Experience. *Proceeding of 18th Asia Pacific Quality Conference.* Colombo: Sri Lanka Association for Quality.

Yadav, M. P. (2012c). Role of Micro Financing in Promotion of Biogas: A Case of Nepal. *Proceeding of International Conference on Economics and Finance.* Kathmandu: Nepal Rastra Bank (NRB).

Yadav, M. P. (2012d). Role of Biogas to Mitigate Climate Change: The Nepalese Evidence. *Proceeding of 8th Global Conference on Human Development.* Kathmandu: The Institute of Cultural Affairs (ICA) .

APPENDICES

Appendix-1: Questionnaire for Field Survey 2013

ROLE OF BIOGAS FOR SUSTAINABLE DEVELOPMENT IN NEPAL: A CASE STUDY OF NIGLIHAWA VDC OF KAPILVASTU DISTRICT

1. General information

Date:

Name of the respondent: Age:

Address: Education:

Occupation: Number of family member:

Land holding (Kaththa): **Sex:** a) Male b) Female

2. Information on biogas plant

2.1. How did you know about biogas?

a) Biogas Company b) Neighbors c) Friends d) Others (specify)…

2.2. Is your biogas plant functioning? a) Yes b) No, If no why?.....

2.3. What is the size of your biogas plant?

a. 4 m^3 b.6 m^3 c. 8m^3 d. Other (specify)……..

2.4. How long have you been using biogas?

a. 2 years or less b. 5 years c. 7 years d. 10 years or more

2.5. Why did you choose to install biogas?

a. Cooking b. Lighting c. Both d) Others (specify)…

2.6. What is your feeling on the taste of food cooked on biogas?

a) More tasty b) Less tasty c) No difference d) Other (Specify)

2.7. Which fuel do you use for cooking and lighting?

Cooking: Now…… Before……

Lighting: Now…… Before……

3. Biogas in relation to health and sanitation

3.1. Have you experienced any change in the frequency of visits to hospital/health post/clinic for checkup after the installation of biogas plant?

a) Decreased b) Increased c) Remained the same c) Others (specify)…

3.2. Do you find any change in the general cleanness of the surrounding after the installation of biogas plant?

a) Yes b) No c) Other (specify)……

3.3. Do you think biogas generates bad smell in the kitchen?

a) Yes b) No c) Other (specify)……

3.4. Do you have toilet? a) Yes b) No

3.5. If toilet is constructed, when did you build it?

a) Before plant install b) After plant install c) Together

3.6. **If toilet is constructed, did it connected with biogas plant?**

a) Yes b) No

If no, why?.....

3.7. Have you felt the decrease in the indoor smoke after biogas plant?

a) Very much b) To some extent c) Not d) Other (specify)……

4. Biogas in relation to income generation

4.1. What was the total cost of the plant?

a) Cash: Rs…… b) Labour……..

4.2. Did you take loan to construct the plant? a) Yes b) No, If yes, how much?....

4.3. What is the source of income for repayment?

a) Sale of crops/animals/vegetable b) Income from business

c) Borrowing from other sources d) Have not planed any idea

4.4. Is biogas more costly than other energy?

a. Yes b. No c. Same d. Don't know

4.5. Saving time (workload)

S.N.	Works	Time allocation		Hours saved per day	By whom (male/female)
		Before install	After install		
1.	Fuel manage (dung cake or firewood)				
2.	Cooking				
3.	Washing utensils				
4.	Other (specify)…..				

4.6. How did you utilize the saved time? (You can choose more than one)

a) Vegetable Farming b) Cattle rearing c) Shop keeping d) Other (Specify)…

4.7. Consumption and saving of fuel before and after Biogas installation (per month)

S.N.	Source of energy	Consumption per week		Saving quantity	Weekly amount (Rs)
		Before install	After install		
1.	Fuel wood				
2.	Agro-residue				
3.	Dung cake				
4.	LPG				
5.	Kerosene				

4.8. Do you use slurry as fertilizer? **a**) Yes b) No

4.9. How do you use it?

a) Directly b) By compositing c) In dried form d) With irrigation channel

4.10. If used, does digested slurry have any impact on the production of crops?

a) Production increased significantly b) Production remained the same

c) Production increased the same what d) Production decreased the same what

4.11.If production increased which crops?

a) Paddy b) Vegetable c) Fruits d) All

4.12.What is the advantage of slurry over dung?

a) More effective/Nutrition b) Same as composing before biogas plant

c) No advantage d) Can't say

4.13.Do you use slurry as feed for fish?

a) Yes b) No If yes, do you think, is it effective feed for fish?

5. Biogas in relation to environment

5.1. Do you think that the installation of biogas plant has saved the other fossil fuel? a) Yes b) No c) Other (specify)…….

5.2. Is the amount of gas sufficient?

Winter Yes No **Summer** Yes No

5.3. How do you manage insufficient of energy from biogas?

a) Firewood b) Dung cake c) Kerosene d) Other (Specify)…

5.4. Deforestation affects environment negatively. Do you agree?

a. Strongly agree b. Agree c. Neutral d. Disagree e. Strongly disagree

5.5. Does biogas help reduce the both indoor and outdoor pollution?

a. Yes b. No c. Other (Specify)….

6. Biogas in relation to Cultural Development

6.1. Do you use human waste in biogas energy? a. Yes b. No

If no, why?.....

6.2. Do you think, people accept to connect toilet with biogas nowadays?

a. Yes b. No

6.3. Who are most benefited by the use of biogas in your home?

a. Males b. Females c. Children d. Others (Specify)….

6.4. Is there any change of the role of women in social activities because of installation of biogas in your house?

a. Positive b. Negative c. Neutral d. Others (specify)…..

6.5. What is the change in rural women's life style after using biogas?

a) They get more time to involve in social activities. b) It changed their economic status. c) It helped improve educational activities. d) Other (Specify)…….

6.6. What kind of social activities after biogas installation are you involved in?

a. Education b. Political activity c. Religious activities d. Entrepreneurial activity

6.7. Biogas plays the vital role for positive cultural changes. Do you agree?

a. Strongly agree b. Agree c. Neutral d. Disagree e. Strongly disagree

7. Some other points related with biogas

7.1. How many hours your do children use it in study?

a) Before Biogas installation……hrs per day.

b) After Biogas installation……hrs per day.

7.2. Are you satisfied with your child education after biogas plant installation?

a) Yes b) No c) Other (Specify)…

7.3. Were the female members consulted for the decision of biogas plant?

a) Yes b) No

7.4. Are you satisfied with the performance of biogas plant?

a) Yes b) No If no, why?.....

7.5. What is the source of water at your home?

a) Tap water b) Public Tap c) River d) Other (Specify)

7.6. Did you get subsidy or grant from any organization?

a. Yes b. No If yes, how much?.....from which organization?.....

7.7. Do you have anything to share?.....

Appendix-2: List of Respondents

SN	Respondents from Niglihawa-6	Age	Education	Occupation	Plants' size	Sex	Remarks
1	Dadiram Pokharel	50	SLC	Farmer	6 m^3	M	
2	Dinesh Maurya	25	10+2	Student	6 m^3	M	
3	Gyancharan Kewat	36	6 Class	Farmer	4 m^3	M	
4	Gyanmati Chauhan	48	Illiterate	Farmer	6 m^3	F	
5	Kamalawati Kewat	50	Illiterate	Farmer	6 m^3	F	Plant is not in operation due to shifting of cow shed
6	Lalit Gurung	45	10+2	Politician	8 m^3	M	
7	Lalji Kewat	30	SLC	Retailer	6 m^3	M	
8	Maharani Chaudhary	23	10+2	Student	6 m^3	M	
9	Phulchan Yadav	45	Barely literate	Farmer	6 m^3	M	
10	Pobi Pousel	35	SLC	Farmer	6 m^3	M	
11	Rakesh Yadav	22	10+2	Student	6 m^3	M	
12	Shivkaran Kurmi	55	Barely literate	Farmer	6 m^3	M	
13	Shivmurat Kewat	45	10 Class	Retailer	6 m^3	M	
14	Surendra Maurya	40	10 Class	Farmer	6 m^3	M	
15	Thakur Pd. Bhusal	58	Barely literate	Cook	6 m^3	M	
16	Tilakram Kahar	23	SLC	Student	6 m^3	M	

Source: Field survey 2013

Appendix-3: Size-wise Number of Biogas Plants for the Period of 1992/93 to 2012/13

Fiscal Year	Size-wise Number of Plants (M3)							Total
	2	*4*	*6*	*8*	*10*	*15*	*20*	
1992/93		75	442	553	1,927	275	46	**3,318**
1993/94		128	534	780	1,722	286	56	**3,506**
1994/95		62	652	1,451	2,633	279	38	**5,115**
1995/96		123	1,190	2,460	3,097	249	38	**7,157**
1996/97		304	2,004	3,201	2,686	175	17	**8,387**
1997/98		265	2,861	4,234	2,303	180	26	**9,869**
1998/99		494	4,268	4,717	1,451	109	13	**11,052**
1999/00		1,771	7,850	3,001	643			**13,265**
2000/01		3,225	11,629	2,616	387			**17,857**
2001/02		2,779	10,597	1,864	287			**15,527**
2002/03		3,391	11,105	1,622	222			**16,340**
2003/04		1,859	8,072	1,191	137			**11,259**
2004/05		2,467	13,352	1,804	180			**17,803**
2005/06		2,058	12,184	1,686	190			**16,118**
2006/07		2,463	13,486	1,550	164			**17,663**
2007/08		2,224	11,558	1,099	3			**14,884**
2008/09		3,420	14,997	1,062				**19,479**
2009/10	1,085	4,979	14,265	829				**21,158**
2010/11	1,019	5,828	12,482	727				**20,056**
2011/12	440	5,903	12,040	596				**18,979**
2012/13	173	4,268	16,892	777				**22,110**
Total	**2,717**	**48,086**	**182,460**	**37,820**	**18,032**	**1,553**	**234**	**290,902**

Source: The database of BSP-Nepal

Appendix-4: Basic Data of Biogas for Cultural Development

Basic Data in relation to Biogas for cultural development for the Period of 1992/93 to 2012/13

Fiscal Year	Total Plants (TP)	Total Volume (M3)	Total energy produced (M3)	Total Family Members of Biogas Users	Measure of energy consumed per capita per year (E)	Measure of efficiency in utilizing energy (T)	Degree of cultural development (P)
1992/93	3,318	31,691	2,637,325	18,581	142	1,424,156	**202,142,048**
1993/94	3,506	32,586	2,711,807	19,634	138	1,464,376	**202,260,628**
1994/95	5,115	47,043	3,914,918	28,644	137	2,114,056	**288,938,582**
1995/96	7,157	62,777	5,224,302	40,079	130	2,821,123	**367,731,856**
1996/97	8,387	68,673	5,714,967	46,967	122	3,086,082	**375,514,363**
1997/98	9,869	78,348	6,520,121	55,266	118	3,520,865	**415,378,330**
1998/99	11,052	81,725	6,801,155	61,891	110	3,672,623	**403,580,466**
1999/00	13,265	84,622	7,042,243	74,284	95	3,802,811	**360,512,620**
2000/01	17,857	107,472	8,943,820	97,142	92	4,829,663	**444,664,487**
2001/02	15,527	92,480	7,696,186	84,467	91	4,155,940	**378,667,796**
2002/03	16,340	95,390	7,938,356	88,890	89	4,286,712	**382,828,206**
2003/04	11,259	66,766	5,556,267	61,249	91	3,000,384	**272,183,115**
2004/05	17,803	106,212	8,838,963	96,848	91	4,773,040	**435,616,443**
2005/06	16,118	96,724	8,049,371	87,682	92	4,346,660	**399,031,911**
2006/07	17,663	104,808	8,722,122	96,087	91	4,709,946	**427,537,961**
2007/08	14,884	87,066	7,245,633	80,969	89	3,912,642	**350,128,777**
2008/09	19,479	112,158	9,333,789	105,966	88	5,040,246	**443,960,302**
2009/10	21,158	114,308	9,512,712	115,100	83	5,136,864	**424,550,076**
2010/11	20,056	106,058	8,826,147	109,105	81	4,766,119	**385,560,761**
2011/12	18,979	101,500	8,446,830	92,618	91	4,561,288	**415,995,008**
2012/13	22,110	124,986	10,401,335	107,897	96	5,616,721	**541,456,232**
Total	**290,902**	**1,803,393**	**150,078,365**	**1,569,364**	**96**	**81,042,317**	**7,918,239,969**

***Sources**:* The database of BSP-Nepal and Central Bureau of Statistics (CBS), Population Census 1991, 2001 & 2011.

Notes:

1) Total annual energy produced (M3) is calculated based on 95% plants are operational as per Biogas User Survey.

2) Measure of efficiency in utilizing energy (T) is calculated taking 54% biogas stove efficiency as a reference.