Impact of Biogas Programme on Forest Conservation:

A case study from Suryapatuwa VDC of Southwestern Buffer zone of Royal Bardia National Park, mid-western Nepal

Ram Kumar Adhikari
B.Sc. Forestry
February 2002

Dissertation submitted in partial fulfilment of the requirement for the degree of Bachelor of Science in Forestry

Institute of Forestry, Pokhara
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Certificate of Acceptance

It is certified that this report entitled **"Impact of Biogas Programme on Forest Conservation"** (a case study from Suryapatuwa VDC of Southwestern buffer zone of the Royal Bardia National Park, mid-western Nepal) is prepared in line with the research proposal agreed upon earlier under my supervision by Mr. Ram Kumar Adhikari (B. Sc. final year student). This paper has been accepted for the partial fulfillment of the requirement of the B. Sc. Forestry and endorsed for further consideration.

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Abstract

KMTNC launched BCP in 1994 as a regular project in Bardia. BCP has been focussing its effort on different conservation activities in Royal Bardia National Park and its periphery. RBNP is the largest wilderness area in lowland terai. BCP has initiated biogas programme since fiscal year 1997/98, though other NGOs already started this programme in Buffer zone of RBNP. BCP has insisted to install 237 biogas plants till mid 2001.

Biogas is an eco-friendly alternative or substitute energy source. So, it can substitute firewood for cooking, heating and kerosene for lighting. Biogas is a clear and odourless combustible gas, which is produced when organic matter contained in animal excrement, such as dung and human night soil and tender plant parts or residues are anaerobically fermented with the help of methanogenic bacteria in air and watertight container called biogas plants. Chemically biogas is just methane gas.

As forest accounts for 78% of energy consumption in Nepal, alternative energy source such as biogas and ICS are necessary to reduce pressure on forest. The present study fills the gap by identifying site specific achievements and problems.

The study aims at identifying impact of biogas programme in forest conservation. The research was carried out in Suryapatuwa VDC, Southwestern buffer zone of RBNP. All the 73 biogas households were taken in to consideration for data collection by semi-structured personal interview.

Eleven biogas plants are completely function less up to now. It was due to lack of the technical supports, frequent monitoring and financial problems of biogas users. The installation of biogas plants has reduced fuel consumption by 54.54% while kerosene by 3.61lt. per hh per month.

Only 14% hhs have assessed slurry as inferior than farmyard manure. This concludes that slurry has positive impact on farm production. After installation of biogas, grazing animals population has decreased by 58.76%, it is also proved by stall feeding animal population increase, though it is not strongly treated as biogas impact. Biogas has positive effect on improvement of users' health as well as indoor and outdoor environment.

Biogas has decreased workload by 2 hours per day due to ease in cooking and quick cleaning of vessels. This is a contributing factor especially for women and girl children. This provides

women to spend more time in caring for their children, educate them and themselves, and engage in income generating activities.

The users having no biogas plants have consuming 95 % more fuelwood than biogas users. All users are more positive towards biogas technology, though they have some problems arises due to frequent maintenance of spare parts.

The above facts conclude that the biogas programme has very positive impact on peoples' socio-economic well-being and forest resource conservation. To strengthen the biogas programme, it should be integrated with other development programme i.e. livestock improvement, plantation and community forestry programme, income generating activities, population control etc. Frequent monitoring of biogas plants is also highly desired.

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Conversion factors

1 *Bojha* = 20 kg
1 *Lariya* = 600 kg
1 *Bigha* = 0.663 ha.
1 *Kattha* = 331.633 m^2
A buffalo (male 350 kg & female 325 kg) = 1 LSU
A cattle (male 220 kg & female 200 kg) = 0.8 LSU
A goat/ sheep (goat 30 kg & sheep 34 kg) = 0.1 LSU]

Note: *Khet* – irrigated land
Bari/Diuwa – rain fed land
Tuki - kerosene oil filled lamp

Acronyms

ADB/N – Agricultural Development Bank (Nepal)
B. S. – Bikram Sambat
BCP – Bardia Conservation Programme
BICP – Bardia Integrated Conservation Programme
BSP – Biogas Support Programme
CF – Community Forest
FUG – Forest User Group
GGC – *Gobar* Gas Company
HH – households
I/NGO – International/ Non- Government Organisation
ICIMOD – International Centre for Integrated Mountain Development
ICS - Improved Cooking Stove
KMTNC – King Mahendra Trust for Nature Conservation
LSU – Livestock Unit
MoF – Ministry of Finance
MOPE – Ministry of Population and Environment
MPFS - Master Plan for Forestry Sector of Nepal
NBPG - Nepal Biogas Promotion Group
NRs. – Nepalese Rupees
RBNP – Royal Bardia National Park
SAP – South Asia Partnership, Nepal
SNV – Netherlands' Development Organisation
TAL – Terai Arc Landscape Programme
UC – User Committee
UMN – United Mission to Nepal
UNCDF – United Nations Capital Development Fund
UNDP – United Nations Development Programme
UNICEF – United Nations International Children's Fund
USAID – United States Agency for International Development
VDC – Village Development Committee

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1.0 Introduction

Background

King Mahendra Trust for Nature Conservation (KMTNC) was involved in a number of conservation activities in Bardia since the translocation of rhinos in 1986, the Bardia Conservation Programme (BCP) was launched in 1994 as a regular project. BCP has been focusing its efforts on community plantation, school support, health care, women development, skill enhancement and crop depredation control programmes. BCP has also undertaken implementations of five components, which includes sustainable agriculture and forestry, animal husbandry and livestock management, natural forest regeneration, alternative income generation schemes and nature-based tourism in collaboration with NGOs with complementary objectives since 1996 (KMTNC, 2000).

BCP focuses its different conservation programmes in Royal Bardia National Park and its periphery. Royal Bardia National Park is the largest national park in Terai covering an area of 968-sq. km. RBNP is located 400 km west of Kathmandu valley in southwestern lowland of Terai, Nepal. RBNP includes 17 Village Development Committees (VDCs) of Bardia and Banke districts in its buffer zone covering an area of 327 sq. km.

BCP has initiated biogas programme since fiscal year 1997/98 under natural forest regeneration component. The biogas programme has been implemented in Park buffer zone and corridor of Royal Bardia National Park and Katarniyaghat Wildlife Sanctuary India. BCP has insisted to install 237 biogas plants till mid-2001.

BCP has provided 188 toilet pans as subsidy to biogas users with the assistance of BICP. Recently, BCP is providing 50 per cent capital subsidy, excluding labor cost, for the maintenance of biogas plants.

Biogas is alternative or substitute energy sources. As a viable eco-friendly alternative technology, it can substitute firewood for cooking, heating fuel and kerosene for lighting. So, it reduces the dependency on forests and increases greenery leading to an improved environment. Biogas being a product of animal refuses and plant residues that are available to farming communities, in general, and also being a sources of energy, has wider socio-cultural implications, particularly for women and children. It has many other direct and indirect impacts too. The present study attempts to outline some direct effects of biogas programme.

Rationale

In Nepal, fuelwood is the main source of energy for cooking and heating purposes and forests remain the single most important source for firewood, particularly for rural people. About 88 % of the total population lives in rural areas. Forest accounts for 78 % of energy consumption. People use 10 % traditional source of energy such as cowdung and agricultural residues while they consume 12 % commercial sources such as coal, petroleum products and electricity. Hence, there are two major characteristics of energy systems in Nepal; excessive dependence on biomass energy and very low efficiency in its use (MOPE, 2001).

There is lack of alternative sources of energy at affordable prices. Firewood is still considered as the free gift of nature and people are reluctant to pay for it. As many rural people depend on firewood, its consumption has increased along with population growth. Therefore, the rapid population growth, which is 2.37 % per annum, is the most important factor for diminishing forest area. It is evidenced from the forest declined from 37.4 % in mid-1980s to only 29 % a decade latter while the shrub land has doubled during the same period. The annual deforestation is estimated to be 1.7 % with 2.3 % in the hills and 1.3 % in the Terai. (MOPE, 2001).

MPFS (1988) has clearly focused on the necessity of alternative energy sources, although the combined impact of energy saving stoves and biogas plants can probably not reduce fuelwood needs by more than 15 % during the period of Master Plan 1988 – 2010 (MPFS, 1988). Biogas is most important and prominent technology which was developed and encouraged to use in Nepal in 70s decades due to global energy crisis (Bhandari, 1995).

Biogas programme is implemented with the purpose of the improvements of sanitation, lessening incidence of eye diseases, easy and efficient cooking and reduction in indiscriminate tree felling and fuelwood consumption. Stall feeding system helps to reduce the livestock pressure in the forest. Slurry used in the field is expected to be useful in soil fertility improvement. BSP is providing financial subsidies through biogas manufacturers and BCP is also providing material subsidies to the biogas users directly. These above overall outcomes are necessary to evaluate quantitatively and qualitatively as far as possible. The study fills the gap by identifying site-specific achievements and problems.

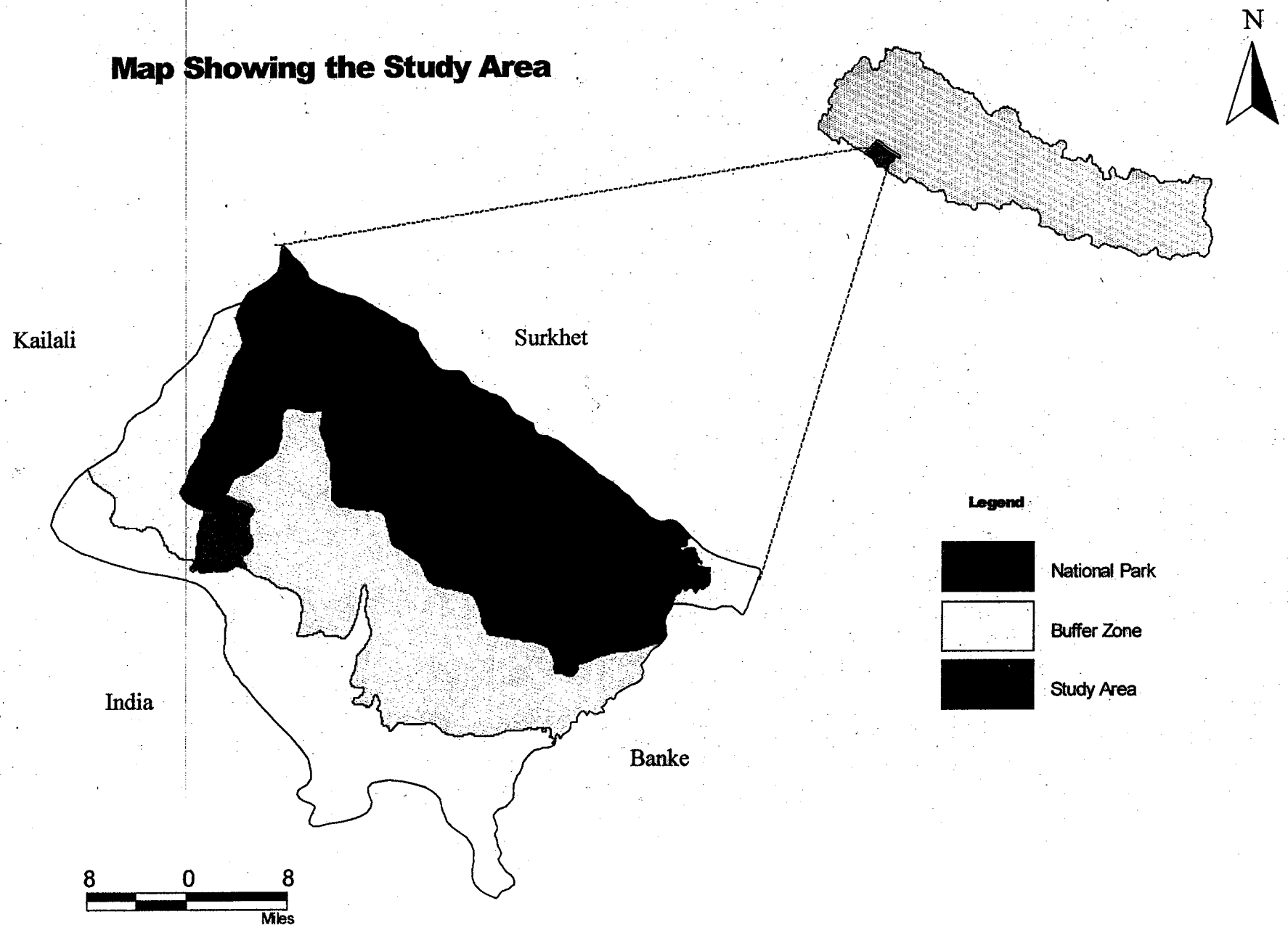
Biogas programme has been implemented by different stakeholders a decade back in buffer zone of RBNP. BCP is working as a leading institution for promotion of biogas programme in coordination with government organization and NGOs. It assists to install the biogas plants by providing materials and services. Hence, all costs regarding biogas plant installation have the goals of conserving biodiversity in and around the National Park and socio-economic well being of local people. The study is imperative to analyze cost effectiveness.

Objectives

The overall objective of this study is to assess the impact of biogas programme on forest conservation in buffer zone of RBNP.

The specific objectives are:

1. To assess the current status of biogas programme in project area.
2. To assess the amount of firewood and kerosene substituted by biogas.
3. To assess the effect of slurry on farm production.
4. To assess the effect of biogas on users' health and environment.
5. To assess the effect of biogas on workload of women.
6. To identify the problems related to the use of technology.
7. To explore attitude of people towards biogas technology.


Map Showing the Study Area
N
Kailali
Surkhet
India
Banke
Legend
National Park
Buffer Zone
Study Area
8
0
8
Miles

2.0 Study area

Country overview

Nepal is a landlocked country bordering India to the East, West, and South, and China to the North, with a total land area of 147,181 sq. km. ranging in altitude from less than 100 m in the South to over 8,800 m in the North. The average length from East to West is 885 km with non-uniform north south width of 193 km (MOPE, 2001). In latitude, it ranges from $26^0$22' to $30^0$27' N and in longitude from $80^0$04' to $88^0$12' E. The country is divided into 75 districts with 16 districts in the North (Mountain region), 39 districts in the middle (Hills) and 20 districts in the South (Terai). Administratively, the districts are further divided into 3,912 Village Development Committees (VDCs), 58 Municipalities including one Metropolitan and three Sub-metropolitan cities.

Nepal's richness of species diversity can be attributed to her large topographical, vertical dissimilarities and climatic variations. About 118 types of ecosystems (natural biomes) have been identified in different physiographic zones of Nepal. In view of species diversity in wild habitat, Nepal occupies 25^{th} position and 11^{th} position on the global and continental basis respectively (MFSC, 2000 reported in MOPE, 2001). Nepal is also rich in wild animals. Several conservation successes are found in protected areas due to increase of wildlife and habitat improvement. 16 protected areas have been established during the last three-decade and the land covered by such areas totals 18.14 % (26,696 sq. km.) of the total area (MOPE, 2001).

Description of Royal Bardia National Park and its Buffer zone

The RBNP has played significant role in the conservation of ecosystem and genetic resources in the country. It is the largest undisturbed wilderness area in the lowland Terai covering an area of 968 sq. km. The RBNP ($81^0$20' E and $28^0$35' N) is situated in the mid western region of Nepal and was declared as National Park in 1988. The park primarily conserves the prime habitat of higher trophic level animals i.e. Bengal tiger, wild elephant, Greater one-horned rhinoceros, etc. About 70 % of the park forest consists of Sal tree with a mixture of grassland and riveraine forest.

In 1997, an area of 327-sq. km. surrounding the park was declared as buffer zone, which consists of forest and private lands. Buffer zone covers 17 VDCs of Bardia and Banke districts and it includes 135.51-sq. km. forestland and 192-sq. km. cultivated land. There is 0.1 million human population in buffer zone.

The climate of park and its vicinities is monsoon with about 85 % of the total precipitation falling in the four months of June to September (HMGN, 1974 reported in Bhatta, 1994). The southern region receives lower rainfall than the northern. The temperature ranges from annual average maximum of 35^0 C and a minimum of 17^0 C. The temperature rises steadily during the hot season up to a maximum of 45^0 C and goes down to 5^0 C in winter (Bhattarai, 1993 reported in Bhatta, 1994).

As already mentioned that BCP has initiated to assist biogas plants installation since four years back. So, following are the distribution of biogas plants by VDCs.

Table 1. Distribution of biogas plants by VDCs in buffer zone.

S. No.	VDCs	Fiscal Years (B.S.)				Total
		2054/55	2055/56	2056/57	2057/58	
1	Thakurdwara	3	8	14	6	31
2	Gola	6	6	34	18	64
3	Suryapatuwa	15	11	8	13	47
4	Shivpur	15	-	6	17	38
5	Manau	-	2	-	-	2
6	Pashupatinagar	-	2	2	3	7
7	Patabhar	-	5	-	12	17
8	Magaragadhi	-	-	7	-	7
9	Dhadhabar	-	-	12	-	12
10	Deudakala	-	-	1	-	1
11	Baniyabhar	-	-	3	-	3
12	Purba-chisapani	-	5	-	-	5
13	Dhodari	-	-	-	3	3
Total		39	39	87	72	237

Table 2. Size-wise distribution of biogas plants in buffer zone.

S. No.	Size (m3)	Fiscal Years (B.S.)				Total
		2054/55	2055/56	2056/57	2057/58	
1	4	-	-	-	4	4
2	6	24	11	32	48	115
3	8	4	14	41	11	70
4	10	11	14	14	9	48
Total		39	39	87	72	237

Source: Shree Ram Ghimire, 2001

Description of Suryapatuwa VDC

Suryapatuwa VDC (longitude $81^0$12'09" to $81^0$15'45" E and latitude $28^0$21'54" to $28^0$26'54" N) is located in southwestern buffer zone of RBNP, Bardia. Geographically, it is situated in plain Terai and the VDC covers 37.2346 sq. km. area. The VDC is attached its northern border with RBNP. The partial area of VDC has been declared as buffer zone

however, it lies totally in corridor area between RBNP and Katarniyaghat Wildlife Sanctuary India.

According to the census carried out by VDC in 2054 B. S. distribution of households and population is as follows:

Table 3. Population of Suryapatuwa VDC, Bardia

Ward No.	Households	Population		Total
		Male	Female	
1	63	259	250	509
2	110	460	456	916
3	136	510	495	1005
4	258	933	922	115
5	51	230	207	439
6	138	660	604	1264
7	105	468	434	902
8	62	225	215	440
9	144	964	592	1556
Total	1067	4722	4164	8886

Source: Suryapatuwa VDC Office, 2001

Table 4. Landuse pattern of Suryapatuwa VDC, Bardia

S. No.	Landuse	Area (*Bigha*)
1	Cultivated land	1731
2	Forest land	475
3	River	100
4	Trail and road	125
	Total	2431

Source: Suryapatuwa VDC Office, 2001

Several types of ethnic groups live in the VDC. They are Tharu, Brahmin, Chhetri, Thapa, Pariyar etc but there is more population of Tharu people. The Hindu is dominant religion in the VDC. The VDC is selected due to installation of high number of biogas plant installation in buffer zone.

3.0 Literature Review

Concept of biogas technology

Biogas or *gobar* gas is a clear and odorless combustible gas, which is produced when organic matter contained in animal excrement, such as dung and human night soil, and tender plant parts or residues, such as leaves, stems, and straw, are anaerobically fermented with the help of methanogenic bacteria in air and water-tight container called biogas plants. Chemically biogas is just methane gas.

Biogas burns with a clear blue flame without giving out smoke. Its flame temperature is up to 800^0 C and it has a calorific value of 5,650 kcal per cubic meter of gas.

Biogas (methane gas) production is complex in process. Simply, it can be represented as shown below.

1. $(CH_2O)_6 \xrightarrow{\text{Bacteria}} 3\ CH_3COOH \xrightarrow{\text{Bacteria}} 3\ CH_4 + 3\ CO_2$
   Carbohydrate — Organic acid

2. $CH_3COOH + 2\ CH_2O \longrightarrow 2\ CO_2 + 4\ H_2$
   Ethanoic acid

$$4\ H_2 + 2\ CO_2 \longrightarrow CH_4 + 2H_2O$$
Methane

Baker (1956) identified four types of bacteria i.e. a) *Methano bacterium* b) *Methano bacillus* c) *Methano coccus* and d) *Methano sarcina.*

Source: Devkota, 1993

In anaerobic fermentation of organic matter, the following gases are along with methane.

Methane (CH_4)	50 – 70 %
Carbon dioxide (CO_2)	30 – 40 %
Hydrogen (H_2)	5 – 10 %
Nitrogen (N_2)	1 – 2 %
Hydrogen sulphide (H_2S)	traces

For the fermentation of organic matter to produce biogas (methane), a sufficient population and growth of methanogenic bacteria are essential, besides the carbon and nitrogen contents of the raw materials in the digester. The optimum temperature for biogas production is 30^0 C. Biogas production could be increased up to $45 – 55^0$ C, but the biogas production could be hampered due to destruction of enzymes at temperatures higher than 55^0 C. Biogas could be produced at temperature of $12 – 18^0$ C but it would not be economically beneficial and production stops at 10^0 C or below it (ICIMOD, 1997).

Table 5. Plant capacity and its daily dung and water requirements

S. No.	Plant size(m^3)	Initially required dung(kg)	Per day dung requirement (kg)		Per day water requirement (ltr.)		Required cattle (no.)
			Hill	Terai	Hill	Terai	
1	4	1450	24	30	24	30	2-3
2	6	2200	36	45	36	45	3-4
3	8	2900	48	60	48	60	4-6
4	10	3500	60	75	60	75	6-9
5	15	5500	90	110	75	110	9-14
6	20	7200	120	150	110	150	>14

Source: *Gobar gas nirman goji pustika,* NBPG

Brief history of biogas in Nepal

The history of biogas development in Nepal began with the fabrication and installation of a prototype unit at St. Xavier's School Godavari in 1955 (by Late father B. R. Sanbolle). It was made using an old 200 litre oil drum and a gas holder made of mild steel sheet (Gongal et. al., 1998). For the first time in 1968, the working model of KVIC was demonstrated in the public exhibition in Kathmandu. By the year 1974, in Kathmandu there were about 4 biogas plants built by some elite on their own initiative. In 1975, for the promotion of the biogas technology Energy Research and Development Group was established under Tribhuvan University (Bajimaya, 2000).

No real interest in biogas was forth coming until the fiscal year 1975/76, which was designed on 'Agriculture Year' to boost farm production. A special plan for biogas promotion was developed, and 199 plants were built by various contractors with interest – free loans made available by ADB/N (Gongal et. al. 1998).

In 1977, the *Gobar Gas Tatha Krishi Yantra Vikas* Ltd. (Biogas and Agricultural Equipment Development Company), popularly known as the *Gobar* Gas Company (GGC), was established for the promotion of biogas technology, as a joint venture investment of the ADB/N, the Development and Consulting Services (DCS) of the UMN, and the Fuel Corporation of Nepal (now called Timber Corporation of Nepal) (Gongal et. al., 1998). Up to the fiscal year 1983/84, the GGC installed 1220 biogas plants of different capacities. In the initial phase of the company it installed drum type plant but because of the several inconveniences from the year 1980 the company started to build dome design biogas plant (Bajimaya, 2000).

Due to the success of biogas development programme and the availability of the government subsidy, as well as the interest and involvement of a number of INGOs and donor agencies, private biogas companies started coming up after 1990 following the government privatization policy. The total number of biogas installed until 1989/90 was only 5,839 (ICIMOD, 1991).

The Biogas Support Programme (BSP) was set up in 1992 as a joint venture between ADB/N, recognized biogas companies, and the Netherlands' Development Organization (SNV-Nepal) to support the biogas programme through subsidies, quality control etc (Gongal et. al., 1998).

There are almost ninety thousand biogas plants installed in the country till mid-2001 and the plant numbers are increased by 40 – 70 %. A million people are directly benefited from biogas and it protects 0.2 million trees per year. There are 49 biogas companies and ten thousands people are directly employed (*Samachhar Patra*, 2001).

Policy Review

There is no Ministry or Department of Energy in Nepal. National Planning Commission is primarily responsible for developing energy policies within substantial input from the Water and Energy Commission Secretariat (WECS). However, an Alternative Energy Promotion Centre (AEPC), a newly established institution under the Ministry of Science and Technology is responsible for the development and promotion of new and renewable energy technologies. There is also BSP for coordination and monitoring of biogas programme at the National level.

A specific policy for energy development was not stated until Fifth Five-Year Plan (1975-80). This energy policy covered only hydropower and forestry sectors up through the Sixth Plan (1980-85). In the Seventh Plan (1985-90), the government began to attach due importance to the development of alternative energy for socio-economic development. It provided subsidies for the installation of biogas plants.

The Eighth-Five Year Plan was a turning point for Nepal, which embraced a market oriented, liberal economic policy for the development of the country. The Eighth Plan (1992-97) focused on sustainable economic growth, poverty alleviation, and the reduction of regional imbalance as its principle objectives and devoted a comprehensive section to the energy sector; and this included alternative energy. In the planning history of Nepal, the effectiveness of private and non-government sectors in development activities was emphasized for the first time (Amatya et. al., 1998).

During the 8th plan period, a total of 30,494 biogas plants were installed as against the target of 30,000 establishment in order to produce 3 % i.e. 72 megawatt energy of the total capacity of 2400 megawatt biogas energy on the basis of the entire existing livestock in Nepal. The existing Biogas Support Programme will be continued in the Ninth Plan. 90,000-biogas plant will be established while taking the Eighth Plan's achievement into consideration. The existing subsidy for this programme will be maintained. Non- collateral investment for rural energy development under the Rural Poor Programme will be encouraged. The rural energy development fund will be mobilized as a revolving fund and used as collateral for this purpose. Research will be carried out in order to produce biogas in the hilly and the northern regions of the country (Ninth Plan, 1998).

Biogas in Forest Master Plan:
In the Master Plan for Forestry Sector (MPFS) of Nepal, biogas plant is appeared as fuel alternatives. The MPFS is planed to continue the plant installation at moderately rates, which is shown in the table as below:

Table 6. Projected plan for Biogas Installation in Nepal

S. No.	Fiscal year	Number of biogas plants (10 m^3 size)
1	1985/86	2140
2	1990/91	3840
3	1995/96	6301
4	2000/01	9753
5	2005/06	14595
6	2010/11	21386

Source: MPFS, 1988

If the projected data would be successful in 2010/11, it would protect the product of 34080 ha. plantation forest from harvesting (MPFS, 1988).

Subsidy Scheme

In the beginning, the biogas programme was primarily based on external assistance. This included community biogas plants built under Small Farmers' Development Programmes of ADB/N which were funded by UNDP, UNICEF, USAID and UMN. A subsidy for household biogas plants was received from UNCDF (United Nations Capital Development Fund). During the Agricultural Year (fiscal year 1975/76) interest-free loans were provided to set up biogas plants. A subsidy of NRs. 5,500 per plant was provided under a special Rice Crops programme (fiscal year 1983/84) in four Terai districts. During fiscal year 1985 and 1986, a 50 per cent interest subsidy was provided on bank loans, but this was discontinued in fiscal year 1987. Again a 25 per cent capital subsidy for 6 and 10 m^3 plants was available during fiscal year 1988 and 1989, but it too was withdrawn in fiscal year

1990 during the interim government after the advent of multiparty democracy. It was observed that the frequent change in subsidy policy made farmers hesitant to commit themselves to installing biogas plants, as reflected in the fluctuating trend in installation rate.

With the initiation Biogas Support Programme in fiscal year 1992 and the announcement of a flat capital subsidy of NRs. 7,000 and 10,000 in the Terai and Hills respectively, the installation rate for all sizes of biogas plants increased rapidly. For example, a total of 24,410 plants were installed in 4 years (fiscal year 1992-1995) compared to 6,620 plants during the 18 years prior to fiscal year 1992. According to the New Government Subsidy Policy following capital subsidies are provided through biogas manufactures.

Table 7. Prevailing Capital Subsidy Scheme of Government

S. No.	Physiographic zone	Size of biogas plant	
		4 and 6 m^3	8 and 10 m^3
1	Terai	NRs. 7,000	NRs. 6,000
2	Hill	NRs. 10,000	NRs. 9,000
3	Mountain	NRs. 12,000	NRs. 11,000

Source: Leaflet of *Rastriya Gobar Gas Nirman Tatha Sewa* Pvt. Ltd., 2001

Since the subsidy is now administered through BSP, instead of ADB/N, it has been possible to reduce the transaction costs to farmers, willing to finance the plants themselves. The farmers need not to go through the loan procedures required by ADB/N as BSP pays the subsidy directly to the construction companies upon completion of the plant.

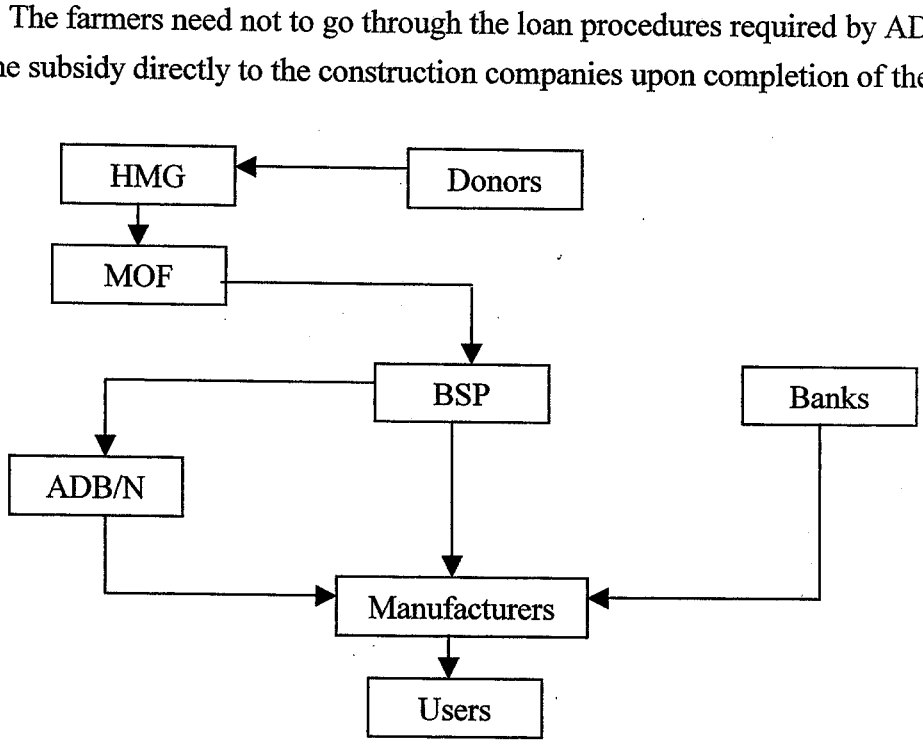


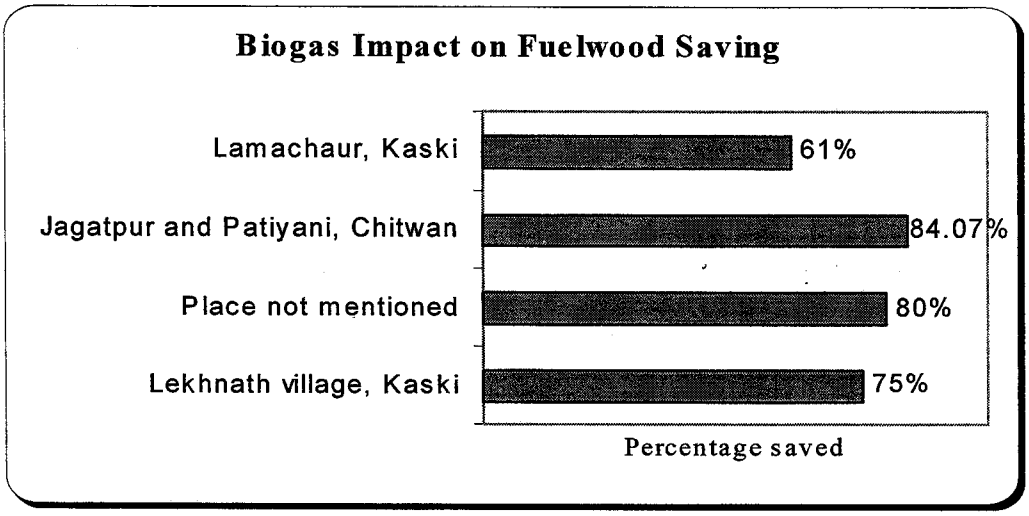
Figure 1. Flow of Biogas Subsidy

Source: Gongal et. al. ,1998

Documented observation on Biogas Impact

Biogas has saved the consumption of fuelwood according to the following figure in different places of the country.

Chart 1. Biogas impact on firewood saving in different parts of the country



Source: Sigdel, 1989, Pokheral, 1990 in Devkota, 1993, Devkota, 1993 and Bhandari, 1995

Sigdel 1989 reported that installation of biogas reduces the 30-35 % cooking time and 40 % cleaning time of utensils. Livestock unit per household reduce from 9.5 to 8.1 after adoption of biogas technology (Devkota, 1993). 100 % female accept about health improve due to the use of biogas stove. 78 % of biogas users stated no difference in the taste of food and 4.5 % felt low quality food while 17.5 % felt high quality. The estimated time saved for firewood collection is 450 hours/household/year (Bhandari, 1995).

Scientifically it is also proved that slurry has Nitrogen, Phosphorus and Potas content than farmyard manure.

Manure type	N %	P %	K %
Farm yard	0.5-1.0	0.5-1.0	0.5-0.8
Digested slurry (liquid)	1.5-2.0	1.0	1.0
Digested slurry (dried)	1.3-1.7	0.85	0.85

Source: ICIMOD, 1997

Connection of toilet with a biogas increases biogas production by 20 % and slurry enrichment by 10 % (ICIMOD, 1997).

4.0 Methodology

Methods

This study was focussed on assessing the impact of biogas on forest conservation and socio-economic wellbeing of the people. Biogas users, RBNP authorities, BCP staffs, biogas plant manufacturer, FUC member and users having no biogas plants were interviewed to elicit relevant data during field study.

In inception phase, questionnaires were prepared for biogas users on the basis of pre-testing on five biogas users and advice do Park authorities and BCP staffs. Semi-structured personal interviews were carried out with 100% biogas users of Suryapatuwa VDC i.e. the study area. Among the 76-biogas plants, 3 plants are under construction, so, they were not included for study. The biogas users were asked according to questionnaire (Annex Ia). During the households' visit, women's views were attempted to incorporate in most instances. All CFUGs were taken into considerations. Either chairman or secretary of Forest User Committee (FUC) was interviewed (Annex Ic) to identify condition of Community Forests.

The 27 users (2.23%) having no biogas plants were also interviewed (Annex Ib). There are 9 Wards in the VDC and each Ward was stratified by mainly wealth condition and ethnicity. Then total three household heads were taken randomly from stratified population. The semi-structured personal interviews with them were intended to identify their attitudes on biogas programme and their constraints not to install biogas plant till now. They were also asked terms for their involvement in the biogas programme.

Park and BCP staffs assisted by guiding how to conduct the research work and providing secondary information. An officer of *Rastria Gober gas nirman tatha sewa* pvt. Ltd., Pokhara helped for this study by explaining cost of manufacture and design standards of biogas plants and its appliances. In addition to above activities during field study phase, observations made on biogas plants. It ensured to identify problems related to the use of technology. The field study was conducted from October 31st to November 26 th 2001.

Quantitative data were thoroughly processed and analyzed using Microsoft excel such as charts, tables and other simple mathematical tools. It includes average, countif, sum, percentage etc. Logical analyses were used for qualitative data.

Limitation of the study

Impact study is difficult to carry out for shortly implemented programme, so the present study just identify effects of biogas. The output of the study is based on the views and responses of the respondents. In some cases biogas users could not exactly tell the amount of dung fed in kg. and water added in liters. The respondents used the terms *Chhitawa*, bucketful etc for estimation. Therefore, approximate quantity was estimated. The respondent when asked time allotted for cooking in biogas and firewood, cleaning utensils and other activities could not give the exact figure so it was tentatively estimated. The date of plant installation is also told as duration. Amount of fuelwood and kerosene used was also estimated accordingly. The users having no biogas plants had been taken as respondents with less sampling intensity. It was somewhat difficult to interview with Tharu women because of language problem. The duration of plant installation has been varied with users. Therefore, the conclusion drawn should be indicative rather than conclusive.

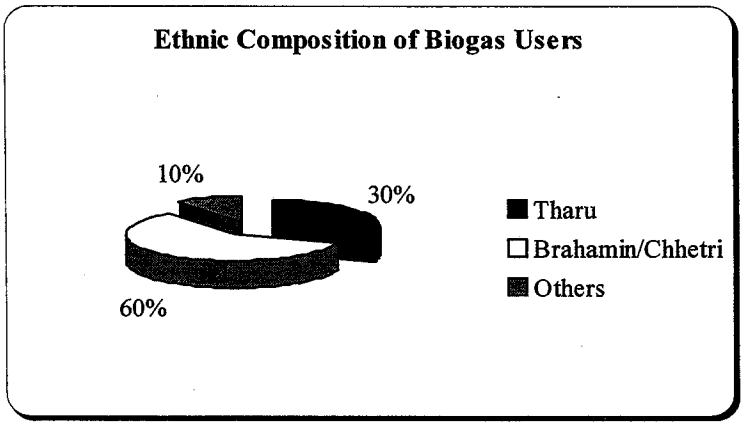
5.0 Results and Discussion

5.1 The socio-economic characteristics of biogas users

Ethnicity

A total of 73 households recognized as biogas user households. Among them 44 households are of Brahmin/ Chhetri, 22 households Tharu and 7 others. Almost 100% biogas users follow the Hinduism.

Chart 2. Ethnic composition of biogas users

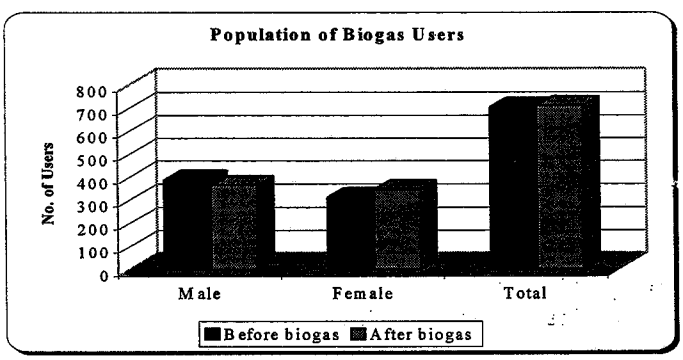


Brahmin/Chhetri have the more biogas plants in comparison to Tharu tribe. Only 10% biogas plants have with other ethnic groups. It includes mainly Disadvantaged Group (DAG) of society. 52% biogas users have at least a jobholder in their family. Therefore, plants installation rate is compatible with better social and economic condition of the people.

Family size

The total population of users is 710 with 364 males and 346 females. The population ranges from 3 to 49 members per household. So, the average family size is 10 per household. Before biogas installation, 704 users (391 males and 310 females) lived in the 73 households, though before biogas duration varies from ten years back to five months ago of study.

Chart 3. Population of biogas users



A biogas household accommodates 10 members in average and a 10-m3 size is sufficient for cooking and lighting for 7-8 people in optimum condition. It shows that the family sized plant (10 m^3) cannot satisfy the user demand. So they must depend on firewood for cooking. Households with large numbers of family members are heavily depending on firewood for cooking. As the population increases rate is relatively constant, users might be motivated to install plants due to small family size initially.

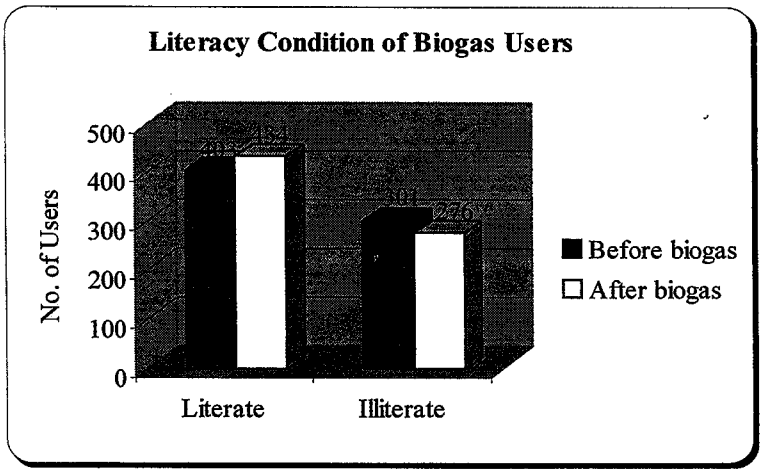
Occupation

The biogas users depend entirely on agriculture for livelihood. 35 households (48%) have not jobholder in their family either in government organizations or non-government organizations.

Literacy

Recently, 61% biogas users are literate and 39% illiterate. Before biogas installation, there were 57% users literate and 43% users illiterate.

Chart 4. Literacy condition of users before and after biogas plant installation

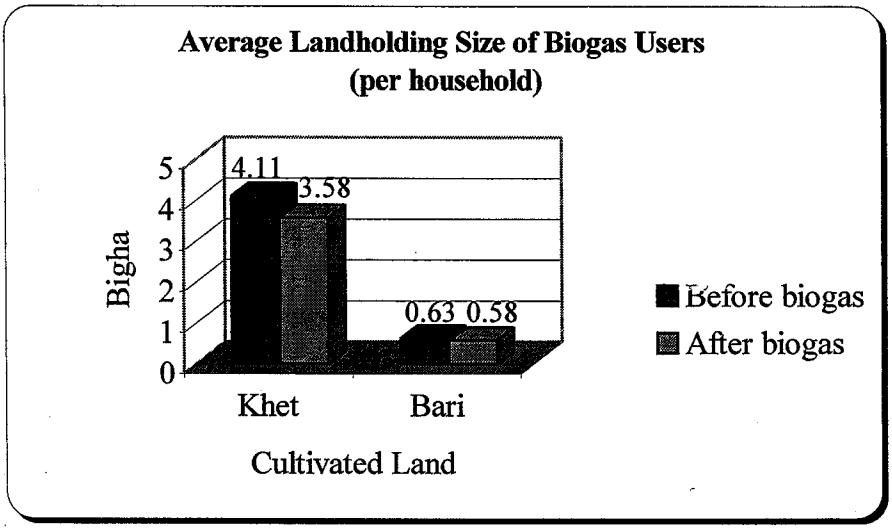


The literacy rate of biogas users is increased in comparison to before installation of biogas plants by 4 %. It cannot be taken as biogas effect but it can be said that mostly children are somewhat free due to reduction of total grazing LSU after installation of biogas plants. And stall-feeding LSU has not increased significantly too.

Landholding size

People cultivate agricultural crops in *khet* and *bari/ diuwa*. Average land holding size is 3.58 *bigha khet* and 0.58 *bigha bari* per household. Before installation of biogas they have average 4.11 *bigha khet* and 0.63 *bigha bari* per household.

Chart 5. Average land-holding size



Average land holding size is decreased with time line per family. It may be due to fragmentation land among large family members. It makes people economically poor.

Livestock population

There are total 245 cattle, 213 buffaloes and 201-goats/sheep population in 73 households or it totals 429.1 LSU. So, there are 3 cattle, 3 buffaloes and 3 goats/sheep or 6 LSU per household. Twelve improved livestock population is also recorded in seven households. Feeding pattern of livestock can be understood as mentioned below.

Chart 6. Total stall feeding livestock population before and after plant installation

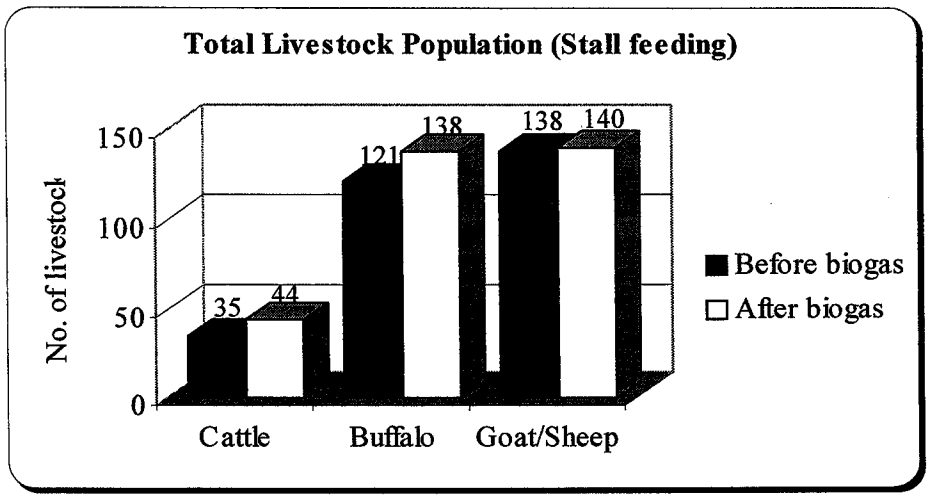
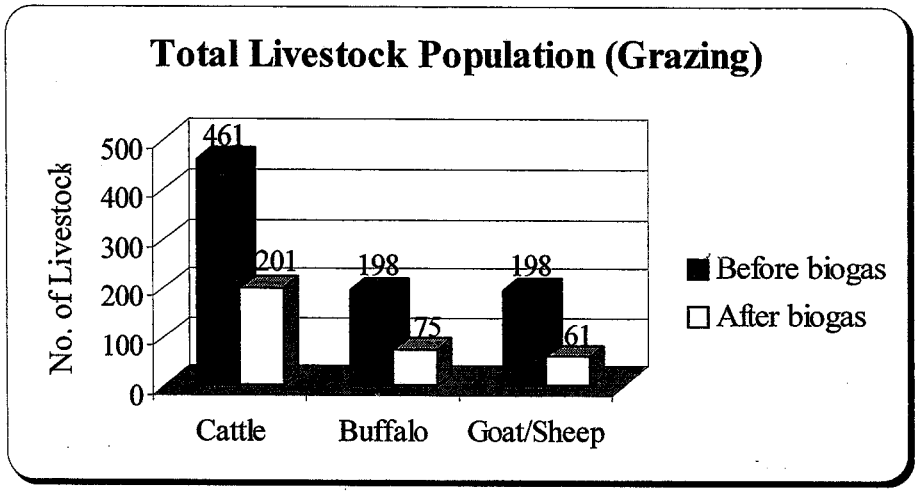


Chart 7. Total grazing livestock population before and after plant installation



Livestock feed on fodder, grasses, agricultural crop straws, other agricultural by-products and feeds while the animals stay at home. 42 households do not graze their animals in forests. 26 households carry their livestock in national forests and 5 households in community managed forests. Livestock remains outside their shed average 6.4 hours per day ranging from 2 to 9 hours. The households near the forest areas keep their animals more times in forestland. There are minimum 131 people investing their daily hours in caring the current livestock population i.e. 429.1 LSU. So, a person is required to care 3 LSU daily.

The major significance of biogas programme is observed on livestock population change, however, it is not strictly treated as biogas effect. Because, there may be several other factors for livestock population decrease for example, unavailability of fodder and grazing land, increase in economic status of users etc. Although the date of biogas installation varies with users, the users had 749.4 LSU and recently the livestock population totals 429.1 LSU by reducing 320.3 (or 42.74 %). So, 88 people became free to look after them daily. The population of grazing animals is also reduced from 586.6 to 241.9 LSU i.e. by 344.7 LSU while stall feeding livestock population is increased from 162.8 to 187.2 LSU.

5.2 Current status of biogas plants

There are total 76 biogas plants in the study area. These were insisted to install 47 by BCP, 24 by SAP Nepal and 5 loan subsidies of ADB/N. Recently, among 76 plants 3 plants with the assistance of BCP are under construction i.e. 2 in Ward no. 6 and 1 in Ward no. 9. Initially, 94 bulbs and 124 stoves were installed in 73 households. Now, 11 plants did not function completely since 3 years back in average. Similarly, the bulbs of 22 plants and stoves of 2 plants were not working completely among 62 working plants. Initially all the users installed the stoves but only 22 households did not install bulbs. The design of BCP assisted plants are of dome type and other plants design cannot be confirmed, however, the capacity of plants assisted by SAP Nepal is based on gas volume.

Table 8. Ward wise distribution of biogas plants

Ward No.	No. of households	No. of plants
1	58	0
2	126	13
3	178	10
4	268	21
5	60	4
6	146	11*
7	170	0
8	62	3
9	204	14**
Total	1272	76

* 2 plants under construction
** 1 plant under construction

Chart 8. Development of biogas plants installation rate with time line

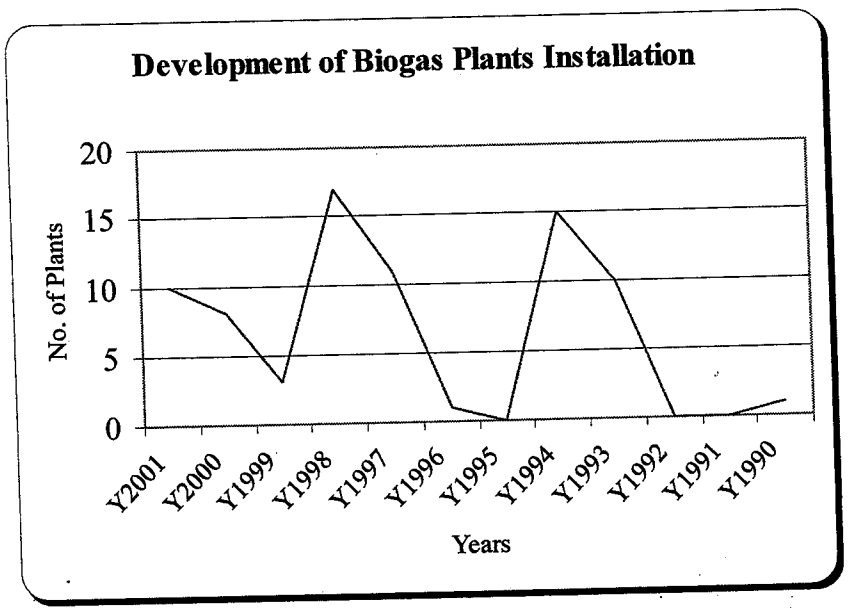
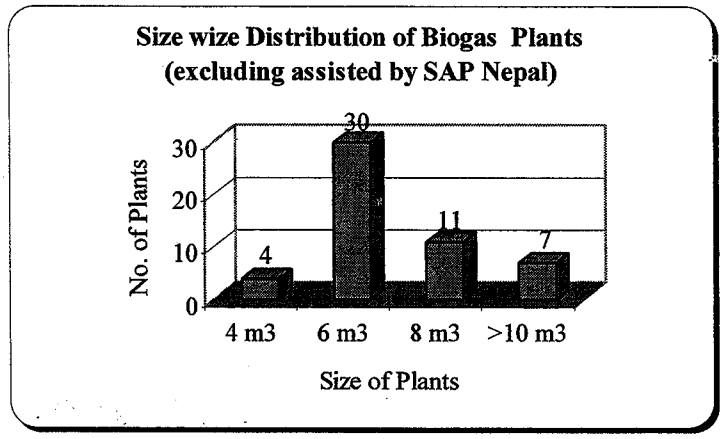
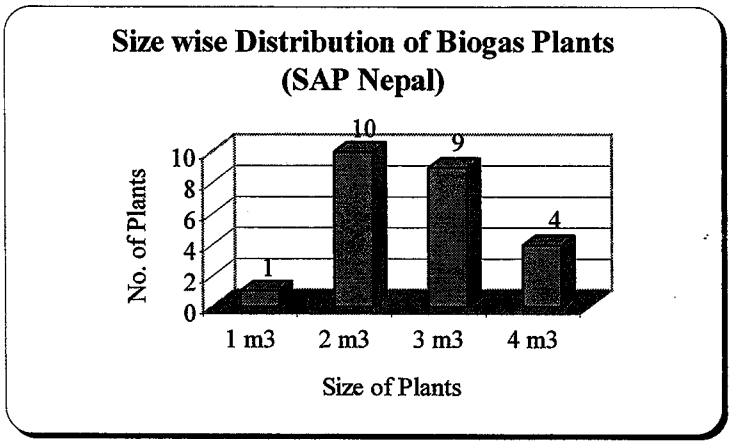


Chart 9. Size wise distribution of biogas plants





The 11-biogas plants were completely functionless due to lack of technical supports and frequent monitoring by SAP Nepal. The problems were also geared due to financial problems of biogas users.

5.3 Direct impact of biogas

Fuelwood consumption

Firewood has occupied great space as energy source for heating and cooking before biogas installation. Biogas reduces the consumption of firewood as mentioned below.

Table 9. Average amount of Firewood saved per month per household (HH)

S. No.	Size of Plants	No. of households	Avg. amt. of firewood saved/month/HH (*Bojha*)
1	4 m^3	2	9
2	6 m^3	28	14
3	8 m^3	11	21.73
4	> 10 m^3	6	24.67

Table 10. Average amount of Firewood saved per month per HH (SAP/Nepal)

S. No.	Size of Plants	No. of households	Avg. amt. of firewood saved/month/HH (*Bojha*)
1	1 m^3	1	5
2	2 m^3	6	8
3	3 m^3	5	17.5
4	4 m^3	10	20

Sixty households are using stoves including 13 plants (which have been repaired recently). Currently, biogas users are consuming firewood too. The rates can be depicted as follow.

Table 11. Average amount of Firewood consumption per month per HH (after biogas)

S. No.	Family Size	No. of households	Firewood used/month/HH (*Bojha*)
1	< 4	2	3.5
2	5 – 8	41	8
3	9 - 12	12	11.08
4	> 13	16	35

Note: Two households were excluded as they were gone out from the village.

The users fulfil their firewood demand from National Forests, Community Forests and Private lands. About 50 % households fetch firewood from CF. Previously, biogas users completely depend on National Forest for firewood, as there had not been emerged the concept of CF within the village. The firewood consumption rate before biogas is understood as below.

Table 12. Average amount of Firewood consumption per month per HH (before biogas)

S. No.	Family Size	No. of households	Firewood used/month/HH (*Bojha*)
1	< 4	8	15
2	5 – 8	32	20
3	9 - 12	15	25.67
4	> 13	14	48.07

Note: Four households were excluded as before they were not separated.

A biogas plant (mostly 6 m^3) reduces 14-bojha firewood per month per household (avg. 10 members). So, firewood consumption is reduced by 54.54%. The biogas plants installed by SAP Nepal did not function at all except 13 plants repaired in 2001. So, they have less efficiency as a substitute energy source. Before biogas installation, all households depended on national forest for firewood but now community forest is conceived within the VDC, however, not all CFs are handed over to FUGs.

Kerosene use

Generally most households use kerosene for lighting purposes. In average, they have three kerosene oil lamps (*tuki*) per household among 68 households. There are 55 lanterns in 46 households. They lighten the *tukies* and/or bulbs at an average of 2.84 hours per day. The biogas users are using 4.13 litters of kerosene per household per month, which amounts NRs 73.68. The users buy the kerosene either from the local market or from nearby villages (Bhurigaun, Thakurdwara, Taratal, etc).

In 18 households, 65 liters kerosene is replaced per month by 33 bulbs. So, a biogas plant replaces 3.61 liters kerosene per month. Before installation of biogas in 69 households, 4.93 liters of kerosene per household were used. Sixteen households have been installed solar panels for lighting and other electric purposes.

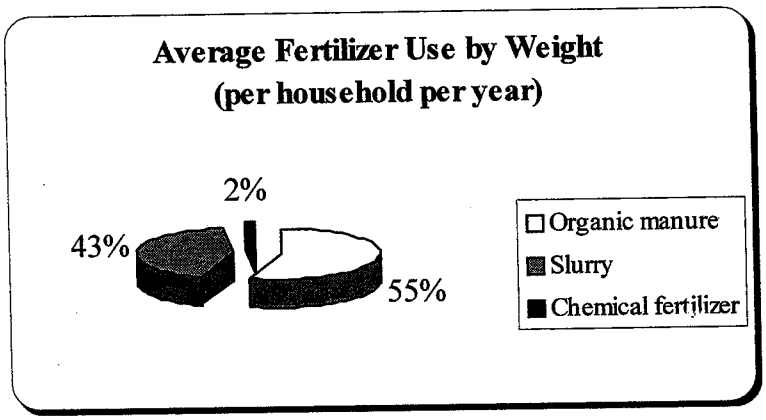
Biogas users are consuming 4.13 lt. kerosene oil per household per month, even who installed gas lamp. People are more dependent on kerosene because biogas bulb is not much efficient in durability sense. The result shows that a plant that installed gas lamp replaces 3.61 lt. kerosene per month per household. Before biogas installation, comparatively less amount of kerosene was used and it was due to low economic condition of the people.

Farm production

Slurry, organic manure and chemical fertilizer are used to improve soil fertility. Forty-two percentage people use sometimes tractor for ploughing. Average 4.16 *lariya* slurry produced per year per household among 57 households as three households does not produce slurry yet. 38% users have only one slurry pit and 62% have two or three pits. Generally, most households use slurry as sundry form but only 50% users use it mixing with other organic matters. Generally, biogas users cultivate paddy, wheat, musuro, mungi, etc in *khet* and maize, mustard etc.*bari* land. Usually, slurry is used in nearby land. They carry the slurry either in Baisakh/Jesth or in Kartik/ Mangsir or in both times which depend quantity produced.

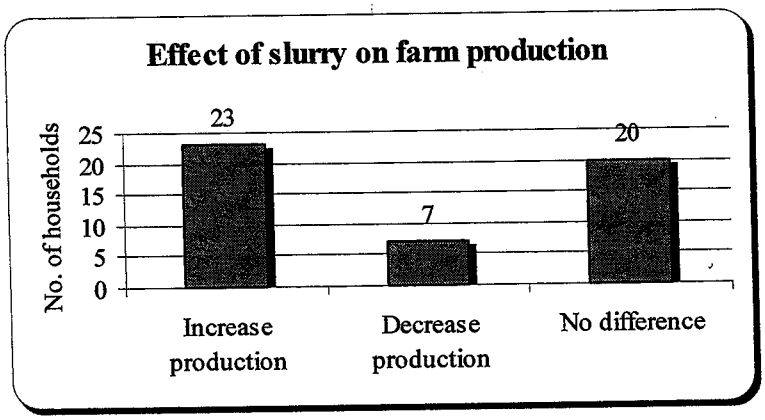
Chemical fertilizers have been used mainly in wheat by 90% users who cultivate wheat crop. In few cases chemical fertilizers were used in paddy and maize. Average 115-kg chemical fertilizers have been used in fields per household per year. There is average 6.4 *lariya* organic manure production per year per household and then used it for farm production.

Chart 10. Average amount of fertilizer use per household per year



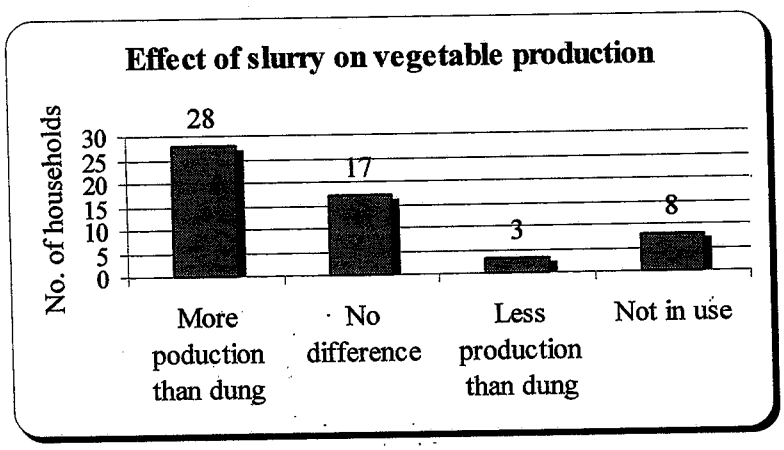
Ten households are currently using improved seed of different crop varieties i.e. paddy, wheat, maize etc. Considering the above factors, fifty households assessed the effect of slurry on farm production in comparision with cowdung.

Chart 11. Effect of slurry on farm production compared to farmyard manure.



Similarly, the effect of slurry on vegetable production is also assessed. 86% households cultivate vegetable for subsistence and 14% households for income. They earned average NRs.6,610 annually and cultivate in average 3.1 *kattha*. Fifty-six households assessed the effect of slurry on vegetable production.

Chart 12. Effect of slurry on vegetable production



In average, there was 5.64 *lariya* more production of organic manure per year per household than post installation.

The biogas impact was assessed in agricultural crop production and vegetable production. It is found that 46 % HH accepted that slurry can increase the production while 40 % HH told "no difference" and 14 % assessed decrease the production in comparison to the use of farm yard manure. Similarly, 50 % HH recognised it superior than farm yard manure while used in vegetable cultivation.

Sanitation

As biogas burns without odor and smoke, it is non- air polluting. All users accept its role in health and hygiene conditions improvement. 75% users realized that it improves outdoor environment too because of toilet connection. Forty-five households have joined the toilet in their biogas plants.

Biogas users got rid from eye disease and respiratory problems, which were previously caused by using firewood stoves. So, it improves the hygienic and health conditions of users and their families. As even night soil can be used as raw material, the sanitation and hygienic conditions of local areas are improved. These would be fewer flies and bad odour would be reduced or eliminated. So, users have unanimously recognised it as eco-friendly technology. However, 27% HH did not attach toilets in biogas digester due to conservative thoughts and financial problems.

Work load on women

Cooking, fuelwood collection and cleaning utensils are the activities most dramatically affected by the introduction of biogas. People could use the biogas stove in morning, afternoon, and evening. Two households did not operate their stoves in morning, thirteen households in afternoon and twenty-nine households in evening among sixty households. So, there are sixteen households who used the stoves generally three times per day. In average, stove is operated 73.75 minutes in morning, 23.81 minutes in afternoon and 60 minutes in evening in all sixty households. It shows that stoves are being used more in morning time due to sufficient gas availability. Biogas stove has saved 80 minutes cooking time per day in comparison to ordinary firewood stove except in winter months. However, 15 households do not agree with the time saved.

As biogas burns without smoke, it has fewer stains on cooking utensils. So it saves 42.72 minutes cleaning time per day in comparison to utensils used in firewood stove. Generally, the VDC is surrounded by forests and it has also many forest patches. So, users, mostly women do not walk far more than 1 hour to reach forest area for firewood and fodder

collection. As already mention that biogas saves 14 *bojha* firewood per HH/ month (in average family size 10 with 6 m^3 plant size). Therefore, mostly woman relieves 14 days time because she would not involve in firewood collection. Due to reduction of 320.3 LSU among 73 households after installation of biogas, 88 people became free daily from caring of livestock.

Recent study has indicated that biogas has time saving effect on women's workload in most instances. The average amount of time saved in cooking and cleaning the vessels were find almost 2 hours per day. In addition to this, firewood collection and livestock caring time were also saved. The time thus freed can ultimately be used for income generating activities, which can be seen as another indirect contribution to the expansion of technology with the economy. Another work related problems for women that biogas installation entail arises from the resulting shift from cattle grazing to stall-feeding and the accompanying increased collection of fodder. In this case, there is not significant change install feeding animal before and after biogas.

It is doubtful whether the overall workload on women is in reality reduced because women having access to biogas were found working longer hours than before its labour activity for another. However, it has definitely provided an opportunity for them to perform their activities in a more relaxed manner, whether these involve tending their babies or spending time in income generating activities.

5.4 Problems related to the use of technology

Several factors affect quality of gas production biogas i.e. water-dung ration, temperature, water dung mixture pH, retention time, raw materials, etc. Only ten households have used 1:1 water dung ratio and similarly, 6 households have used less water and more dung and 46 households more water and less dung.

Table 13. Comparison among current water-dung fed situation and livestock keeping pattern with standard requirements

S. No.	Size of plant (m^3)	Daily fresh dung fed (kg)	Standard dung requirement for Terai (kg)	Daily water use (lt.)	Standard water requirement (lt.)	Current livestock number	Approx. no.of cattle requirement
1	4	20	30	25	30	2-3 (2)*	2-3
2	6	22.1	45	33.28	45	3-10 (3)*	3-4
3	8	21	60	30	60	2-5 (3)*	4-6
4	10	30	75	41	75	2-10 (5)*	6-9

Asterisk (*) represents the average number of cattle.

Source: SNV/BSP-Nepal, 1999

The above facts are assessed based on the experience of the biogas users.

The following spare parts of biogas were found to be frequently repaired in 62 households.

Table 14. Frequency of repaired appliances

S. No.	Spare parts	No. of households
1	Bulb/ gas cock	25
2	GI pipe	15
3	Main gas valve	14
4	Stove and rubber pipe	13
5	Water drain	7
6	Gas tap	6
7	Outlet	1
8	Inlet	1
9	Washer	1

Water and dung are under fed into biogas plants and there are also 16 HH only to use water dung ratio in 1:1 or 1:>1. The livestock numbers according to plant capacity are not also satisfactory. Most users have possessed small and unfertile livestock.

Biogas lamp and main gas valve are most frequently repaired spare parts. The bulbs are completely functionless in 23 HH (43 %) excluding 11 completely functionless biogas plants due to improper handling or duplicate spare parts. There were 51 (or 70 %) plants only installed bulbs initially.

5.5 Peoples' attitude towards biogas

5.5.1 Attitude of biogas users

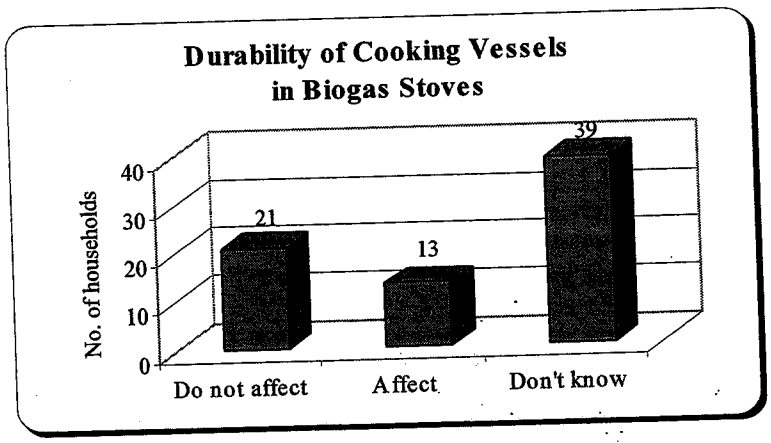
People acknowledge biogas due to comforts in handling. Biogas users were informed from following information source and installed plants.

Table 15. Initial sources of information

S. No.	Sources	Household percentage
1	Neighbours	33 %
2	Relatives	41 %
3	Others (NGOs, Company, Bank, etc)	26 %

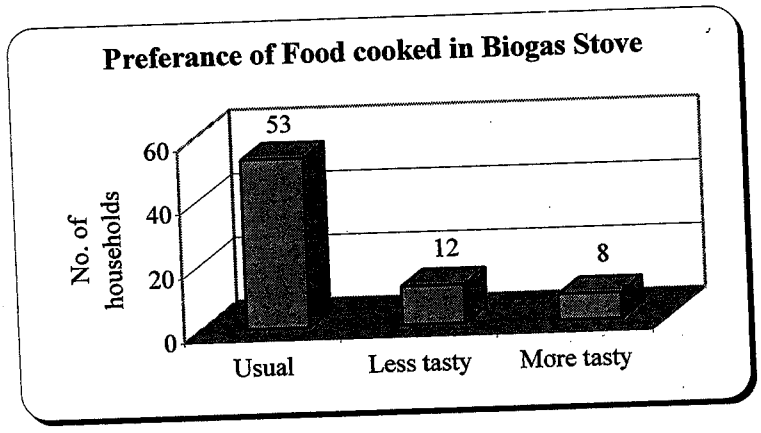
The gas flame may affect the durability of cooking vessels. People are pragmatic on taste of food prepared in biogas stove.

Chart 13. People perception on durability on cooking vessels



There is more number of households that they did not know the effect of biogas flame on cooking vessels due to relatively low experiences.

Chart 14. Peoples' preference on the food cooked in biogas stove.



Night soil is highly emphasized as best source for biogas production in addition to this, 45 % households accepted as cow dung is best, 20 % to buffalo and 35 % told that they didn't know. The cow dung was preferred due to easy handling while buffalo dung is very soft. The buffalo dung was preferred only due to bulk production and easy for dilution in mixture. All biogas users accepted biogas bulb lights brighter than *tuki*. Hot season is favorable for biogas production.

Biogas users identified following positive and negative aspects of biogas as a whole.

Positive aspects

1. It is non-polluting, as it does not give out smoke and odourless when burning.
2. It uses wastes for example animal and human excreta and plant residues, which can otherwise create undesirable conditions.
3. Its slurry could be used as nutrient rich manure on farms and could improve agricultural production.
4. Slurry has good effect on vegetable production as it lessens insect attack on it.
5. It can give a hygienic, clean and safe atmosphere in and around dwelling places. Organic and human night soil, which, if not properly disposed off, can be utilised to produce useful soil and slurry, thereby destroying germs/bacteria.
6. Socially, it can save a lot of time and labour in such activities as cleaning and cooking, these time they can use for other income generating activities and education.
7. Environmentally, it can save fuelwood and through that help in protection of vulnerable forest, soil and water and cleaning up the environment.
8. It saves kerosene consumption thereby increasing brightness of lamp than kerosene lamp.

9. Women got freedom to remain close to fire in hot months, which is considered very hard.
10. It reduces the chances of fire hazard.
11. Mostly women use kerosene oil while setting fire in fuelwood but it is not needed to ignite biogas stove. Thus it saves kerosene consumption.
12. Hands are less cracked in cleaning the cooking vessels.

Negative aspects

1. Biogas plants can only be installed in households with the required number of animals of a dependable daily dung supply.
2. Its initial cost is very high for low economic groups.
3. It requires the potential users to have a sound economic status. The biogas appliances need frequent repair and only one-year warranty except digester. Users should have capacity to pay bank loan.
4. It increases the extra work by way of feeding biogas plants and handling slurry.
5. Water supply is needed near by for plenty of water to dilute the fresh dung.
6. There is less gas production in winter, so it causes more time for cooking than summer.
7. It requires permanent settlement in the private land resources.
8. It costs more to buy match than ordinary stove.
9. Some one does not like the taste of food if toilet is connected.
10. Some people believe that slurry does not have adequate fertility than farm-yard manure and it is also difficult for handling.
11. The volume of slurry is lesser than its input i.e. fresh dung.
12. Slurry will turn to soil if it is not used within certain period.
13. Buffalo dung is difficult to carry and cow dung is difficult to make dilution.
14. It is difficult to get skilled manpower and appliances for maintenance.
15. It has expensive spare parts due to monopoly market.
16. Animals, children may fall into slurry pit, it may end in fatal case.
17. The burners may get off due to sudden technical problems.
18. Big biogas plants are difficult in handling.
19. Biogas plants need to be used continuously.
20. It corrodes iron-cooking vessels.
21. Generally, the gas availability is least in evening.
22. Food gets cold early.

5.5.2 Attitude of users having no biogas plants

Socio-economic characteristics

The users having no biogas plants have average family size of 10 individuals (5-male, 5-female) per household. They have average 4 cows, 1 buffalo and 5 goats or 5 LSU per household. They have 60 % grazing animals. 15 % household did not have cows and buffaloes. The average land holding size is 1.4 *bigha* per household. However, 15 % households were landless. Only 22 % households have somewhat good toilets, fitting within ring slabs.

Energy consumption pattern

Firewood is the only one source of energy for cooking. 21.56 *bojha* firewood is being consumed per household per month. Kerosene oil is used for only lighting purposes. They consume 3.18 litres of kerosene per household per month, though, 11 % households have installed solar panel for light and other electric purposes.

Some other observed issues

1. Neighbour/relatives, BCP, Terai Arc Landscape Programme are the first source of information about biogas in 67 %, 15 % and 18 % households respectively.
2. 19 % households have shown the interest to install biogas plant under terms and conditions of BCP assistance. 11 % households have shown interest to install biogas plants not with BCP, but with TAL Programme. Similarly, 59 % households rejected to install biogas plants currently due to different reasons and 11 % do not confirm yet.
3. The reasons not to install the biogas plants can be depicted as mentioned below.

Table 16. Reasons for not installing biogas plants

S. No.	Reasons	Respondents percentage
1	Financial problems	63 %
2	Lack of sufficient information	29.63 %
3	Low no. of livestock	29.63 %
4	Adequate firewood availability	7.41 %
5	Due to large family size	3.7 %

All the households were aware of biogas. They predicted following positive and negative aspects of biogas.

Positive aspects

1) It burns without smoke.
2) It cooks the food with good taste.
3) It does not stain the cooking vessels.
4) It saves firewood and kerosene consumption.
5) Slurry has good fertility.
6) It ensures easy and fast cook.
7) It can operate with small number of livestock.
8) It improves community health and sanitation.

9) It protects the forests.
10) Toilets can be attached.

Negative aspects

1) It requires permanent settlement.
2) The bulbs are not durable.
3) It is difficult to repair frequently. It is capital intensive.
4) It affects iron-cooking vessels.
5) It takes more time in cooking in winter.

People are very much positive towards biogas as its easiness and fast handling mechanism and reduction in time to go to firewood collection. So, it is gaining popularity among users, although it is not suited for large size family, need frequently maintenance and capital intensive.

The users having no biogas plants are much aware of biogas programme from their neighbors and relatives. It can also be proved due to their ability to predict positive and negative aspects of biogas technology. Recently, they are consuming 10.48 *bojha* (or 95%) firewood more than biogas users per household per month. Lack of sufficient information about how to install, financial problems, lack of permanent settlement etc. are the root cause of not to install plant yet, however, they are getting wide opportunities in biogas installation from BCP and TAL programme. Though, TAL programme has not started plant installation works.

5.5 Forest condition

There are 24 forest patches managed by different forest user groups. It covers an estimated area of about 1420.7 ha. including 316 ha. plantation area in 18 patches. Forest user groups have began to manage their surrounding forest areas since five years ago, according to their rules and regulations, however, most forest areas are not formally handed over to FUGs.

Naturally, forest areas comprise mainly of *Dalbergia sissoo, Acacia catechu, Bombax ceiba, Calamus tenuis, Eugenia spp. Shorea robusta*, Velor, *Aegle marmelos*, etc. Similarly, *Dalbergia sissoo, Leucaena leucocephela, Artocapus lacoocha, Tectona grandis, Eucalptus camaldulansis, Acacia nilotica* (Chinese babul), *Calamus tenuis,* etc. are planted species. Almost all the forest patches in the VDC are being conserved.

Recently estimated area of forest land is contrast with estimated area of VDC record of 2054 B. S. it might be due to unscientific estimations and users also estimated their use zone beyond VDC boundary. The plantations patches are being sustained and conserved rather than its establishment momentum. It is because of releasing livestock and firewood

collecting pressure. Community managed forests are conferring more domestic products such as dry grass and firewood.

6.0 Conclusion

There are altogether 76 biogas plants installed in the study area including under construction three plants. SAP Nepal assisted to install 24 biogas plants, among 24 plants, 13 has been recently repaired while 11 plants are completely functionless due to lack of technical supports, frequent monitoring and financial problems of biogas users. Now, 62 plants are in function. Biogas Programme has affected on following specific elements:

- fuelwood consumption
- kerosene use
- farm production
- livestock population
- user's health and environment
- women's workload

The installation of biogas plants has reduced fuelwood consumption by 54.54 % while kerosene by 3.61 lt. per month per household. Only 14 % HH have assessed slurry as inferior than farm yard manure. This concludes slurry has positive impact on farm production.

After installation of biogas, grazing animals population has decreased by 58.76 % and increased the stall feeding livestock population by 14.99 % as compared to pre-installation. Though it is not strictly assumed as biogas effect, however, the role of biogas Programme to reduce livestock population cannot be denied because stall feeding animal population is increased. The population of stall feeding animals is increased but it is not significant to pre-installation, fodder pressure is limited within users' private land. Therefore, forest resource has faced less pressure. So, the community forestry in this area is sustaining in better way.

Biogas has positive effect on improvement of users' health as well as indoor and outdoor environment. Biogas has decreased workload by 2 hours per day due to ease in cooking and quick cleaning of vessels. This is a contributing factor especially for women and girl children. This provides women to spend more time in caring for their children, educate them and themselves, and engage in income generating activities.

The users having no biogas plants have consuming 95 % more fuelwood than biogas users. Financial problems, lack of sufficient information on technical know how, lack of permanent settlement etc. are the major causes for not installing biogas plants, however, 30 % households are interested to install biogas plants.

Therefore, in general the programme has positive effect on people's socio-economic well being and forest resources conservation.

7.0 Strategic Recommendations

Biogas Programme is cost effective and being succeeded to conserve forest resource as well as socio-economic well being. So, programme should be continued considering with the following recommendations.

1. Initiate integrated programme in livestock improvement, plantation and promotion of community forestry, income generating activities, population control, etc. Co-ordination and co-operation among different organizations should be followed so that all the problems of buffer people should be addressed properly.

2. Continue subsidy schemes giving emphasis to low income group on the basis of government job holding and land holding size. In addition to government subsidy scheme, the subsidy for bricks, toilet pan and maintenance should be continued and also initiate community loan schemes arrangement. The availability of spare parts should be arranged in minimal price. Equal emphasis should be given to ICS, which is also suitable for low-income groups.

3. Initiate demonstration programme via progressive farmers especially for slurry management.

4. Enforce standardization and quality control by providing warranty of spare parts and reducing cost of plant's manufacture. A skilled manpower should be developed in VDC for maintenance works.

5. Conduct awareness programmes about advantages and disadvantages of biogas plants and how to install them even at village level schools. Training should be given for operating biogas appliances and slurry management. Frequent monitoring of biogas plants is also highly desired and it can be performed through user committee.

6. User Committee should be encouraged to generate funds via sale of forest products from CFs, revenue sharing of buffer zone, tourist development activities etc. So that the project subsidy scheme should be replaced continuously in long run or ended in 20 years. The income generating activities may be helpful to biogas users for raising maintenance costs.

7. This research could not identify the exact relationship impact of biogas on grazing animal population decrease, education level change, increase in income generating activities, so further research is recommended to resolve it.

Reference

1. Amatya V. B. and G. R. Shrestha 1998. 'Review on Policies and Their Implication on RETs. In Rijal K. (ed.). Renewable Energy Technologies: A Brighter Future. Kathmandu: ICIMOD.

2. Bajimaya Susan, 2000. *An Impact Assessment of Biogas in the Buffer zone of Royal Chitwan National Park (Kumroj)*. St. Xavier's Collage, Kathmandu.

3. Bhandari (KC) Puspa, 1995. *Impact of Biogas on Women: A case study of Lamachaur VDC of Kaski district.* Institute of Forestry, Pokhara.

4. Bhatta S. R., 1994. *Beginning with Buffer zone Management: A case study from Royal Bardia National Park, Nepal.* M. Sc. Thesis. Agricultural University of Norway.

5. BSP, 1999. Index BSP Quality Standards Construction: SNV/BSP Nepal.

6. *Gobar gas nirman Goji Pustika* NBPG.

7. Gongal R. N. and S. Shrestha, 1998. 'A case study of biogas programme in Nepal'. In Rijal K. (ed.). Renewable Energy Technologies: A Brighter Future. Kathmandu: ICIMOD.

8. HMGN (1998). Master Plan for Forestry Sector of Nepal (main report). Ministry of Forests and Soil Conservation, Kathmandu.

9. ICIMOD, 1997. Manual of Rural Technology with Implication for Mountain Tourism, Kathmandu: ICIMOD and Centre for Rural Technology.

10. KMTNC, 2000. Annual Report 2000. King Mahendra Trust for Nature Conservation, Lalitpur.

11. Leuschner, W. A., 1984. Introduction to Forest Resource Management, John Wiley and Sons: New York, USA.

12. MOPE, 2001. Nepal's State of the Environment (Agriculture and Forests). Ministry of Population and Environment, Kathmandu.

13. Pant M. M., 1984. Forest Economics and Valuation: Medhawi Publishers, Dehra dun, India.

14. *Samachar Patra*, December 8, 2001. Daily News Paper in Nepali.

15. Wagle, Mohan, 1996. Lecture Notes on Range Management.

Annex I

Questionnaires

a. <u>With biogas users</u>

1. Personal profile

Name of respondent: Gender: Age:

Caste: Occupation: Religion:

Family size: Male Female

Literate Illiterate

Livestock (stall feeding and grazing)

Cattle, Buffalo, Goat/ Sheep

Land holding size: *Khet* *Bari/ Diuwa*

Economic Condition:

2. Biogas

Plant establishment date

Plant size

Bulb #: Stove #:

Bulb use Hours/ day

Stove use hours/ day- morning, afternoon and evening

Existing stove users

Maximum capacity to feed/ cooked

Users' initial establishment costs

Maintenance costs

Amount of water dung fed daily

Amount of Kerosene replaced by biogas lamp lighting(lt. Per month)

Amount of Firewood replaced by biogas stove in cooking (*Bojhal* month)

Amount of slurry production and use time in field

No. of pits and state of slurry used

3. Existing fuelwood consumption condition

Per month requirement

Source of firewood

Others

4. Existing Kerosene consumption condition

Per month requirement

Sources

Costs per litre

# of kerosene lamps/*tuki*

Others

5. Other sources of energy

Esp. Solar energy

6. Livestock feeding situation

Feed, grasses, straw/hay amount

Grazing duration and place

Farmyard manure production pre year

Number of people necessary to care livestock daily

Improved livestock number

Other

7. Forest condition

Name of forest and time to reach

Existing forest conditions

8. Farm production

Cultivated agricultural crops

Slurry used agricultural crops.

Effect of slurry on farm production

Irrigation, tractor use, farmyard manure use conditions

Chemical fertiliser used species and amount

Improved crop species

Main cultivated vegetable species and area

Income/year

Effect of slurry on vegetable

9. Social conditions

Health condition

Time saved in cooking and cooking vessels

Effect of biogas flame on cooking vessels

Toilet

Sanitation conditions

10. Technological problems

Minimum livestock number

Best dung animal and why frequently changed spare parts.

Taste of food and bulb brightens

11. People's attitude towards biogas

Information source of biogas

Positive and negative aspects of biogas
Further assistance that will need & other

12. Miscellaneous
Monitoring and evaluation
Match costs
Water source
Pit place – open/shade/partially shade

13. Baseline data (before biogas)
Family size
Literacy
Stall feeding and grazing animal
Firewood requirement
Kerosene requirement
Farm production
Amount of farmyard manure production per year
Forest condition
Others

b. <u>With users having no biogas plant</u>
1. Personal profile
Name of respondent
Family size, literacy rate
Livestock (grazing and stall feeding)

2. Source of fodder to livestock grazing place
3. Information source about biogas
4. Reasons not to install biogas
5. Positive and negative aspects that were heard
6. Installation interests
As per BCP's terms and conditions
Others
7. Fuelwood and kerosene use
8. Other energy sources
9. Toilet
10. Others

c. <u>With user committee member</u>
1. Total number of household in FUG
2. Name of CFs

Area, date of began to manage
Plantation area, date, species
Natural species
Management options

Annex 2

Benefit Cost analysis

For Benefit Cost analysis of total investment, a biogas plant was selected specially with 6 m^3 size because there are 36 m^3 plants in the study area. It belongs to a biogas user of ward no. 3 Kailashi, Miss Saraswoti Swar. The analysis is based on the following assumptions

1. The durability of a plant is assumed 20 years. This idea is taken from ICIMOD publications.
2. It is not applicable for sudden disasters.
3. Initial establishment costs are taken from leaflet of company, BCP office and users.
4. No associated costs are considered.
5. Similarly no indirect benefits are assessed.
6. Users did not take the bank loan for plant manufacture so, he forgone only 5 % interest rate instead of 12 % average interest rate of banks.
7. Currently the plant has just completed 4 years
8. It has a bulb and a stove
9. Cost analysis assumptions

For maintenance costs up to 4 years, they paid recently only NRs 150. Taking average of 73 households, there is NRs 92.95 maintenance costs incurred per household per year. So, it is also assumed for next 16 years. Match costs, bulb costs and /or miscellaneous costs are similarly assumed.

10. Benefit analysis assumptions

Fuelwood and kerosene replacement and time save are assumed as benefits and these are converted to monetary terms. The biogas stove replaces 10-*bojha* firewood in cooking per month. So, it equals 120-*bojha* replacement per year. As a man/woman can collects 2 bojha firewood in a whole day which equals NRs 80 opportunity cost or forgone value if he was involved in daily unskilled labour works. So, it costs 120 x NRs 40 = NRs 4800.

In case of kerosene oil, the bulb replaces 2 litres per month in lighting. So, it totals 24 litre/year. In local market a litre kerosene costs NRs 19 and so the whole kerosene replacement costs NRs 456 per year.

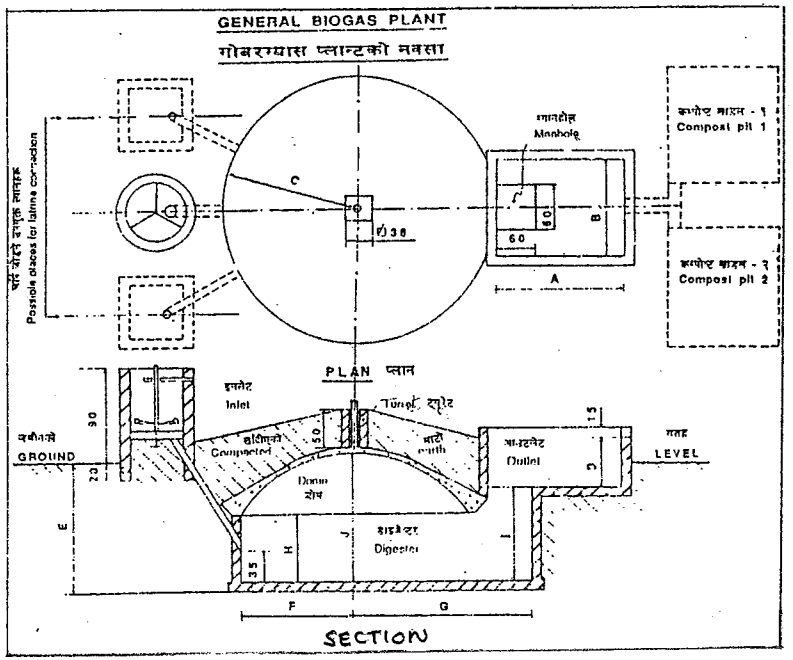
100-minute time is saved per day due to quick cooking and cleaning the vessels. So, it saves total 600 hours per year. 10% time is considered as leisure, remaining 540 hours time is assumed to engage in daily unskilled labour. If 8 hours labour work costs NRs 60 the whole time will be monetized NRs 4050.

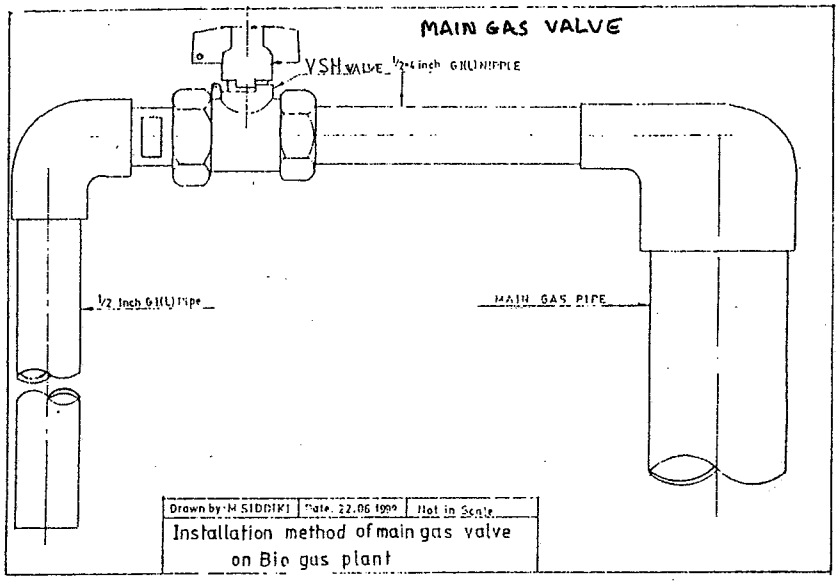
S.N.	**Cost items**	Price(NRs.)
1	Initial establishment costs	
1.1	Manufacturer's costs, NRs. 11704.00 @ 12% inerest rate upto 4 years	18416.47
1.2	BCP's costs(bricks & toilet pan) ,NRs. 4650 @ 12% interest rate upto 4 years	7316.86
1.3	Biogas user's costs NRs. 6500 @ 5% interest rate upto 4 years	7900.79
	Sub total	33634.12
2	Regular maintenance and other costs upto 4 years	
2.1	Maintenance costs	150.00
2.2	Match costs NRs. 60/yr. @ 5% interest rate	258.61
2.3	Bulb net costs NRs. 60/yr. @ 5% interest rate	258.61
	Sub total	667.22
3	Regular maintenance and other costs for next 16 years	
3.1	Maintenance costs per year	92.95
3.2	Match costs per year	60.00
3.3	Miscellaneous costs per year	200.00
	Sub total	352.95
	Present value @ 5% discount rate	3825.19
	Present value @ 12% discount rate	2461.47
	Grand total of compounded and discounted costs at 5% (at present)	38126.53
	Grand total of compounded and discounted costs at 12% (at present)	36762.81
	Tangible benefits items	
1	Benefits received till the end of 4 years	
1.1	Fuelwood benefits per year	4800.00
1.2	Kerosene benefits per year	456.00
1.3	Time save benefits per year	4050.00
	Sub total	9306.00
	Present value @ 5% interest rate	40110.02
	Present value @ 12% interest rate	44476.43
2	Benefits receives for next 16 years	
2.1	Fuelwood benefits per year	4800.00
2.2	Kerosene benefits per year	456.00
2.3	Time save benefits per year	4050.00
	Sub total	9306.00
	Present value @ 5% discount rate	100856.28
	Present value @ 12% discount rate	64899.92
	Grand total of compounded and discounted benefits at 5%	140966.30
	Grand total of compounded and discounted benefits at 12%	109376.35
1	**Present Net Worth (PNW)**	
	PNW @ 5% interest rate NRs.(140966.30-38126.53)	102839.77
	PNW @ 12% interest rate NRs.(64899.92-36762.81)	28137.11
2	**Benefit Cost ratio**	
	@ 5% interest rate (NRs. 140966.30/NRs. 38126.53)	3.70
	@ 12% interest rate (NRs. 64899.92/NRs. 36762.81)	1.77

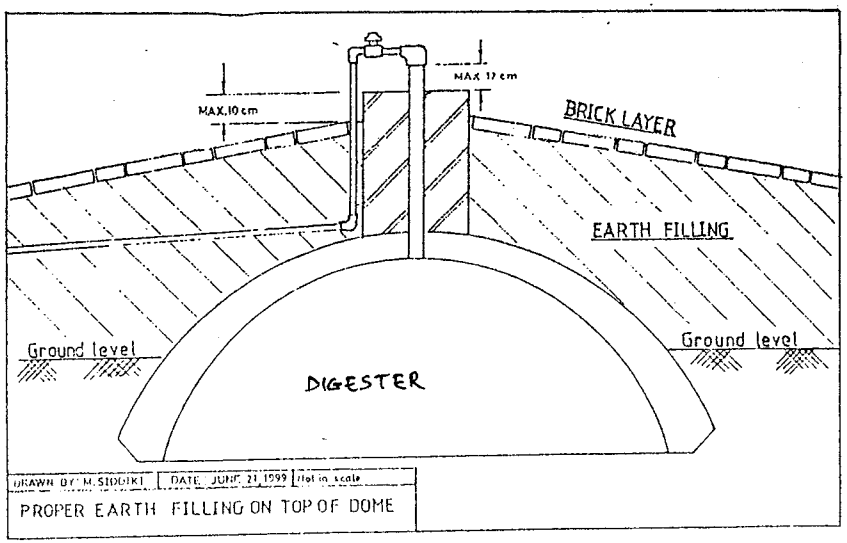
Figure 2. Biogas appliances

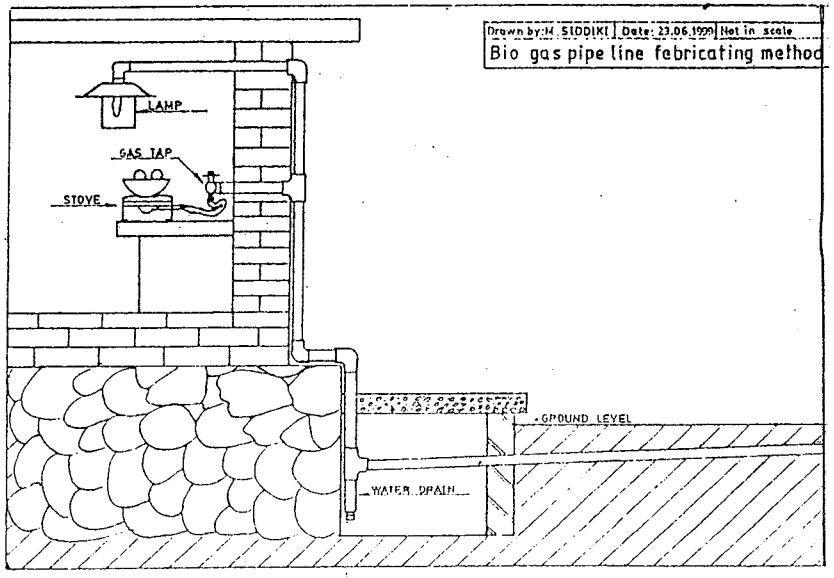
Plan of Biogas Model 2047

Source : SNV/BSP Nepal, 1999

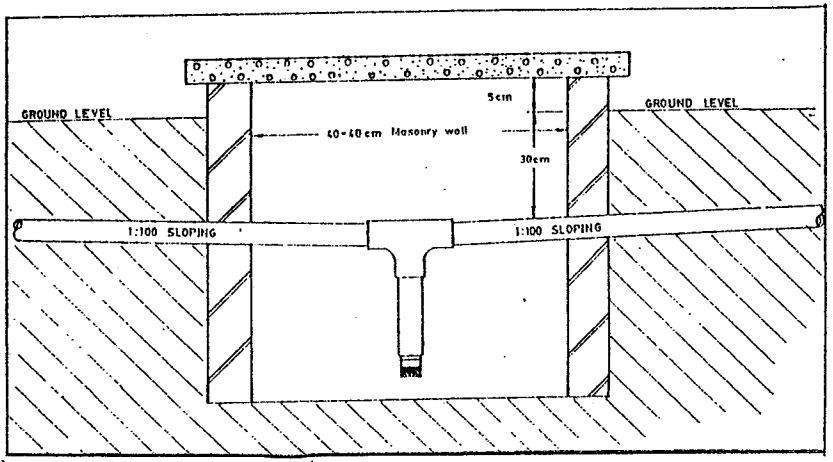




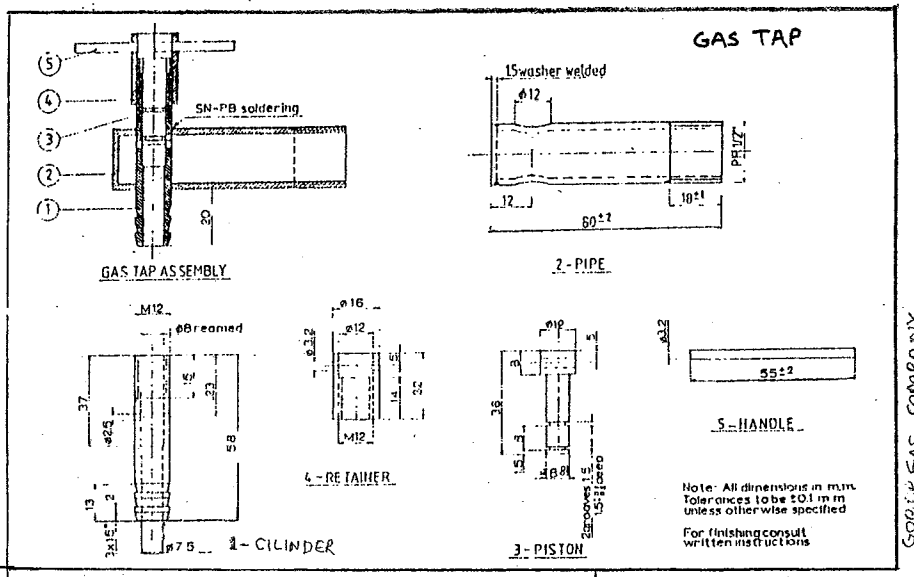




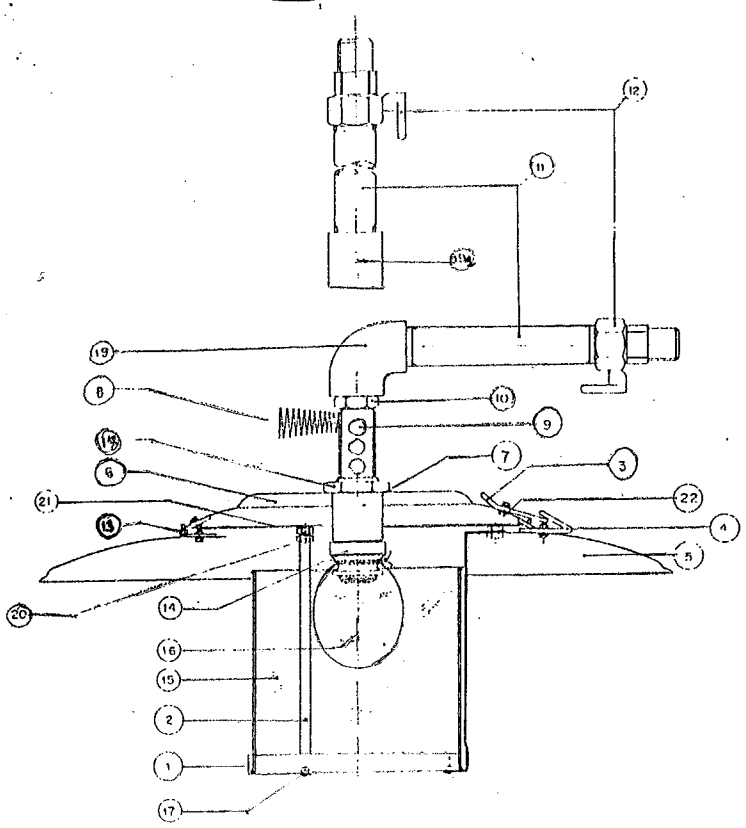
WATER DRAIN & DRAIN PIT



GAS TAP

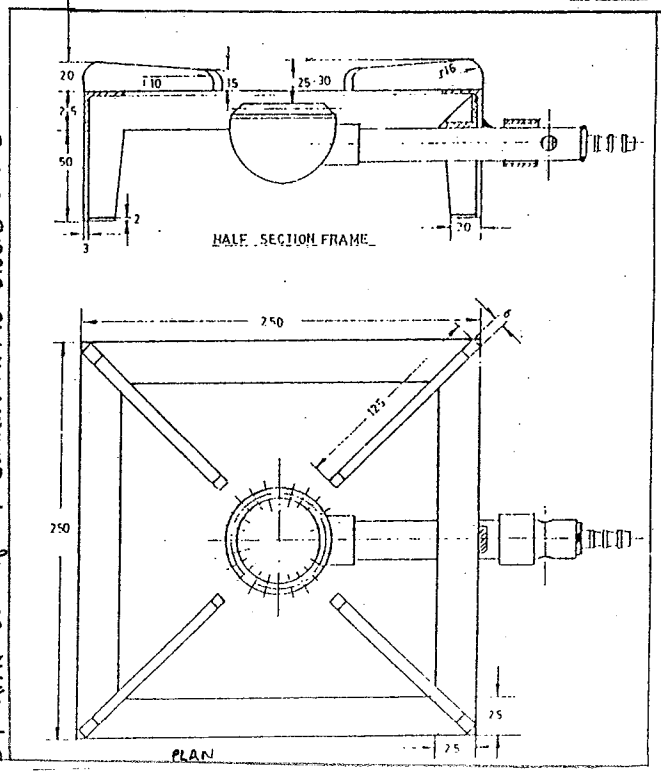


GOBAR GAS COMPANY
WORKSHOP BUTWAL MANSIR 2049



UJELI BIOGAS LAMP

BSP APPROVED 16cft ANGEL IRON FRAME BIOGAS STOVE



Biogas bulb parts

1 - glass holder
2 - Spoke
3 - Lock
4 - Lock
5 - Reflector
6 - Upper reflector ϕ 7"
7 - Mantle holder
8 - Air sleeve handle
9 - Air sleeve
10 - Reducer bush
11 - Nipple ϕ ½" - 5"
12 - Balb valve ½"
13 - Hinge
14 - Carborendum venturi
15 - Glass
16 - Mantle gauze
17 - Pop revit
18 - Back nut
19 - Elbow
19, - Socket
20 - Hexagonal bolt
21 - " nut
22 - Spring washer