SESSION TWO

RELEVANCE OF BIOGAS TECHNOLOGY TO NEPAL

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2.1 Introduction

The basic components of biogas technology as a complete system were discussed in the previous session. This session highlights the relevance of the technology in terms of its potential to ameliorate some of the development problems and the potential that exist for the promotion of this technology in Nepal. By the end of this session, the participants will be able to:

- enumerate problems generally' faced by developing countries that can be resolved through the
- adoption of biogas technology:
- explain the potential of biogas technology in Nepal; and
- explain how biogas technology can help improve the socio-economic condition of women in Nepal.

The attainment of the national objective of providing better life for its citizens depends upon various factors such as agriculture, industry, health, infrastructure and education to name a few. Energy consumption is so much a common factor in all these sectors that the per capita energy consumption is taken as one of the indicators to assess the quality of life in a country. All economic policy planning initiatives have a direct and/or indirect impact on the demand for and supply of commercial and non commercial energy. Furthermore, various policies of energy consumption and energy investment influence the performance of the non-energy sectors of an economy.

> *"Plans and Master Plans have been completed for the development of forestry, agriculture, tourism etc. Hut these plans will prove to be ineffective in the long run in achieving broader national development objective if they arc not linked to the overall energy implications."* (WECS-1994)

2.2 Energy Situation in Nepal

The energy situation in Nepal is characterized by a very low annual energy consumption per capita of 14.06 GJ (WECS. 1994). The sources of energy are conventionally grouped into three categories as discussed below.

2.2.1 Traditional Sources of Energy

This group of energy sources includes fuelwood. agricultural residue and animal waste. Sustainable fuelwood supply from existing forest and other sources was estimated at 7.5 million tons for the year 1993. Agricultural residue and animal waste production for that year was estimated at 11.0 million tons each ("WECS, 1994). These sources meet about 91 percent of total national energy consumption as shown in Chart 2.1.

Nepal has an estimated area of 9.2 million ha of potentially productive forest, shrub and grassland, of which 3.4 million ha are considered to be accessible for fuelwood collection. Sustainable yield from this accessible area was estimated to be about 7.5 million tons, while total fuelwood consumption was estimated to be about 11 million tons. The deficit was met mainly by felling of trees and burning more of agriculture and animal waste.

In the face of dwindling forest area in fragile geology and its consequences, the possibility of fuelwood substitution by kerosene is limited to urban areas alone due to the limited transport network and low affordability of a majority of the population.

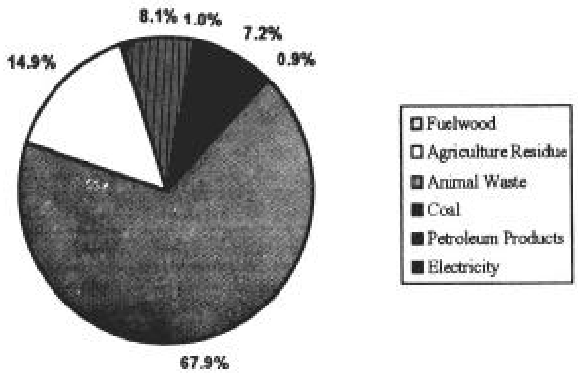


Chart 2.1 Domestic Sector Energy Consumption (WECS, 1994)

2.2.2 Commercial Sources of Energy

Nepal fully relies on the import for all commercial fuels except electricity. In 1992, Nepal spent about 32 percent of its merchandise export earning for the import of fossil fuel. With increasing cost and unreliable supply of some of the commercial fuels such as coal, use of firewood in the commercial sector is also increasing (WECS, 1994).

Electricity : Nepal has an estimated theoretical hydropower potential of 83,000 MW, out of which 42,000 MW seems to be economically feasible. However, the present installed capacity of Integrated Nepal Power System (INPS) is about 268 MW of which 232 MW is hydropower and the remaining 36 MW is generated from diesel and multifuel plants. About 12 percent of the population are connected to electricity distribution system, 3 percent of which comprises of rural population.

Petroleum and Natural Gas : Nepal has started conducting various surveys and measurements to explore the possibility of fossil fuel and gas in the country. However, any finding of practical implication is still awaited except the deposition of about 300 million m^3 of natural gas in the Kathmandu valley.

Coal : Except for small deposition of lignite in different locations, no coal deposition has yet been identified that could be economically mined.

2.2.3 Sources of Alternative Energy

This category includes solar, wind, micro-hydropower generating less than 100 kW and biogas.

The potential for wind energy in the country is yet to be determined. The solar energy potential is estimated at about 26.6 MW. Use of these sources of energy in a mass scale is limited by the high level of technology involved and the mis-match with the end-use pattern in the Nepali context. For example, people would not prefer to cook outside of the house using solar energy.

Of all types of alternative energy' sources known, it is only the biogas technology that has established itself as a viable and feasible technology in a wide range of socio-physical conditions of Nepal which is characterized by:

- low level of per capita energy consumption;

- a large share of energy consumed in the domestic sector, in scattered dwellings, mainly for cooking and lighting;
- low rate of literacy and skilled human resource;
- low investment capacity; and
- farming combined with a few cattle heads practised by majority of the population.

As pointed out earlier, the gap between the sustainable production of firewood from existing forest area and the level of firewood consumption is about 3.5 millions tons (WECS, 1994). A large part of this gap can be bridged with the use of existing biogas potential as is revealed from the following calculation.

- 1 m^3 biogas is equivalent to 3.5 kg of firewood
- A family size biogas plant of 8 to 10 m^3 produces about 2 m^3 gas per day
- A family size biogas plant saves an average of 7.0 kg firewood per day or 2.55 tons per year
- 1.3 million plants (potential) will save an equivalent of 3,320,000 tons firewood per year

Realizing this situation, the following policy provision has been made in the current Five year Plan (1992-97).

- Replace the fossil fuel energy needs of the individual, commercial and transport sector by indigenous energy production whenever possible, and
- Encourage the development of renewable and alternative energy technologies in order to reduce the heavy dependence on traditional and imported fuels.

2.3 Biogas in Other Countries

The implementation of biomethanation in the developing world has a history as long as in the developed world. Biogas technology is being widely used both in the developed and developing economies in agricultural or rural, industrial, and municipal waste systems. The incentives of these projects and programmes may differ, but the main ones are energy generation and/or environmental protection.

During the World War II, many farmers in England, France and Germany built family scale digesters to produce methane from their household and farm waste. Use of these plants declined as other forms of energy became cheaper with supply assurance. The World energy crisis of 1973 stimulated the promotion of this technology, specially in the developing countries.

In developing countries, biogas is valued more as a source of energy for household cooking than the slurry is for its fertilizing value. Since 1973, the technology has spread at a faster rate in developing countries compared to the developed countries. Nearly 6 million digesters were installed in 53 countries of the Third World by 1987 compared to only 669 digesters in Europe. Most of these 6 million plants were of small scaled household plants while those installed in developed countries were of larger scale.

The stages of biogas development in different countries vary. In some countries, development of biogas programmes has lacked urgency because of the ensured supply of cheap energy sources other than biogas In China, India and Nepal, accelerating diffusion is taking place due to increasing scarcity of other sources of energy. In other countries such as Latin America, shift in the sectors of application and changes in implementation strategies can be observed.

China and India are among the leading countries both in terms of the technological development and the rate of adoption. Thailand, Republic of Korea, the Philippines and Nepal have also achieved significant progress on the development of this sector. In terms of ratio between number of plants and the size of population. Nepal ranks highest in the world.

Among the Latin American and the Caribbean countries, Brazil has made some significant development in the biogas sector. Other countries that are at different stages of promoting the technology with varying degree of success include Argentina. Barbados. Bolivia. Colombia. Costa Rica. Chile. Dominican Republic, Ecuador, El Salvador. Grenada, Guatemala. Guyana, Haiti, Honduras, Jamaica, Mexico. Nicaragua, Panama, Peru, Tobago, Uruguay and Venezuela.

Africa lags behind in the biogas development sector. Some efforts were undertaken on biogas in Kenya. Rwanda, Burundi, Lesotho and Benin but the programmes failed to pick national momentum in these countries.

2.4 Biogas Potential in Nepal

The potential for biogas production in Nepal is based on the number of cattle/buffalo in the country, or specifically on the quantity of dung that could be available for biogas. and the micro-climatic pockets in different parts of the country. The potential for biogas generation based on the number of cattle and buffalo in 1991/92 is presented in Table 2.1.

Table 2.1
Biogas Potential

Animal	Number (million)	Dung Available/ Animal/Day (kg)	Total Dung Available/Day (ton)	Biogas Yield per Kg of Dung (m^3)	Gas Volume (m^3)
Cattle	7.4	10	74.000	0.036	2,664.000
Buffalo	3.1	15	46,500	0.036	1,674,000
Total	**10.5**		**120,500**		**4,338,000**

The daily dung production from cattle and buffalo alone is about 120,500 tons which has theoretically a potential to produce 4,338,000 m^3 of biogas. Practically, only 75 percent of the potential, i.e., 3.253.500 m^3. would be available since the number of animals also include households with only one cattle or buffalo and hence do not have enough dung volume to feed the smallest size biogas plant (4 m^3) which requires 24 kg of dung per day. These calculations do not take account of the dung available from poultry and other domestic animals such as pigs and goats (van Nes, 1991). While such a huge energy potential remains unused which otherwise could have enhanced the rate of employment and the level of rural income, the rural communities continue to face energy starvation.

The potential number of biogas plants in the plains, hills and mountain has been estimated to be 800,000 (61 percent). 500,000 (38 percent) and 10,000 (1 percent), respectively. By June 1991, only about 0.5 percent of the potential of 1.3 million was realized (van Nes, 1992). But as a result of increasing number of private biogas companies (23 companies by February 1996), this number has increased to 1.92 percent (25,000 plants). This is graphically depicted in Chart 2.2. Compared to 1991, although the progress seems remarkable, there is still a long way to go so far as substantial achievement of the potential is concerned. It is estimated that about 25 to 50 percent of the technically potential plants are economically feasible. The number of households with animals, potential biogas households by district as per July 1995 are given in Annex 2,1 (BSP, 1996).

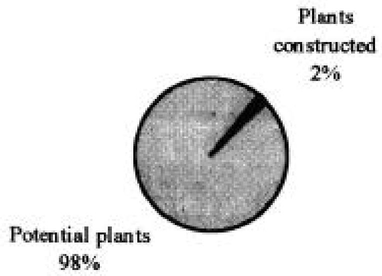


Chart 2.2 Biogas Potential

Chart 2.3 shows the rate of growth in the number of biogas plants installations.

2.5 Uses of Biogas

Like any other fuel, biogas can be used for household and industrial purposes, the main prerequisite being the availability of especially designed biogas burners or modified consumer appliances. Possible use of biogas as energy source is shown in Chart 2.4 (Ni Ji-Qin and Nynl, 1993).

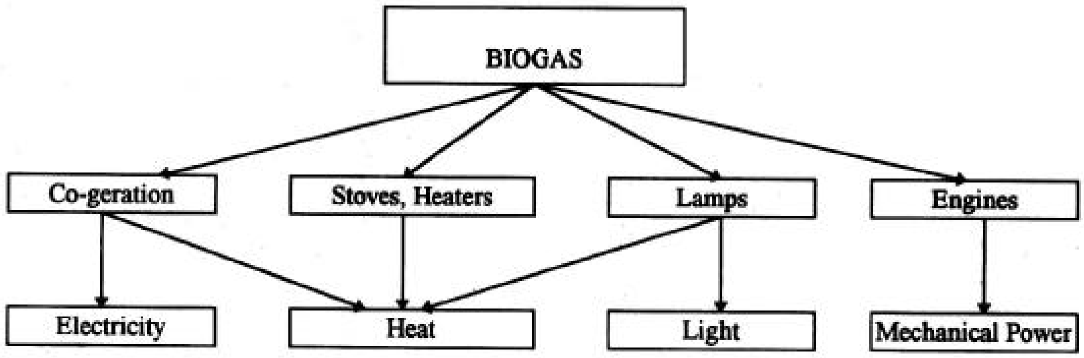


Chart 2.4 Utilization of Biogas as Energy Resource

2.5.1 Cooking

Cooking is by far the most important use of biogas in the developing world. Biogas burners or stoves for domestic cooking work satisfactorily under a water pressure of 75 to 85 mm. The stoves may be single (Figure 2.1) or double (Figure 2.2) varying in capacity from 0.22 to 1.10 m^3 gas of gas consumption per hour. Generally, stoves of 0.22 and 0.44 m^3 (8 and 16 cu ft) capacity are more popular A 1.10 m (40 cu ft) burner is recommended for a bigger family with larger plant size.

Gas requirement for cooking purposes has been estimated to be 0.33 m^3 per person per day under Indian or Nepalese conditions. If a family of 6 members owns a plant producing 2 m^3 of gas per day, usually two stoves (one with 0.22 m^3 and the other with 0.44 m^3 per hour capacity) can be used for one and half hours each in the morning and the evening to meet all cooking requirements of the family (Karki and Dixit, 1984).

Biogas stoves are also produced in Nepal but not in sufficient quantities to meet the demand and therefore, additional stoves have to imported from India.

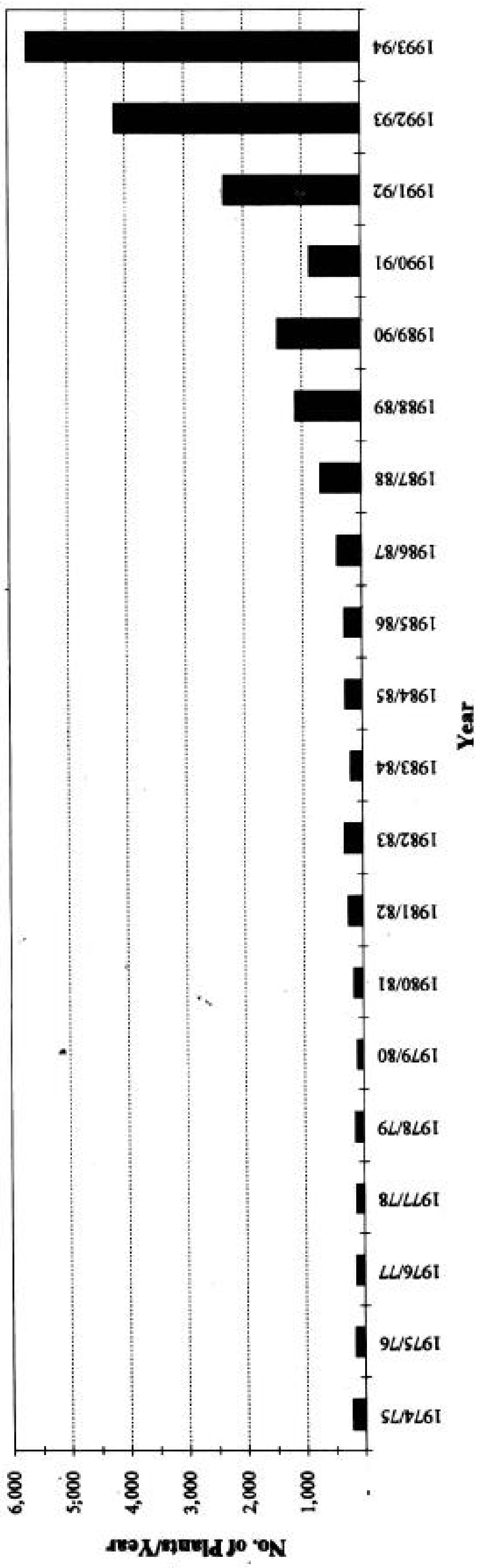


Chart 2.3 Number of Biogas Plants Built in Nepal From 1974/75 to 1993/94

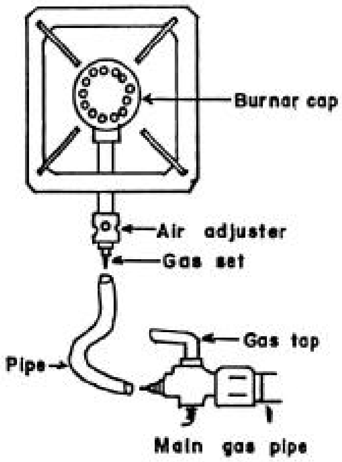


Figure-2.1 Biogas Burner Manufactured By GGG Workshop At Butwal, Nepal

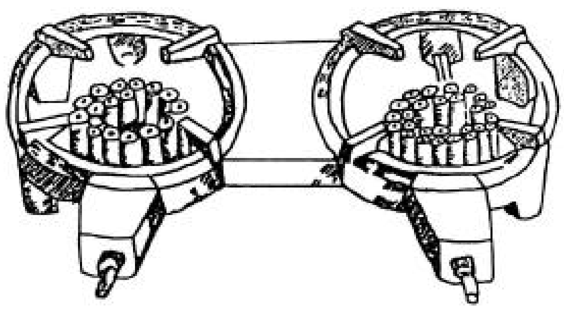


Figure-2.2 Biogas Burner With Two Mouths Manufactured In India

2.5.2 Lighting

Biogas can be used for lighting in non-electrified rural areas. Special types of gauze mantle lamps consuming 0.07 to 0.14 m^3 of gas per hour are used for household lighting. Several companies in India manufacture a great variety of lamps which have single or double mantles. Generally, 1-mantle lamp is used for indoor purposes and 2-mantle lamps for outdoors Such lamps emit clear and bright light equivalent to 40 to 100 candle powers. These are generally strong, well built, bright, efficient and easy to adjust Compared to stoves, lamps are more difficult to operate and maintain. The lamps work satisfactorily under a water pressure of 70 to 84 mm (Karki and Dixit, 1984). Until now, biogas lamps are not manufactured in Nepal and are imported from several companies in India. A sketch of the typical biogas lamp manufactured in India is given in Figure 2.3.

Different types of lamps are in use in China. They are simple in operation and easy to manufacture and are low priced. In remote places, clay lamps that do not need much skill to manufacture are still being used by Chinese farmers.

Biogas requirements for various appliances are indicated in Table 2.2.

Table 2.2
Biogas Requirements for Various Appliances

S.N.	Description	Size	Rate of Gas Consumption (m^3/hour)
1.	Stove	2" diameter	0.33
2.	Stove	4" diameter	0.44
3.	Stove	6" diameter	0.57
4.	Lamp	1 mantle	0.07 - 0.08
5.	Lamp	2 mantle	0.14
6.	Refrigerator	18"xl8"x 18"	0.07
7.	Incubator	18" x 18" x 18"	0.06
8.	Table Fan	12" diameter	0.17
9.	Room Heater	12" diameter	0.15
10	Running Engine	per HP/hour	0.40
11.	Electricity Generation	per unit	0.56

Apart from household cooking and lighting, some other uses of biogas are discussed below.

2.5.3 Refrigeration

Biogas can be used for absorption type refrigerating machines operating on ammonia and water and equipped with automatic thermo-siphon. Since biogas is only the refrigerator's external source of heat, just the burner itself has to be modified Refrigerators that are run with kerosene flame could be adapted to run on biogas. A design of such a burner successfully tested in Nepalgunj is given in Figure 2.4. With a gas pressure of 80 mm and gas consumption of 100 litres/hour, this burner operates a 12 cu ft refrigerator.

In a country like Nepal where only about 12 percent population has access to the electricity supply, biogas run refrigerator could be of high importance for safe keeping of temperature sensitive materials such as medicines and vaccines in the remote areas. Gas requirement for refrigerators can be estimated on the basis of 0.6-1.2 m^3 per hour per m^3 refrigerator capacity (Updated Guidebook on Biogas Development, 1984).

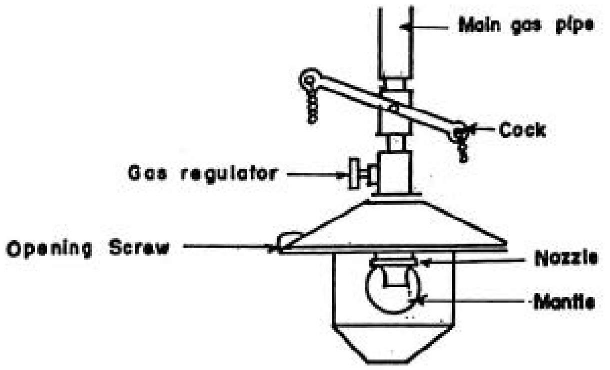
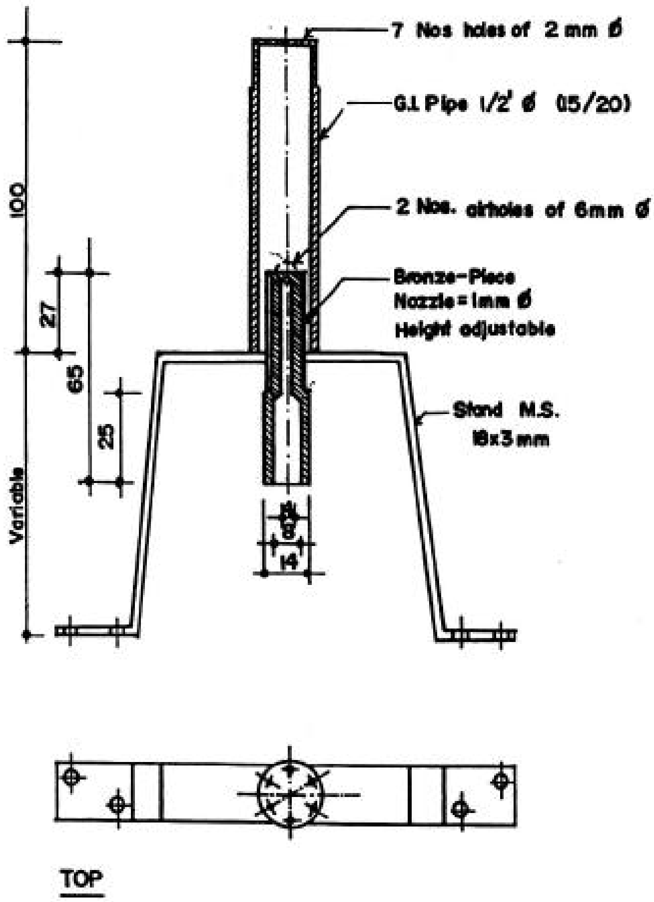


FIGURE-2·3 SKETCH TYPICAL BIOGAS LAMP MANUFACTURED IN INDIA



FGURE- 2·4 DESIGN OF A BIOGAS BURNER ADAPTED TO RUN KEROSENE REFRIGERATOR

Measurements in mm

2.5.4 Biogas-fueled Engines

Biogas can be used to operate four stroke diesel and spark ignition engines. Biogas engines are generally suitable for powering vehicles like tractors and light duty trucks as has been successfully experimented in China. When biogas is used to fuel such engines, it may be necessary to reduce the hydrogen sulphide content if it is more than 2 percent. Using biogas to fuel vehicles is not so much of an attractive proposition as it would require carrying huge gas tanks on the vehicle.

Diesel engine can be converted to dual fuel engine in which as much as 80 percent of the diesel used can be replaced by biogas. In these engines, biogas is used as the main fuel while diesel is used for ignition. When gas runs out, the duel fuel engine can be switched back to run fully on diesel. Pre-converted dual fuel engines are available in the market. Such engines could be used for pumping water both for drinking and irrigation purposes. This utility is of high importance in hilly areas where rivers flow nearby, while the adjacent field dries up due to lack of irrigation.

2.5.5 Electricity Generation

Generating electricity is a much more efficient use of biogas than using it for gas light. From energy utilization point of view, it is more economical to use biogas to generate electricity for lighting. In this process, the gas consumption is about 0.75 m^3 per kW hour with which 25 40-watt lamps can be lighted for one hour, whereas the same volume of biogas can serve only seven lamps for one hour (BRTC. 1983).

Small internal combustion engines with generator can be used to produce electricity in the rural areas with clustered dwellings Biodigesters can be used to treat municipal waste and generate electricity. The anaerobic digestion process provides energy in the form of biogas per ton of organic municipal solid waste (MSW) digested. One of the options to utilize biogas is to produce electricity using a gas engine or gas turbine (ETSU. 1994).

2.6 Biogas and Agriculture fin

In Nepal, biogas was included for the first time in the government programme in 1976 which was observed as "Agriculture Year". The emphasis was then laid to promote the technology mainly for its utility in returning more of the nutrients to soil in the form of organic manure. With the passage of time. the technology is now valued more for its energy rather than manure

In many parts of the country, the productivity of soil is declining mainly because of continuous cropping without the use of quality manure and fertilizer in required quantities. Nepal does not produce any chemical fertilizer and has to fully rely on imports. Because of the declining net profit from agricultural enterprises and increasing prices of imported fertilizer, many farmers can not afford to use chemical fertilizer to replenish the soil nutrients. Also, the availability of chemical fertilizer at the time of need in the required quantity and the desired form can not be ensured. In this context, the importance of biogas technology for Nepal's agriculture has become more prominent as a means to produce easily available localized organic manure at low cost.

Biogas technology fits well in an agricultural system, especially in subsistence farming where cattle and poultry raising becomes an integral part of it. Animal dung is the primary input for biogas and it therefore encourages farmers to rear cattle and other animals. With biogas plant, farmers are also more likely to stall feed their cattle to optimize dung collection. This practice could increase cropping intensity in the areas where some farmers are forced to leave their land fallow because of the problem of free grazing, especially during winter crop season. Stall feeding not only enhances the rate of regeneration of pasture and forest land, but also makes more organic fertilizer available for improving texture and structure of soil along with its fertility. Biogas can also motivate farmers to incorporate integrated farming system because of the feed value of the slurry for fish and piggery. Integration of biogas with agriculture put forth by N. A. de Silva in 1993 for use in the Latin America is shown in Chart 2 5 (Ni Ji-Qin and Nyns, 1993).

China has a long tradition of utilizing human waste as an input material for the production of fuel and fertilizer. In most cases, the sources of carbon such as leaves, grass and straw are loaded in the digester in batches, while the sources of nitrogen are slowly added every day. For example, pigsty and latrine attached to the household digester serve as the sources of nitrogen for daily feeding. Similar practice can be introduced in Nepal to augment the total production of organic manure in the villages.

Biogas technology supports agricultural system through various uses of slurry as listed below.

- Slurry as a basal manure
- Diluted slurry for foliar application or spray as manure
- Application of slurry as manure with irrigation
- Slurry as insecticide and pesticide
- Slurry treatment of seeds for higher rate of germination, disease resistance, better yield and improved colouration of fruits
- Slurry as a means to increase die protein content of low quality fodder
  Slurry as a part of concentrate ration for cattle, pig and fish
- Slurry as a means to increase the quality and quantity of organic manure production at the farm level

2.7 Biogas and Forests

Comprehensive data are not available to quantify the overall impact of biogas adoption on the nearby forest. However, as result of a case study conducted in 1994 at two Village Development Committees (VDC) in Chitwan district, Mr. Binod P Devkota, Forest Officer, has come up with the following findings.

- The number of animal heads kept by a farming family decreased after installation of a biogas plant, compared to non-adopters.
- Biogas technology led to the adoption of stall feeding practices which reduced the pressure on nearby forest and pasture land by animals grazing there.
- Biogas replaces 80 to 85 percent of firewood consumption of a family.

These preliminary findings exhibit die positive impact of biogas installation on the regenerative capacity of existing forest and pasture lands along with the qualitative improvement in animal husbandry.

2.8 Biogas and Women

The heavy reliance on fuelwood has caused not only irreparable damage to the sustainability of agriculture and ecosystems in Nepal but has also increased the workload of 78 percent of rural women and a large number of children, mostly girls, who have to allocate 20 percent of their work time for fuelwood collection (WECS, 1995).

Comprehensive studies on women's workload in different parts of Nepal conclude that a day's work consists of nine to 11 hours. A study by BSP conducted in 1992 estimates that almost 75 percent of households spent more time collecting firewood in 1988 than in 1983. Two-third of them spent about six hours a day (Britt, 1994). van Vliet and van Nes (1993) studied the effect of biogas on the workload

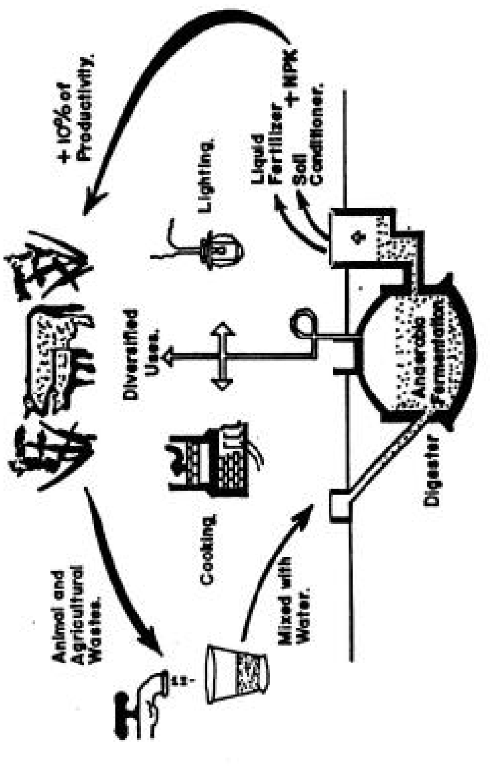


Chart-2.5 INTERGRATION OF BIOGAS WITH AGRICULTURE of women in Rupendehi district in Nepal. They concluded that the reduction in workload of women as a result of installing biogas plants amounts to a minimum of two hours and maximum of seven hours per family per day. When pressed with the labour shortage for such works in a family, it is the female children who have to forego their schooling.

Cooking with traditional fuels such as firewood and waste from agriculture and livestock produces obnoxious odorous and smoke that pollute the kitchen. Long hours of exposure in such smoke polluted environment is known to cause various coronary and respiratory diseases (Hurst and Bamett, 1990). Use of biogas helps relieve women from such diseases. Studies have shown that women cough less and have fewer eye problems once they switch to biogas from firewood. Cases have been reported about older women who could no longer cook on open fire, being able to cook with biogas. Many studies have reported the substantial improvement in in-house pollution and the sanitary condition of homestead after installation of biogas plants.

As biogas helps to do away with the need to collect fuelwood, it indirectly helps women in so many different ways such as opportunity for income generation, education, and improvement in health by providing some leisure time. Results of studies on saving of time for women's work in user households are summarized in Table 2.3.

Table2.3
Average Saving in Women's Work in Selected Districts and Villages

	Rupandehi District	Nuwakot District	Madan Pokhara Village	Pithuwa Village	Hathilet Village
Average Plant Size	10 m^3	10 m^3	6 m^3	10 m^3	15 to 20 m^3
Average Saving of Women's Work Time	4:30 hrs	2:35 hrs	1:55 hrs	3:14 hrs	-0:15 hrs (increase)
Sample Size (Households)	100	100	4	4	4
Limiting Factor	Fuelwood	Water	Water	Fuelwood	Water

Source: Charla Britt, 1994.

The table illustrates that the introduction of biogas in regions where fuelwood is readily available and where water is in short supply or the source is located at a great distance from die plant site, biogas may actually increase the workload of women.

A study of 100 biogas households in 16 districts of Nepal has shown a net saving on workload of 3 hours 6 minutes (3:06 hrs or 3.10 hrs) as a result of installing a biogas plant (East Consult, 1994). Time saving on account of biogas related activities is shown in Table 2.4.

Table 2.4
Average Effects of a Biogas Plant on the Workload of a Household

S. N.	Activity	Saving **in Time (Hour/day)**
1.	Collection of water	(-)0:24
2.	Mixing of water and dung	(-)0:15
3.	Collection of firewood	(+) 1:24
4.	Cooking	(+) 1:42
5.	Cleaning of cooking utensils	(+) 0:39
	Total	(+) **3:06**

Source: East Consult, 1994

It is worth mentioning that the first design of biogas plant developed by Jashu Bhai 3 Patel of India around 1956 was named *"Greeha Laxmi"* (housewife) to indicate its relevance to the well-being of housewives. In view of the traditional role that a female member plays in a family, following are some of the prominent aspects of biogas that help women in particular.

- Reduction of in-house pollution in general and that of kitchen in particular.
- Biogas flame does not leave black soot on the pots. Cleaning is easy, cleaning time is lessened and life of the utensils is prolonged.
- It reduces the time required for cooking. The time saved can be used for other useful purposes.
- Healthy environment - free from flies and mosquitoes is produced. Most of the pathogens are destroyed in the process of anaerobic digestion.
- hi remote villages, where there is no possibility for electrification, children can devote their time in study and the family can perform some income generating activities with the help of biogas lamp.

Generally, it is the housewife who is more involved in operating and maintaining a biogas plant. This has forced all development workers in the biogas sector to focus their activities to the female members of a family. In other words, use of biogas technology has been instrumental in enhancing the role of women not only in matters of family decisions but also in planning and implementation of other development activities.

2.9 Health and Sanitation

As pointed out earlier, smoke is the main cause for lung and eyes diseases in the rural community. As a result of biogas installation, improvement in the health and hygiene has been reported by the housewives.

Infestation of various water-borne diseases occurs due to faecal contamination such as worms (hook worms, round worms), bacterial infections (typhoid fever, paratyphoid, dysentery, cholera) and viral infections (gastro-enteritis resulting in diarrhea and vomiting, hepatitis). The anaerobic digestion process has proved effective in reducing the number of pathogens present in the faecal matters to a considerable extent. Studies carried out in China on the survival of pathogens showed that about 90 to 95 percent of parasitic eggs are destroyed at the mesophilic temperature while at times ascaris are reduced by 30 to 40 percent (UNEP, 1981).

Chinese experience shows that if the faeces are fed into the digester at one feeding (without daily addition of fresh faeces) and kept fermenting for a reasonable retention time, satisfactory results of faeces treatment are achieved. On the other hand, if faeces are added to the digester every day, the effluent has to be used only after it has been treated by ovicide and bactericide. Treatments with Calcium Cyanide, Calcium Hydroxide and Caustic Soda have been found to be effective. However, manure treated with Caustic Soda is not recommended for use as fertilizer (UNEP, 1981).

In the Nepalese context, there are only a few ethnic groups (e.g. *Pode)* who are accustomed to handling night soil, whereas a larger section of the population still faces social or cultural resistance towards such an activity and cooking food with biogas produced from human faeces. These days, because of increasing cost of the conventional fuel, the biogas users are forced to connect their biogas plant with latrines. About 40 to 50 percent of the biogas plants presently installed are found to be connected to latrines and this tendency is likely to increase in the future (van Nes, 1996).

If human faeces are used as an input material for methane generation, one has to be cautious due to high concentration of pathogens present in it. Depending on the hydraulic retention time, it is likely that some digested sludge may still contain a few pathogens. Based upon the lessons learned from China, there is every need to ensure that the digested slurry is completely free from pathogens. Appropriate R&D has to be carried out in this direction.

2.10 Municipal Waste

Biogas technology or biomethanization can be used to treat all types of organic wastes and crops not only to produce gas and manure, but also to reduce pollution.

Haphazard disposal and accumulation of the city refuges have resulted in environmental degradation in the Kathmandu valley. Other cities and towns of the country are also facing similar problems of increasing waste and pollution in dense settlements. Refuges from the household, small scale industries and construction activities constitute the major sources of the wastes generally encountered in the cities. Quantities of waste generated in the three cities of Kathmandu valley are given in Table 2.5 (Karki, Gautam and Gautam, 1995). With the use of biogas technology, such municipal wastes can be profitably utilized as resources for the production of biogas and stabilized manure.

Table 2.5
Waste Generation Per Day in Kathmandu Valley

S.N.	Waste	Kathmandu	Lalitpur	Bhaktapur
1.	Generated per day (m^3)	350	106	40
2.	Actually collected per day (m^3) (50% of 1)	175	54	NA[+]

[+]NA denotes Not Available

There are different technologies available to treat municipal solid waste as shown in Chart 2.6. However, it is the anaerobic process that has proved to be the most economical option in terms value of energy and manure production. The chart illustrates that treating municipal waste through anaerobic digestion process has more benefits than other methods such as incineration or landfill (Ni Ji-Qin and Nyns. 1993). This process has also been used in other countries to treat sewage for two distinct benefits: (a) for production of useful energy; and (b) for reduction of the cost of sewage treatment with some other technologies.

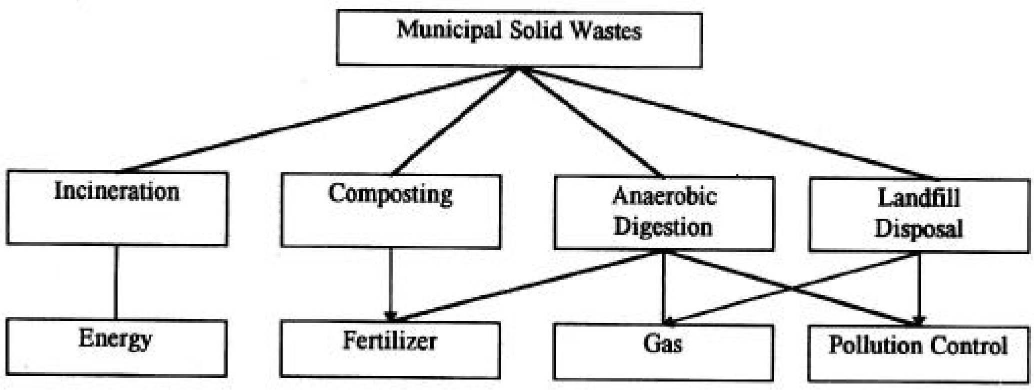


Chart 2.6 Treating Municipal Waste Through Anaerobic Digestion Process

Collection of biogas generated from the landfill sites is yet another way of deriving energy from municipal waste. The proper management of landfill sites for gas production has been found to be a cost effective way of treating municipal solid waste in terms of the investment cost.

Nepal has limited experience in the use of biogas technology for processing of the municipality waste.

Municipalities that have started to connect municipal toilets with biodigesters are Biratnagar and Hetauda. These plants have proved useful in improving the sanitary condition of the area. The experience with plants in schools, jails, military barracks, hotels and other such group livings has also shown encouraging results. With this experience, it is likely that more municipalities will follow the suit in the coming years.

2.11 Economy and Employment

Presently, there are 23 companies that are involved in the construction of biogas plants. In addition, there are many NGOs that are also involved in promoting the biogas technology. As the demand for biogas is ever increasing, so will the workload of these companies and NGOs. In other words, the potential of the biogas development to create employment opportunities in the rural areas has already been demonstrated. Because of this labour intensive nature of the technology, it helps ameliorate some of growing socio-economic problems such as rural out-migration and social woes of unemployed rural youth. Presently, there are about 900 people employed in the biogas sector in Nepal.

Once installed, the biogas plant becomes an additional resource base of the user. This resource base could lead to other economic activities such as fish culture, piggery, and small cottage industries. Experiments carried out in other developing countries have shown that the slurry could be used to replace a part of the feed for fish and pig resulting in higher production (see Session Four).

Except for a few stoves, almost all appliances related to a biogas plant are imported, even though the technology for their production within the country is available and the investment cost is not high either. With the existing level of demand for such appliances in the country, it will not be economically viable proposition to establish production units. However, as the number of biogas installation will go on increasing, the demand for its appliances will rise and the in-country production of such appliances could become an economically viable industry.

Millions of tons of agricultural and livestock wastes are burnt every year in the country in the process of meeting household energy requirements. In other words, millions of tons of soil nutrients are burnt every year causing (a) increase in the cost of importing the chemical fertilizers which is paid in convertible currency that the country is always in short of, and (b) decrease in agricultural production. This two fold economic loss could be avoided to a certain extent with the use of biogas technology. Similar relation can also be viewed in terms of decreasing number of tourists due to increasing pollution and the possibility of generating commercial energy with the refuge of the growing urban population.

2.12 Session Plan

Activity No.	Topic and Area of Discussion	Time (min.)	Methods of Training	Teaching Aids
1.	Introduction and highlight the objectives of session	3	Lecture	O/H projector, screen, sheets or flip chart
2.	Energy situation in Nepal	5	Lecture cum discussion	O/H projector, screen and flip chart
3.	Biogas in other countries	5	Lecture	O/H projector, screen
4.	Biogas potential in Nepal	5	Lecture cum discussion	O/H projector, screen
5.	Various users of biogas	5	Lecture cum discussion	O/H projector, screen
6.	Agriculture	4	Lecture cum discussion	O/H projector, screen, flip chart
7.	Biogas and forest	2	Lecture cum discussion	O/H projector, screen
8.	Women and biogas	**4**	Lecture cum discussion	O/H projector, screen, flip chart
9.	Health and sanitation aspects	4	Lecture cum discussion	O/H projector, screen
10.	Municipal waste	4	Lecture cum discussion	O/H projector, screen
11.	Economy and the employment	4	Lecture cum discussion	O/H projector, screen
12.	General discussion	15	Discussion	
Total Time		**60**		

2.13 Review Questions

– How can biogas influence the overall development pattern of Nepal?

– In the context of Nepal, how does biogas compare with other alternative sources of energy?

– Comment on: "The single most important reason for relevance of biogas technology to Nepal is the fact that more than 90 percent of the total energy is consumed in the domestic sector".

– Explain how biogas can help improve the balance of payment of developing countries.

– How significant is the role of biogas in increasing the employment opportunities in Nepal?

– Comment: "Biogas technology is not neutral to gender issues of developing countries."

2.14 References

BSP(1992) Implementation Document. ADB/N, GGC and SNV/N.

Britt, C. (1994) The Effects of Biogas on Women's Workloads in Nepal: AJI Overview of Studies Conducted for the Biogas Support Programme. Submitted to BSP - SNV/N.

Britt, C. and S. Kapoor (1994) The Effects of Biogas on Women, Workloads and Division of Labour in Hathilet, Janakpur Zone, Nepal. BSP-SNV/N.

Devkota, B. P. (1994) Personal Communication

East Consult (1994) Biogas Users Survey-1992/93. Final Report. BSP

ETSU (1994) Biogas from Municipal Solid Waste - Overview of Systems and Markets for Anaerobic Digestion of MSW Harwell. United Kingdom.

Hurst, C. and A. Baraett (1990) The Energy Dimension: A Practical Guide to Energy in Rural Development Programmes. Intermediate Technology Publications Ltd.

Karki. A. B. and K. Dixit (1984) Biogas Fieldbook. Sahayogi Press, Kathmandu, Nepal.

Karki, A B., K. M Gautam and S. R. Joshi (1993) Proposal on Future Structure of Biogas Sector in Nepal. Consolidated Management Services Nepal (P) Ltd.

Karki, A. B.. K. M. Gautam and U. Gautam (1996) Biological Waste Treatment through Biogas Digesters in Rural Nepal. In "Management of Urban Biodegradable Wastes." Published by James & James (Science Publishers) Ltd, London for International Solid Waste Association, ISWA, Copenhagen.

Karki, A. B., R. Gautam and U. Gautam (1995) Municipal Solid Waste in Kathmandu Valley : A Review Consolidated Management Services Nepal (P) Ltd. Ni Ji-Qin and E. J. Nyns (1993) Biomethanization - A Developing Technology in Latin America. Bremen Overseas Research and Development Association (BORDA).

Optner, S. L. (1997) System Analysis. Penguin Books Ltd, Harmondsworth. Middlesex, England.

UNEP (1981) Biogas Fertilizer System. Technical Report on a Training Seminar in China. United Nations Environmental Programme. Nairobi, Kenya.

Updated Guidebook on Biogas Development-Energy Resources Development Series (1984), No. 27. United Nations. NewYork,USA.

van Nes, W. J. (1996) Biogas Support Programme : Activities and Results in the Period July 1992-1995. Paper presented by BSP on the occasion of the Meeting for the Development of a National Biogas Policy Framework organized by FAO on 7 February 1996, Kathmandu.

van Nes, W. J. (1991) Technical Biogas Potential per District in Nepal. Gobar Gas Company, Butwal, Nepal.

van Vliet, M. (1993) Effect of Biogas on the Workload of Women in the Village of Madan Pokhara in Palpa District in Nepal. BSP - SNV/N.

van Vliet, M. and W. J van Nes (1993) Effect of Biogas on the Workload of Women in Rupandehi District in Nepal. Biogas Forum, No. 53, pp. 12-16.

WECS (1995) Alternate Energy Technology: An Overview and Assessment. Perspective Energy Plan, Supporting Document No.3. Report No. 2/1/010595/2/9 Seq. No. 468

WECS (1994) Energy Synopsis Report Nepal 1992/93. Perspective Energy Plan, Supporting Document No.l. Report No. 4/4/270494/1/1 Seq, No. 451

2.15 Further Reading Materials

Acharya, Meena and Lynn Bennett (1981) The Rural Women of Nepal : An Aggregate Analysis and Summary of Eight Village Studies, Vol. 2, Part 9 of The Status of Women in Nepal. Kathmandu: Centre for Economic Development and Administration, Tribhuvan University, Kathmandu, Nepal.

Gaulam. K M. (1996) Country Paper on Biogas in Nepal Paper presented at International Conference on Biomass Energy Systems organized by Tata Energy Research Institute, British Council Division and British High Commission. New Delhi, India. 26-27 February 1996.

Gunnerson, C. G. and D. V. Stuckey (1986) Integrated Resource Recovery-Anaerobic Digestion-Principles and Practices for Biogas Systems. The World Bank Technical Paper Number 49.

Karki, A. B., K M. Gautam and S. R. Joshi (1993) Present Structure of Biogas Sector in Nepal. Consolidated Management Services Nepal (P) Ltd.

Karki, A B. R. Gautam and U. Gautam (1995) Municipal Solid Waste in Kathmandu Valley: A Review. Consolidated Management Services Nepal (P) Ltd

Technology of Biogas Production and Applications in Rural Areas (1989) A Report by World Energy Conference. London, United Kingdom.

World Bank (1991) Poverty and Incomes (a World Bank country study). Joint study by the World Bank and the United Nations Dev

Number of Households with Animals, Potential Households with Biogas by Districts
(As of July 1995)

District	Households with Animals (No)	Potential Biogas Households (No)	Households with Biogas	
			(No)	(%)
Mountain Region :	**192.609**	**9.630**	**253**	**2.63**
Taplejung	16,110	805	0	0
Sankhuwasabha	18,662	933	29	3.11
Solukhumbu	9,789	489	0	0
Dorakna	2,854	1.493	10	0.67
Sindhupalchoke	31,562	1,578	210	13.31
Rasuwa	2,920	146	0	0
Manang	421	21	0	0
Mustang	1,230	61	0	0
Dolpa	2,117	106	0	0
Jumla	8,531	427	0	0
Kalikot	13,987	699	0	0
Mugu	5,516	276	0	0
Humla	5,345	267	0	0
Bajura	15,793	790	0	0
Bajhang	18,110	906	0	0
Darchula	13,180	659	4	0.61
Hill Resion:	**967.638**	**483.819**	**11,188**	**2.31**
Panchlhar	24,957	12,478	28	0.22
Ham	28,983	14,492	289	1.99
Dhankuta	14,724	7.362	167	2.27
Terhathum	14.531	7,266	63	0.87
Bhojpur	31,399	15,699	35	0.22
Okhaldunga	23,264	11,632	0	0
Khotang	35,468	17,734	0	0
Udayapur	14,481	7,240	104	1.44
Sindhuli	36,172	18.086	571	3.16
Ramechhap	23,130	11,565	0	0
Kavrepalanchok	33,932	16,966	131	0.77
Lalitpur	10,216	5.108	54	1.06
Bhaktatpur	11.795	5,897	22	0.37
Kathmandu	18.281	9.140	301	3.29
Nuwakot	10.471	5,236	530	10.12
Dhading	35,055	17,528	238	1.36
Makwanpur	26,695	13.,348	439	3.29
Gorkha	3,340	1,670	376	22.52

Lamjung	14,980	7,490	1.042	13.91
Tanahu	26,479	13,239	1.194	9.02
Syangja	55,789	27.895	815	2.92
Kaski	21,744	10,872	3,057	28.12
Myagdi	15,172	7.586	21	0.28
Parbat	16,239	8.119	43	0.53
Baglung	32,675	16.337	93	0.57
Gulmi	39,316	19.658	202	1.03
Palpa	28,400	14,200	579	4.08
Arghakhanchi	29,447	14,723	225	1.53
Pyuthan	24,280	12,140	203	1.67
Rolpa	23,472	11,736	4	0.03
Rukum	25,212	12.606	32	0.25
Salyan	27,731	13,867	6	0.04
Surkel	31,830	15,915	248	1.56
Dailekh	26.668	13,334	44	0.33
Jajarkot	12,629	6,314	2	0.03
Achhain	28,973	14,486	0	0
Doti	23,359	11,679	11	0.09
Dadeldhura	7,971	3,986	0	0
Baitadi	24,176	12.088	19	0.16
Terai Reeion :	**821,290**	**821,290**	**12,421**	**1.51**
Jhapa	27,753	27.753	1.546	5.57
Mo rang	54,533	54,533	1,555	2.85
Sunsari	31.773	31,773	605	1.90
Saplari	49.988	49.988	97	0.19
Siraha	62,658	62.658	356	0.57
Dhanusa	55.466	55.466	199	0.36
Mahottari	31,833	31.833	248	0.78
Sarhi hi	53,704	53,704	666	1.24
Raulahat	45,596	45.596	153	0.34
Bara	36,885	36.885	447	1.21
Parsa	37.310	37.3 H	126	0.34
Chilwan	41,767	41,767	2.187	5.24
Nawaiparasi	41.141	41,141	469	1.14
Rupandchi	63,367	63.367	1,414	2.23
Kapilbastu	39.728	39,728	217	0.55
Dang	37.133	37.133	741	2.00
Banke	32,018	32.018	167	0.52
Bardiya	7,870	7,870	405	5.15
Kailali	35,975	35,975	521	1.45
Kanchanpur	32,006	32,006	302	0.94
Nepal	**1,988,695**	**1,314,739**	**23,862**	**1.81**