【Article】

Contribution of Biogas Technology in Well-being of Rural Hill Areas of Nepal: A Comparative Study Between Biogas Users and Non-users

Manjeshwori SINGH
PhD Student, Graduate School for International Development and Cooperation
Hiroshima University, 1-5-1 Kagamiyama, Higashi-Hiroshima 739-8525, Japan
Email: sijin52@hotmail.com

Keshav Lall MAHARJAN
Associate Professor, Graduate School for International Development and Cooperation
Hiroshima University, 1-5-1 Kagamiyama, Higashi-Hiroshima 739-8525, Japan
E-mail: mkeshav@hiroshima-u.ac.jp

Abstract

One of the major constraints in rural development for most of the developing countries is lack of efficient and affordable energy technology. Adopting a new technology in providing basic energy needs in an effective manner is an important issue for the rural people where the majority of farmers are living in subsistence level. Biogas technology can play a vital role in enhancing the socio-economic status of such farmers by providing environmentally friendly and economically beneficial energy from animal dung, a by-product of farming system with livestock. Hill farming in Nepal is integrated with livestock and dung is easily available at farmyard. This paper will highlight the problems caused by the lack of efficient and affordable energy and its effect in the rural livelihood, and contribution of biogas technology in overcoming them, in the hill areas of Nepal.

1. Introduction

Nepal is an underdeveloped country inhabited by over 22 million people; more than 80% of them live in the rural areas and are deprived of electricity. Commercial energy such as petroleum and coal has to be imported from abroad. Due to the country's typical geo-topographical features and the absence of adequate infrastructure, these energy sources are accessible to only about 15% of the total population and just 1% in the rural areas. Installation of facilities to generate other alternate energy, such as, solar, micro hydropower or wind energy are costly and limited to center areas only, hence are not readily accessible by the subsistence farmers. They have to depend only on traditional sources that include, fuelwood, agricultural residue and animal dung, and forest is the main source for fuelwood. Thus, the pressure on the forest due to increasing rural population has resulted in various natural hazards threatening not only the ecosystem but also the lives of large number of human beings.

Journal of International Development and Cooperation, Vol.9, No.2, 2003, pp. 43–63

People use forest for living but have not replenished it. Loss of forest in the vicinity due to overuse makes people travel long distances for the collection of fuelwood. This has led to increase in time for the fuelwood collection, which can be otherwise used in other activities. Scarcity of fuelwood has also forced to an increase use of dung and agriculture residue as sources of fuel rather than as compost, adversely affecting the farming. Use of traditional energy resources in traditional mud stove for cooking creates lots of indoor smoke that negatively affects the health of the people. Under these circumstances biogas technology that produces energy by the decomposition of animal dung, human excreta and solid wastes to produce methane gas with calorific value of about 26,500k-kj/cubic meter, that is burnt to provide heat and light, can be one such effort that directly contributes in minimizing the use of fuelwood, consequently alleviating the problems caused by over use of fuelwood.

Biogas, the energy produced by biogas technology is used for household purposes such as cooking, heating, lighting. Availability of biogas for these purposes means reduction of use of fuelwood, which reduces pressure on the forest. Consequently it reduces deforestation that ultimately lessens soil erosion and maintains the land productivity. The use of biogas helps to reduce the increasing burning of biomass that provides manure for farmland. Animal dung and night soil that is used for producing biogas itself converts as good manure, which is better than dung in nutrient contents (Devkota, 2001). It can be directly used in farmland. This leads to increase crop yield. The use of biogas also helps to reduce time in collection of fuelwood and other household activities such as cooking and cleaning. The time thus saved can be devoted in other income generating activities, which also increases the income of the users. Since biogas is smokeless and environmentally friendly energy technology, it can create the clean cooking environment and effects positively on the health of family members. Healthy environment and increased income may help to enhance the socio-economic status of the people. Thus, biogas technology can play a vital role in not only providing energy, very much in need for rural households, but also can positively contribute in rural development as a whole, by enhancing the well-being of the rural people, biogas users in particular, in a sustainable manner through protection of environment. Hence, it is important to study the implications of biogas technology in actuality in rural setting. Consequently, the main objective of this study is to assess the contribution of biogas technology in uplifting the well-being of rural people in a given setting, i.e. village. This will be further studied by making a comparative analysis of socio-economic conditions of biogas users and non-users on the basis of in depth field survey data of a hill village in Kavre (Kavrepalanchwok) district of Nepal. Prior to that, general trend of energy consumption and available energy resources base for hill region of Nepal will be reviewed. Biogas technology will be reviewed and discussed briefly.

2. Energy Situation of Nepal

The energy situation of Nepal is characterized by a very low per capita primary energy consumption of 14.6 GJ for the fiscal year 1999/00. The total energy consumption in the year 1994/95 was 285.2 Million GJ and is increased to about 292 Million GJ in 1995/96 and about 340.42 GJ in 1999/00 (Water and Energy Commission Secretariat,1999 & Economic Survey of Nepal, 2000/2001:35). The energy use pattern in Nepal is highly dependent on the traditional form of energy (fuelwood, agricultural residue and animal dung) that provides most of the energy needs of the country. The contribution of these energy sources in the total energy consumption in the year 2000/2001 is shown in **Table 1**. It shows the highest percentage (77%) of country’s energy is met by fuelwood. It is followed by petroleum products, animal dung, and agricultural residue. Contribution of electricity and coal is negligient.

Table 1 Energy Consumption by Fuel Type in Nepal (2000/2001)

S.N.	Fuel Type	Consumption (Million GJ)	%
1	Fuelwood	263.00	77.26
2	Agricultural Residue	12.00	3.52
3	Animal Dung	19.00	5.58
4	Petroleum Products	32.00	9.40
5	Electricity	5.00	1.47
6	Coal	9.42	2.77
Total		340.42	100.00

Source: Economic Survey of Nepal, 2000/01.

Figure 1 shows the biggest energy consumer is the residential sector. About 89% of the total energy consumption in 1998/99 were consumed only in the residential sector and the rest 11% in the other sectors such as industrial, transport, commercial and agriculture sector. Industrial sector is the second largest energy consumer but way behind the residential sector.

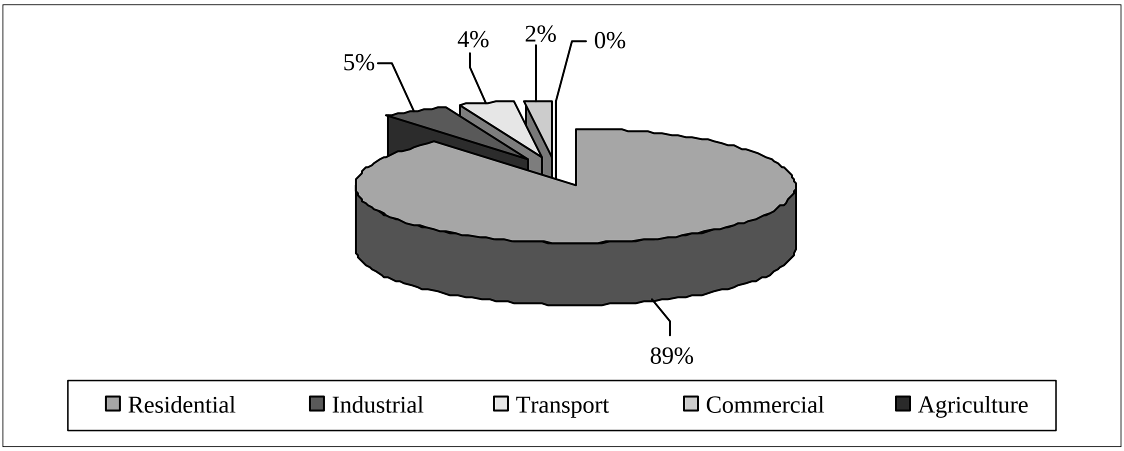

Figure1 Sectorial Energy Consumption in Nepal (1998/99)

Source: Water & Energy Commission Secretariat, 1999.

Table 2 shows in residential sector also fuelwood contributes maximum amount about 188 (10^6 GJ) of energy, which is about 73% of the total energy consumption in residential sector only. This is followed by, agriculture residue (16%), animal waste (9%), petroleum products (2%) and electricity (0.4%). These data show that the traditional energy dominates in total energy consumption in Nepal.

About 90% of Nepal's population lives in the rural areas and a bulk of energy is consumed in the rural areas. Rural people have always relied on biomass and animated energies for meeting their basic energy needs. So a new alternative technology to cope with such need in an efficient way is an urgent issue. In this regard, different renewable energy technologies, such as, biogas, solar, micro hydro has

Table 2 Residential Sector Energy Consumption by Fuel Type (1994/95)

S.N.	Fuel	Consumption (10^6 GJ)	%
1	Fuelwood	188.4	72.6
2	Agriculture Residue	42.5	16.4
3	Animal Waste	23.0	8.9
4	Petroleum Products	4.4	1.8
5	Electricity	1.0	0.3
	Total	259.3	100.0

Source: Rural Energy Development Program, 1998.

been introduced, at different places and times. Of them, biogas technology may be one of the most appropriate sources of energy for the rural households, as it is simple and produces gas from cattle and buffalo dung readily available in the rural areas. Since this technology is the main subject of this study, it will be discussed in detail in the next section.

3. Biogas Technology in Nepal

Biogas technology has proved itself to be one of the most promising and sustainable sources of alternative energy in Nepal. Nepal being predominately an agricultural country, livestock plays an important role on Nepalese farming system. The total cattle and buffalo population in Nepal was estimated to be 10.4 million (i.e. 7.0 m cattle and 3.4 m buffalo) in 1998/99 (Agriculture Statistics Division 1998/99). The potential number of biogas plants in Nepal is estimated to be about 1.3 million out of which 62%, 37%, 1% falls in Tarai, Hills and Mountains respectively. According to Netherlands Development Organization/Biogas Support Program (SNV/BSP), a total of 60,321 plants have been installed in Nepal by August 1999. Thus based upon the total number of biogas plants constructed in the country, it comprises only about 4% of the total potential of 1.3 Million. The contribution of energy from biogas plants in Nepal is estimated to be about 30 Mw annually or an equivalent of a fuelwood supply from 4-5 thousand hectares of forestland. Hence, much more efforts at all levels are necessary to make better use of this resource, otherwise wasted or used partially only.

In the beginning, floating drum type[1] plants of Khadi and Village Industries Committee (KVIC) was used for producing biogas from animal dung. The floating drum design encountered a number of technical problems. To overcome these problems some plants based on the Chinese Model was developed. This model being durable and cheaper than KVIC plant was popularized by Gober Gas and Agricultural Equipment Development Company which is commonly known as Gober Gas Company (GGC) and it gradually substituted KVIC model from 1987 onwards. The fixed dome type[2] plant (Chainese Model) developed by GGC about 17 years ago and later approved by SNV/BSP has been found very effective regarding gas production and operational aspect. According to SNV/BSP, more than 90% of the GGC model plants are in operation showing a very high rate of success compared to other countries. A Deen Bandhu Model plant that was established by Action for Food Production (AFPRO) as a low cost plant in India was also introduced in Nepal. However, this model of bio-digester has not gained popularity so far in Nepal because of the Chinese Model. Till now, six different sizes of biogas plants are constructed by biogas companies in Nepal; $4m^3$, $6m^3$, $8m^3$, $10m^3$, $15m^3$ and $20m^3$.

The prescribed feeding rate, animal required and average gas production for the different sizes of plants based upon the GGC model are shown in **Table 3**. After installation of plant, the equal amount of dung and water need to be fed in the plant and mixed with the help of hand mixer properly as shown in the **Figure 2**. For example, for 8 m^3 plant about 48 kg of dung and 48 litre of water is needed. To get that much of dung one should own 4-6 animals (cow or buffalo). This will produce about 1.9 m^3 of gas which is sufficient for 6-7 persons for two meals in the morning and evening.

Table 3 Prescribed Initial Feeding Rate, Daily Feeding Rate, Animal Required, and Average Gas Production for Hill Region

Size of plant (m^3)	Initial dung feeding (kg)	Daily dung feeding (kg)	Daily water (lit.)	Animal required	Average gas production (m^3/day)	Gas sufficient for persons
4	1450	24	24	2-3	1.0	3-5
6	2200	36	36	3-4	1.4	4-6
8	2900	48	48	4-6	1.9	6-7
10	3500	60	60	5-7	2.4	7-9
15	5550	90	90	9-14	3.6	9-12
20	7200	120	120	>14	4.8	12-18

Source: Silwal B.B., 1999.

Figure 2 Woman mixing dung and water with hand mixer

It has been assumed that the life span of a biogas plant is 25 years. The cost for installation of the plants varies from one place to another and also from one size to another. However, the quotation issued by Nepal Biogas Promotion Group (NBPG), which applies to most of the companies for the fiscal year

2001/02 has been shown in **Table 4**. There is a subsidy of NRs. 8,500 to 9,500 from the government to install the biogas plants. This subsidy covers the costs of biogas appliances and their fitting costs, three years guarantee insurance of the appliance and the promotion fee. This would mean that the technology itself is basically given free of charge to the villagers.

Table 4 Cost of Various Sizes of Plants in the Hill Region

Particular	Size of Plants			
	4 m^3	6 m^3	8 m^3	10 m^3
Biogas appliances and their fittings	4,842	5,399	6,251	6,601
Construction charge	4,100	4,800	5,200	5,800
3 Years guarantee	600	600	600	600
Promotion fee	525	525	525	525
Materials cost	10,194	11,944	14,628	17,135
Total cost (a)	20,261	23,268	27,204	30,661
Subsidy (b)	9,500	9,500	8,500	8,500
Total Investment (a-b)	10,761	13,768	18,704	22,161

Note: Subsidy rate is for FY 2001/02 onwards. (US $ 1=NRs. 75)
Source: Devkota G.P., 2001.

The optimum plant size in the hill region on the basis of average livestock holding and the average household size is 8 m^3. The cost of an 8m^3 plant at present is estimated at Rs. 27,281 (Devkota, 2001). The detail actual cost for installation of a particular 8m^3 plant is shown in the **Table 5**.

Table 5 Actual Installation Cost of 8m^3 Biogas Plant

Particular		Amount
Biogas appliances		5,081
GI pipes and its fittings		1,170
Construction charge		5,200
3 Years guarantee		600
Promotion fee		525
Sub-total		12,576
Meterial & labor costs:	Quantity:	
Brick or stone	(1700 PC)	5,100
Sand	(80 bags)	1,200
Gravel	(40 bags)	480
MS-rod-8mm	(13.5 kg)	378
Cement	(21 bags)	5,670
Labor	30 man days	1,800
Sub-total		14,628
Total Cost		27,204

Source: Devkota G.P., 2001.

Devkota (2001) had found the pay back period with subsidy and without subsidy for the 8 m^3 plant in the hill region to be four and six years, respectively.

4. Chronological Development and Current Status of Biogas Technology in Nepal

The biogas researcher (teacher) B. R. Saublle at St. Xavier's School Godawari, Kathmandu established the first historical biogas plant in Nepal in 1955 with 200-liter capacity. After that, nine plants were installed on an experimental basis in various parts of the country. It is only in the fiscal year 1975/76 the real interest on biogas began and the government decided to launch a special program on biogas technology. The main objective of this program was to control deforestation and prevent the burning of animal dung, valuable manure for farming. As a result, about 290 family size (6, 8 and 10 cu. m) plants were installed with interest free loan from the Agricultural Development Bank (ADB/N).

In 1977, GGC was set up to promote biogas technology in Nepal. GGC as a leading biogas company has been the only organized body responsible for the over all development and management of the biogas sector for 17 years in Nepal. By 1978, the country has a total of 708 plants and all were of floating drum type. Realizing the importance of this technology, in acheiving its target of controling deforestation and dung burning, the government set general target to install 4,000 plants in the Seventh Five-Year Plan (1985-1990) and 3,862 plants were actually installed during the plan period. Encouraged by this achievement the government set up a target to install 30,000 plants in the Eighth Five-Year Plan (1992-1997). In 1992, the Biogas Support Program (BSP) was set up as a joint venture between private companies recognized by ADB/N, and Netherlands Development Organization, Nepal (SNV-N) to support the biogas program through subsidies, quality control and training. Ever since, BSP became responsible for the overall implementation of the biogas program in the country. It encouraged the involvement of private sector in the program and various private companies have been set up for the construction of biogas plants.

The current state of development of biogas in Nepal is largely due to the incentives of His Majesty's Government of Nepal (HMG/N). It provides loans at the community level for biogas through ADB/N against collateral in the form of land (0.09-0.12 hectare in rural areas) for family size plant . Biogas development has also been promoted by the manufacturing companies like Balaju Yantra Shala (BYS), United Mission Nepal (UMN) and GGC and donors like United Nations Capital Development Fund (UNCDF), SNV-N, and United Nations International Children's Emergency Fund (UNICEF). UNICEF has provided a subsidy for the installation of family sized biogas plants with additional support and subsidies given to GGC for promoting biogas in remote districts of Nepal. SNV-N has provided capital subsidy as a grant for each plant established by GGC.

As to the current status of the biogas program in Nepal, a total of 50 private biogas companies are engaged in the installation of the biogas plants in 64 districts of the country. Out of these installations, 48% has direct involvement of GGC while the rest 52% is installed with the active participation of the private companies as of the fiscal year 1998/99. The share of private companies is increasing as the numbers of the biogas plants are increasing. Although there are some incremental decreases during the 1990/91, 1994/95 and 2000/01 fiscal years, mainly due to policy discrepancies, budgetary management issues and political disturbances, the biogas plants have been increasing steadily since it took off in 1990 (Figure 3). This could be regarded as the outcome of proper use of government subsidy policy, active involvement of private biogas companies and the positive attitudes of the some of the donor agencies.

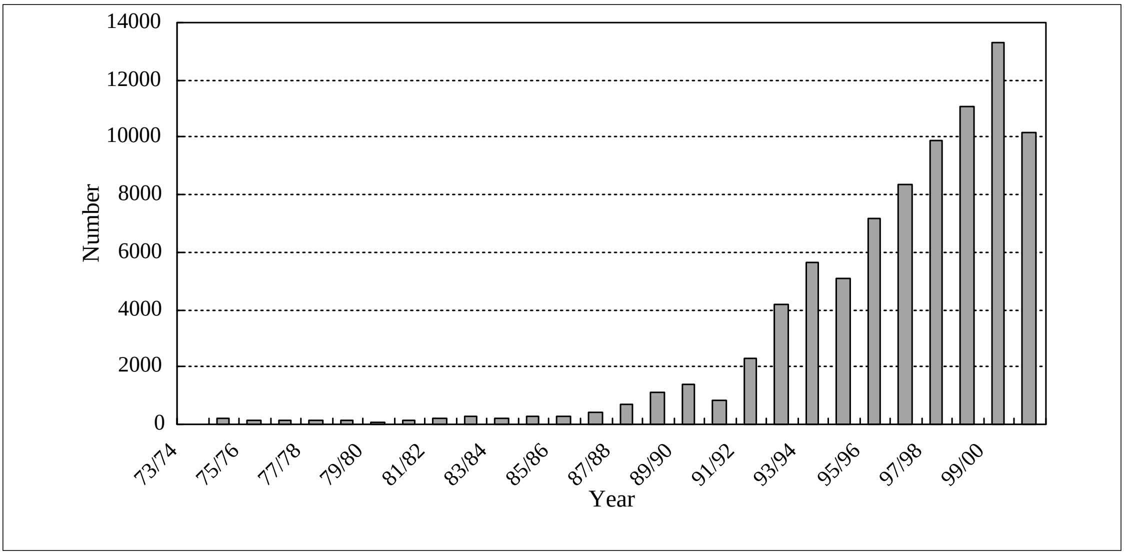

Figure 3 Annual Number of Biogas Plants Installation in Nepal

Source: Devkota G.P., 2001.

5. A Case Study of Biogas Technology in Nayagaun Village Development Committee in Kavre District

A detailed field study was conducted in a village with recent promotion of biogas technology, located in Kavre district, in the hilly areas of central development region of Nepal. Subsistence farming with livestock as an essential component is the basis of livelihood in this study village as in many villages of Nepal. Animal dung and crop residues are important by-products of this farming system, generally returned to the farming as manure, contributing in production and bio-economic environment as a whole. Depletion of forest and lack of fuelwood compels farmers to use these by-products as a source of energy for cooking, heating and lighting. Since they are burnt, the farming is deprived of its valuable manure, which consequently causes damage in production and environment.

Nayagaun Village Development Committee (VDC Administrative village) where the study was conducted has 864 households as of 1999 and 108 biogas plants were installed in the VDC by 2000. The in depth household level study was done in a natural village in this VDC that covers ward numbers 5,6, and 7 and consists of 236 households. Eighty-eight households installed biogas plants of $6m^3$ size, in 2000 and form cluster for biogas plant installation in this VDC. Thirty-five households (about 40%) with biogas plant were randomly selected for the detailed study. About 20% of households without biogas plant were also randomly surveyed for comparative study, especially focusing on non-users in the same area[5]. In either case the farmers were surveyed with structured questionnaire, and site observation during September 2000. The socio-economic condition and findings of the survey are presented hereafter.

5.1 General Features of Nayagaun VDC

Nayagaun, one of the remote VDC of Kavre district, is situated in Central Development Region in the hill areas of Nepal. The nearest place of the district is about 35 kilometer east from Kathmandu, the capital of Nepal. The study village is 16 km away from district headquarter having altitude 900m-1500m above from see level. It can be reached, by two and half hours walking from nearest road head, Kuntabesi, alternatively after walking more than two hours from Nagarkot, a tourist area.

The total population of Nayagaun VDC is 5141 with 864 households. The population in the VDC is mixed with different ethic groups like Tamang, Brahmin, Chhetri, and Newar and so on. The average household size of the VDC is 6, which is slightly greater than district household average size 5.3 and national average 5.38 recorded in the preliminary census of 2001. Sample household with maximum number of family members have 16 persons where as the minimum number was 3. The settlement of Nayagaun is very much scattered and spread among the terraced fields with individual house linked by pathways. Almost all the households are surrounded by the sloped agricultural fields with animal shed near by or attached with the houses.

5.2 Energy Situation and Biogas Plant in Nayagaun VDC

As there are no alternative sources of fuel, all household of the sample village used fuelwood for household purposes. It was found that, about 27% of the households have met their fuelwood needs from their own farms and the remaining 73% have been depending on community forest. As a result forest resources and environment had been deteriorated noticeably and fuelwood is becoming scarce. Villagers have been facing problem in collection of fuelwood and fodder for the livestock. In order to collect one *bhari* of fuelwood (1 *bhari*=30 kg) at least three hours time had to be spent. This is a big pressure in family labor use for the villagers directly translated into hardship of their life. Many alternative means are sought in order to overcome this hardship. Recently about 18 households have solar panel installation for only lighting purpose. But this is very few and the use of other commercial energy sources is negligible. Thus, the villagers are attracted towards the biogas technology for fulfilling their energy needs, especially, for cooking.

The biogas program with combination of toilet has been implemented with the financial support of District Development Committee: Rural Energy Development Sector (DDC: REDs), Kavre and partly with subsidized grant of HMG/N in this VDC. It has introduced biogas program in this VDC since March 2000. The major characteristic of biogas plant under this program is biogas plant with combination of human excreta (toilet-attached biogas plant) a new development in the expansion of biogas plants. This was introduced with multiple aims; 1) making use of human excreta, otherwise wasted and secure enough slurry for plant even at families with lesser number of animals, and 2) habituating the people to use toilet and enhance health and hygiene of individuals, household and community. All together 108 biogas plants were installed. **Table 6** shows ward-wise total number of biogas plant installed by September 2000 with 88 households (85%) being installed in ward 5,6, and 7. The biogas

Table 6 Total Number of Biogas Plant According to Ward

Ward	1	2	3	4	**5**	**6**	**7**	8	9	Total
Total number of household	263	46	80	67	**60**	**70**	**106**	125	47	864
Number of biogas plant	0	11	9	0	**24**	**29**	**35**	0	0	108

Source: Field Survey, 2000.

program has not yet covered ward 1,4,8 and 9 but the process to install biogas plant there is undergoing. These wards are mostly dominated by the Tamangs and have less accessibility to water sources. Thus, the program started with more feasible areas, i.e., ward 5,6, and 7 where the water is comparatively easily available and the villagers more ready to accept the technology.

5.3 Characteristic of Biogas Users and Non-Users

5.3.1 Ethnicity

The ethnic group composition of the study village is classified in three main groups. They are Tamang, Brahmin/Chhetri, and others including Magar and Newar. The dominant ethnic group among the total household in the village is Tamang, followed by Brahmin/Chhetri (37%) and others (17%). **Table 7** shows the highest biogas users (74%) come from the Brahmins/Chhetris ethnic group, followed by Tamangs and others. The main reason for that is most of the Brahmin/Chhetri have been raising more cows and buffaloes that produce sufficient amount of animal dung for biogas plant. The highest biogas non-users are Tamangs (55%). Most of the Tamangs are not interested in biogas installation. Two main reasons are; firstly, Tamang Community has been practicing drying meat over the *chulo* (traditional mud stove) to make *sukuti* (dry meat), which can be stored for long period, and forms one of the delicious food in their food culture. But biogas is not suitable to use for making *sukuti*. Secondly, they are also making *rakshi* (local alcohol) in their own house. For this purpose also biogas stove is not suitable. Generally a large sized stove is needed for making r*akshi*. The biogas stove installed at that moment is found to be small in all the households. Further, most of them live in the upper part of the hill away from the water resource. They have to carry the water from the lower part and feed the plant, which they feel as an additional work burden.

Table 7 Caste/ethnic Group Composition of Biogas Users and Non-Users

Ethnic Group	Number of Biogas Users	%	Number of Biogas Non-users	%
Brahmin/Chhetri	26	74	3	17
Tamang	7	20	10	55
Others	2	6	5	28
Total	35	100	18	100

Note: Others include Magar and Newar ethnic groups
Source: Field Survey, 2000

5.3.2 Education Status

The average literacy rate for the study village is 68.2% much is higher than district literacy rate 40% (HMG/JICA/JMA, 1997). Education status of the biogas users and non-users is classified into five stages. These are, literate, primary schooling, secondary schooling, School Leaving Certificate (S.L.C.), signifying the end of ten years of schooling, and above S.L.C. None of the respondents were found to be illiterate in both the cases of users and non-users.

Most of the Brahmin/Chhetris biogas users are highly educated and than Tamangs and others (**Table 8**). About 12% of them have attained above S.L.C. where as most of the Tamangs are less educated. But there is no visible difference in using the biogas plant according to education. It is a simple technology and anybody can understand its application method with simple training after its installation. However, there could be a difference in literate and illiterate people. There are no illiterate biogas users and the high percentage biogas users being Brahmins/Chhetris coincide with their higher literacy rate.

Table 8 Educational Status of Respondents of Biogas Users and Non-users According to the Ethnicity

Ethnic Group		Educational Status					
		Literate	Primary (1-5)	Secondary (6-10)	S.L.C	Above S.L.C	Total
Biogas Users	Brahmin/Chhetri	10	0	7	6	3	26
	Tamang	5	2	0	0	0	7
	Others	1	1	0	0	0	2
	Total	16	3	7	6	3	35
Non-users	Brahmin/Chhetri			2	1		3
	Tamang	5	4	1			10
	Others		4			1	5
	Total	5	8	3	1	1	18

Note: Others include Magar and Newar ethnic groups.
Source: Field Survey, 2000.

5.3.3 Occupation

The dominant occupation of the villagers including biogas users (94%) and non-users (78%) is farming (**Table 9**). Most of the biogas users are engaged in farming and rearing the livestock. Among the non-users comparatively more percentage are engaged in non-farming jobs such as teaching and teashop keeping. Even those engaged in farming have comparatively less land and less number of animals.

Table 9 Occupation Structure of Biogas Users and Non-users According to Ethnicity

Ethnic Group		Main Job Categories			
		Farming	Teaching	Business*	Total
Biogas Users	Brahmin/Chhetri	26			26
	Tamang	7			7
	Others		1	1	2
	Total	33 (94)	1 (3)	1 (3)	35
Non-users	Brahmin/Chhetri	2		1	3
	Tamang	8		2	10
	Others	4	1		5
	Total	14 (78)	1 (5)	3 (17)	18

Note: * Business means small teashops and petty shop, () Indicates percentages, Others include Magar and Newar ethnic groups.
Source: Field Survey, 2000.

5.3.4 Land Holding

The land is categorized in four types in the study village. Paddy field (*khet*), Homestead (*bari*), terrace land (*pakha*) and private forest. As shown in **Table 10**, all the biogas users hold paddy field and homestead with an average holding size of 0.61 ha and 0.38 ha, respectively. About 13% of biogas users owned private forest with an average size of 0.2 ha. As all the biogas users owned paddy field with highest average holdings, all the households are self-sufficient in meeting their food needs for the whole year. In case of non-users their food self-sufficiency level is comparatively lower than the users, as they owned less paddy field. About 39% have terrace field covering 3.6 ha of land. None of the non-users own private forest.

Considering the land holding size, most of the households (71%) among the total biogas users are medium farmers (**Table 11**). They are followed by the large farmers (17%) and the small farmers (12%), respectively. Most of the Brahmins/Chhetris have more land holdings. The non-users are mostly small and landless farmers. This may imply the small and landless farmers are lagging behind in using of biogas[3].

Table 10 Land Holding Size of Biogas Users and Non-users According to Land Type

Biogas	Land Type	No.HH	%	Total Land (Ha)	Ave.Land Holding (Ha)
Users	Paddy field (*Khet*)	35	100	21.5	0.61
	Terrace (*Pakha*)	15	43	2.1	0.14
	Homestead (*Bari*)	35	100	13.5	0.38
	Private forest	5	13	0.6	0.12
	Total	90		37.7	1.07
Non-users	Paddy field (*Khet*)	12	66	1.3	0.12
	Terrace (*Pakha*)	7	39	3.6	0.51
	Homestead (*Bari*)	18	100	2.0	0.13
	Total	37		10.1	0.56

Source: Field Survey, 2000.

Table 11 Land Holding of Biogas Users and Non-users According to Ethnicity

Biogas	Categories	Brahmins/ Chhetri	Tamangs	Others	Total HH	% Holding
Users	Small	3	1		4	12
	Medium	17	6	2	25	71
	Large	6			6	17
Total		26	7	2	35	100
Non-users	Landless		3		3	17
	Small	3	4	3	10	55
	Medium		3	2	5	28
Total		3	10	5	18	100

Note: Small: household with land under 0.5 ha, Medium: household with land 0.5 ha and more and under 2 ha, Large: household with land 2 ha and over

Source: Field Survey, 2000.

5.3.5 Livestock Holdings

Livestock holding is the key factor for installation of biogas plant. The average number of livestock, including buffaloes and cows, within biogas household is 5.3 per household[4]. The average number of buffalo is more than the cow (**Table 12**). The average dung produced is about 14kg per head including both cows and buffaloes. Generally in the hills, dung required for daily feeding in the biogas plant is 36 kg for the 6 m^3 capacity plant. Integrating cow and buffalo, 3-4 animals are sufficient for 6 cubic meter plants that can produce 1.4 cubic meter of gas sufficient for cooking two meals a day for the households with 4-6 people. In the case of non-users, the livestock holding is very less, an average of one animal per household, and they are not in a position to meet the necessary dung for the biogas plant.

Table 12 Livestock Holding by Land Holding and Ethnic Group Within Biogas Users and Non-users

	Ethnicity	Land Category	Animal Holdings: Cow		Animal Holdings: Buffalo		Total		Ave. Hold-ings	Total Dung Produced	Ave. Dung (Kg)
			No	HH	No	HH	No	HH			
Biogas Users	Brahmin/Chhetri	Small	6	3	6	3	12	3	4.0	156	13.0
		Medium	28	17	50	17	78	17	4.6	1092	14.0
		Large	15	6	32	6	47	6	7.8	682	14.5
	Tamang	Small	2	1	4	1	6	1	6.0	78	13.0
		Medium	10	6	21	6	31	6	5.2	456	14.7
	Others	Medium	8	2	5	2	13	2	6.5	193	14.8
Non-users	Brahmin/Chhetri	Small	2	2			2	2	1.0	25	12.5
		Medium	3	2	2	1	5	3	1.8	70	14.0
	Tamang	Medium			3	3	3	3	1.0	38	12.6
	Others	Small	1	1	3	3	4	4	1.0	52	13.0
		Medium	1	1	3	3	4	4	1.0	53	13.0

Source: Field Survey, 2000.

6 Survey Result and Discussion

6.1 Fuelwood Use

The entire sampled household of the study area used fuelwood before installation of the biogas plant. They met their basic needs of fuelwood by using forest resource and some of the agricultural residues. According to this survey, it was found that there is a drastic reduction in fuelwood consumption among the biogas users before and after the installation of biogas plant. **Table 13** shows the amount of fuel-wood consumption in Newars and Magars has the highest reduction in fuelwood used before and after the installation of the biogas plant. They are followed by the Tamangs and Brahmin/Chhetris. Thus, the result shows that the demand of fuelwood has reduced from 12.86 *bhari* to about 7.76 *bhari* of fuelwood per month, an average decrease of about 60.3% per household after the installation of the biogas plant. In case of non-users, it remains same in most cases. Their changes in use of fuelwood are due to their engagement in other activities; Tamangs increased fuelwood use due to their increase in alcohol making and Brahmin/Chhetris increased fuelwood use to prepare feed to their increased livestock.

Table 13 Amount of Fuelwood Used Within Biogas Users Before and After Installation of Biogas Plant (Per Month)

Ethnicity	Household no.	Before biogas use (bhari)	After biogas use (bhari)	Difference (bhari)	%
Brahmin/Chhetri	26	340.7	136.7	204.0	59.8
Tamang	7	89.2	34.5	54.7	61.3
Others	2	20.2	7.3	12.9	63.8
Total	35	450.1	178.5	271.6	60.3
Average per household		12.86	5.1	7.76	

Note: 1 Bhari = 30 kg, Others include Magar and Newar ethnic groups.
Source: Field Survey, 2000.

6.2 Domestic Labor and Time Allocation

The analysis of the data in this regard reveals that there is a significant change in time required for household activities such as fuelwood collection, cooking and cleaning after installation of biogas plants. Due to the availability of cooking fuel, no/less family labor and time is needed for fuelwood collection. Although the time required for water collection has increased, and mixing of dung and water in feeding the biogas plant is an additional work, the total time saving after the installation of biogas plant is calculated to be about four hours per day among the biogas users (**Table14**). While comparing time allocation of biogas users with non-users, the total time difference between these two groups is calculated to be about three hours per day. This difference of time is accrued mainly from difference in fuelwood collection and cooking activities. Generally, women do these activities but in the study village, except cooking, all other are activities equally shared by men and women.

Table 14 Time Allocation for Household Activities

Household Activities	Biogas Users			Non-users (now) (Mean) (b)	Time difference (b)-(a)
	Before biogas use (Mean)	Now (Mean) (a)	Time saved Mean (-)		
Cattle care	1.50	1.48	-0.02	1.30	-0.18
Water collection	0.89	1.58	+0.69	1.09	-0.49
Feeding biogas plant	0	0.28	+0.28	0	-0.28
Cooking	5.01	3.20	-1.81	4.55	1.35
Cleaning vessels	1.48	0.67	-0.81	1.08	0.41
Fuelwood collection	2.60	0.66	-1.94	3.16	2.50
Total	11.48	7.87	-3.61	11.18	3.31

Note: Unit is hours per day.
Source: Field Survey, 2000.

Among the biogas users, thus saved time is being used in various activities. About 43% used the saved time in farming, which can lead to increase in crop yield. However, there is no exact calculation that how much crop yield is increased. About 23% are not doing any productive activities. The rest are using the saved time in income generating activities, such as, laboring, livestock raising and business activities, and domestic activities, such as, child caring (**Figure 4**).

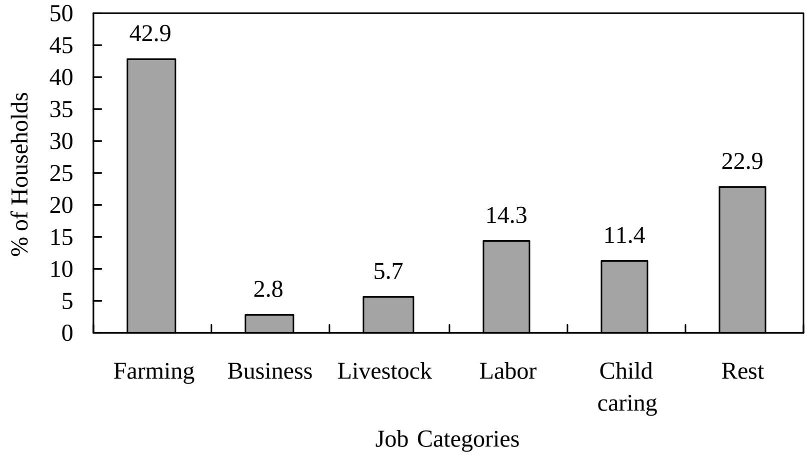

Figure 4 Saved Time Uses Pattern Among Biogas Users

Source: Field Survey, 2000.

6.3 General Health and Sanitation

The contribution of biogas use in improving the users' health and sanitation is summarized in **Figure 5**. Since it is a smokeless and environmentally friendly gas, it helps to reduce occurrence of diseases caused by smoke such as eye infection, headache, cough and others by eliminating indoor air pollution as well as keeping the domestic utensils, bedding and surroundings clean (**Table 15**). Nearly two-third of the respondents mentioned that the frequency of suffering of various diseases such as dizziness, headache, diarrhea, eye infection, cough, have been reduced after the use of biogas. Further, biogas being produced by the use of animal dung, human excreta and solid wastes, makes homestead and surroundings cleaner. With the installation of biogas, villagers are encouraged to build the toilet that they are not used to before, thus, preventing contamination of water. Hence, it helps to minimize the occurrence of intestinal warm infection, and other epidemic diseases such as diarrhea, dysentery and others. Therefore, the use of biogas helps to improve the health and sanitation and the cooking environment.

6.4 Contribution in Household Income

The contribution of biogas in increasing the household income found mainly in three simple ways in the village is summarized in **Table 16**. Biogas not only helps to reduce the use of fuelwood for energy, but also helps to reduce the burning of biomass that provides manure for farmland. The digested slurry, which is better than the fresh dung can be directly used in farmland as manure in this fertilizer scarce village of the hill areas and contributes in sustaining and increasing the productivity of the marginal lands. The savings from purchasing fuelwood, expected increased income from farming by using slurry

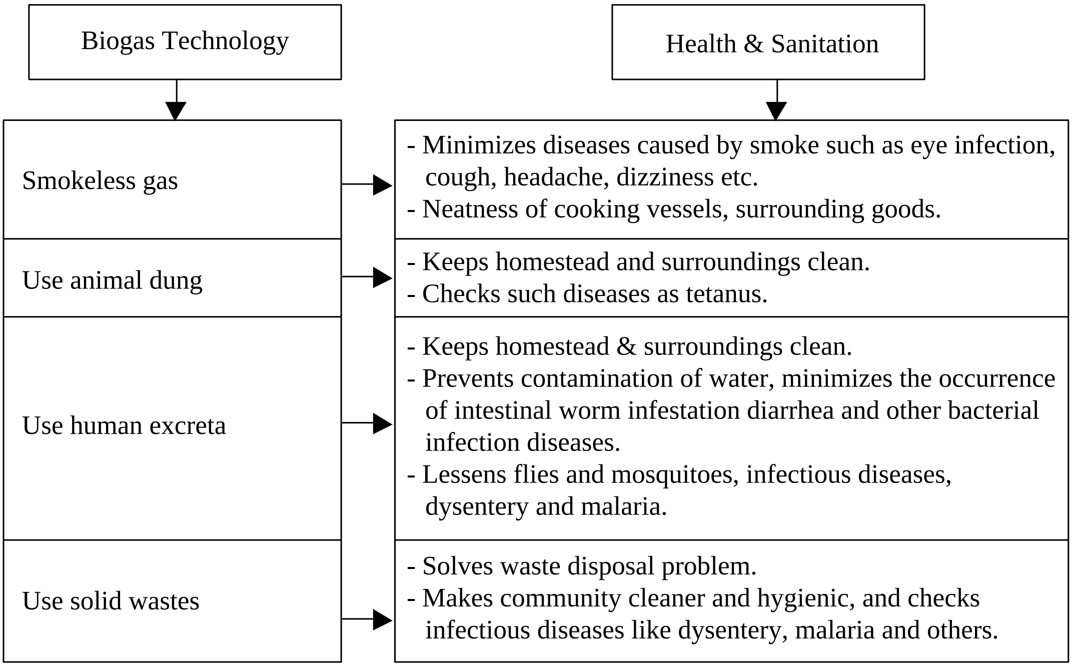

Figure 5 Relation of Biogas & Human Health & Sanitation

Table 15 Health Situation After Using Biogas Based Upon Respondents

Categories	Decreases	Increases	Do not Know
Dizziness	34	1	0
Headache	30	3	2
Diarrhea	28	0	7
Eye Infection	26	0	9
Dysentery	25	0	10
Cough	25	0	10
Nauseous	21	0	14

Source: Field Survey, 2000 (Sample size = 35)

as manure, and savings from buying soap for cleaning are the direct monetary benefits in using the biogas. The total evaluated savings per year varies from about NRs.16,000 to NRs.21,000, amounting to 30% to 40% of the annual salary of a government primary school teacher, NRs. 50,000 per annum. Where as the total cost of installation for $6m^3$ plant is NRs. 23,268 including NRs. 9,500 subsidy and the average operating and maintenance cost is about NRs.400 per year. This would mean that the installation cost of the biogas plant, if used properly, could be paid back within a year or two. Even if the earnings from farming is not evaluated, as they are indirect benefit, there would be around NRs. 6,000 savings per year and the installation cost can be covered well within four to five years. This also confirms the findings by Devkota mentioned earlier.

Table 16 Household Economic Benefits of Biogas Users

Item	Quantity	Saved Amount/year
Fuel wood saved	* 8 Bhari/month	NRs.5760
Earning from farming	Using slurry plus extra labor	NRs.10000~ Rs.15000
Saved soap for cleaning	** 1 Kg/month	NRs.216
Total		NRs. (15976~20976)

Note: *1 bhari = 30 kg, NRs.2/bhari **1 kg Soap = Rs. 18 $ 1= NRs. 74.35.
Source: Field Survey, 2000.

6.5 Villagers' Perception Towards Biogas Use

The villagers' perception regarding the biogas use is mostly positive in the study village. Completion of cooking work in about half the time, easy vessels cleaning, smokeless kitchen and households' environment, clean clothes and helping to reduce hardship, especially for women, are some of the positive aspects of the biogas use, according to the villagers. These all have encouraged them to install and maintain the biogas plant. All the biogas plants are connected with toilet. In the initial stage people hesitated to use the gas that is produced with the use of dung and human excreta for cooking food. During the survey some of them expressed that food will not be as tasty as cooking in firewood in the starting days but latter on not felt any differences. One respondent mentioned that villages where biogas plants have not been installed faced the problems of night soil in the village trials. But, such problems have been overcome, in those wards of the village where biogas plants have been installed. Even all the non-users in these wards have expressed that they want to install the plant in their houses as soon as possible.

Though people mentioned number of positive impacts of biogas technology, they also pointed out its negative aspects. There is severe problem of mosquitoes after installation of biogas plant. So in future it may create the problems of mosquito born diseases in those wards. But the villagers were unaware of reason behind the increasing number of mosquitoes. In the authors' observation the reason behind it is due to the open slurry pit. They generally drain the slurry openly from plant to pit. Sometimes the slurry is freely flowing in the ground. But the government has already implemented the program of making covered pit to manage the slurry properly. Villagers who are undertaking this program of making covered pit is not facing this problem anymore.

Some of the respondent (11%) complained that the loans created unnecessary tension for them, as they did not have such practice of taking loan before. They feel the tension more when the interest rate for the loan changes with the changes in government policies, which is rather high (18%). But most of the respondents in this area have installed the plant without taking any loans.

The majority of respondents also mentioned that there is no warmth in the house in winter with use of biogas and food became cool very quickly in absence of fire in the kitchen. But, most biogas users agreed that the biogas is better for cooking than wood or kerosene, especially when the performance of the plants is good. Since all the plants are newly installed in the study area, the plant has been working properly and has no problem in operating it. Hence, all these negative implications are comparatively minor issues and lesser number of the people complains about them.

7. Conclusion

Nepal is energy poor country, bulk of energy comes from traditional energy sources mainly fuelwood, agricultural residue and animal dung and the rural residential sector is the biggest energy consumer. Overuse of fuelwood causes deforestation, consequently, soil erosion, and natural hazards make rural life harder. Biogas technology is regarded as an appropriate technology to generate energy from animal dung in Nepal where livestock is an integral part of farming. This technology is simple, uses animal dung, readily available in the rural region, as a raw material. Recognizing the multiple benefits of this technology government of Nepal is encouraging the expansion of its use and closely working with donors and private sectors to promote it. Government also provides subsidy to the farmers in its installation as an incentive. With these endeavors the uses of biogas have increased constantly and reached 83,829 by 2001, 5.6% of the total potential users, producing 37.6million m^3 gas annually.

At the village level, it is popular among the farmers, especially, with livestock. It helps in saving time in fuelwood collection and cooking. Such saved time is used in farming and other income generating activities and in domestic activities. The cost of installation of the plant can be easily covered within four to five years. It also lessens fuelwood consumed and reduces burning of biomass that can be used in farm to generate more yield and income. It improves health and hygiene of individuals, household and community and contributes in saving money used for purchasing soap. Availability of fuel reduces the pressure on forest leads to reduce causes of deforestation and natural hazards, and providing environmentally friendly energy leads to maintain environment and makes health good. These all finally lead to well-being of the rural people. Although there are some negative aspects pointed by few farmers in using the biogas they are rather minor ones that could be easily overcome with proper plant management. The relation between biogas technology and well-being of the biogas users are summarized in **Figure 6**.

It is observed in this study that, the biogas users are generally literate and better-educated farmers, most of them being Brahmin/Chhetri, with more numbers of livestock and often better landed. This would imply that the biogas technology is benefiting only the villagers who are better landed and have large numbers of livestock. People without livestock, landless farmers and or small farmers tend to be excluded from getting its benefit. Most of the Tamangs having a different food culture are also lagging behind in its use. Authors are well aware of this issue not only among the rich and poor farmers but also among the farmers of different communities and it is difficult to address the complicated problems faced by the poor farmers. Thus, more study is needed to involve all these people who are supposed to be the main target group for development activities and be benefited from this technology. It may have to be integrated with other development programs, such as, dairy farming, community forestry, agro-forestry, etc. and will be undertaken in future research work.

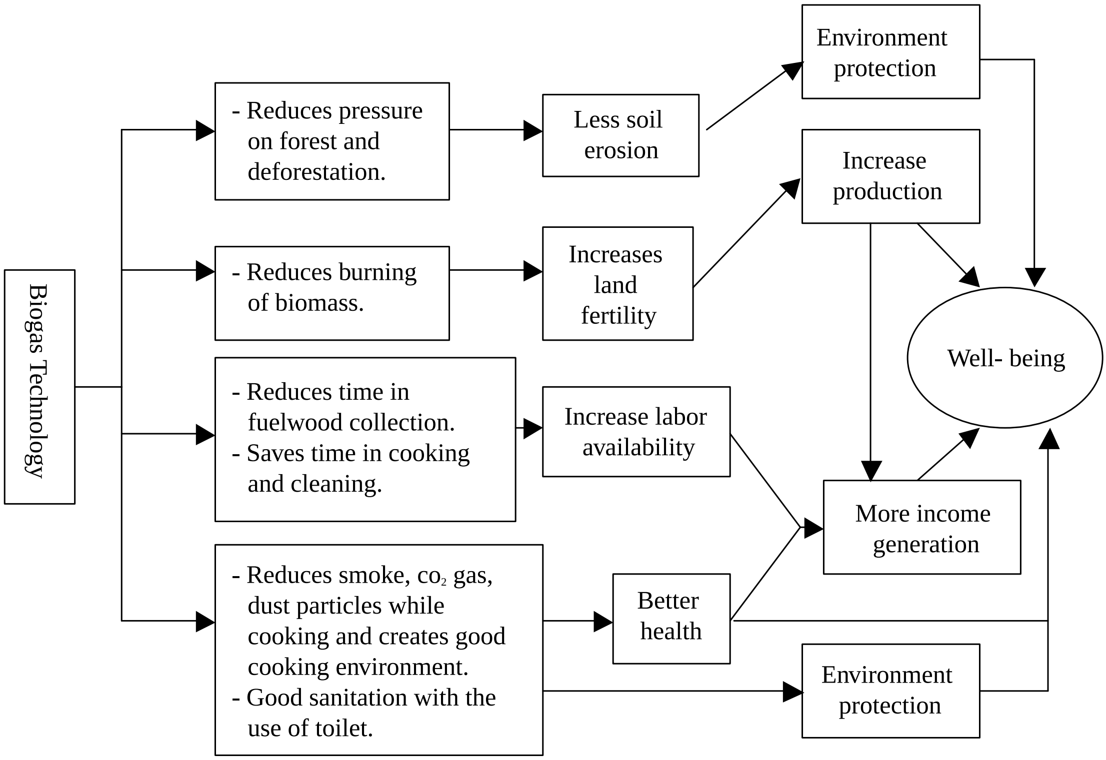

Figure 6 Relation Between Biogas Technology and Well-being of Biogas Users

Endnotes

(1) The drum type consists of a two-chamber underground digester pit with a floating steel drum gasholder. Slurry is fed into the base of one chamber from the cemented inlet pipe. The gas rises and is collected inside the drum, the effluent overflows into the second chamber and the slurry is expelled through an outlet pipe that is at a lower level than the inlet pipe. The Khadi and Village Industries Commission (KVIC), India, to suit Nepalese conditions, modified the design. In the modified design the pit is designed to taper down into the ground; gas is removed through a central guide pipe; and there is a two-compartment chamber design. (**Figure A**)

(2) The fixed dome plant is introduced by GGC in Nepal, which is an adoption of a design developed originally in China. It consists of and underground digester pit with a concrete dome shaped cover for collecting gas from the slurry. The concrete dome is casted over a mud mould. The gas pipe is placed at the center of the dome and fixed with anchors and supported with turret. The digester wall, inltet and outlet wall is made with quality bricks or stone. Several air ceiling materials such as wax, coal tar and acrylic plastic emulsion paints were applied under the dome. (**Figure B**)

(3) This is an important issue in expansion of biogas users and must be well introduced. However, this issue is beyound the capacity of this paper and will be dealt later in a different paper.

(4) This average number of animals per household is nearly equavalent to the figure of the whole VDC; 6 per household.

(5) The authors are well aware of the small sample size of the biogas non-users. But the authors had to work with this sample as the villagers, being non-user, were hesitating to respond to the questionnaire survey. They were not motivated and hence the quality of information they provided was rather low, some of which had to be discarded. Considering this fact and the time factor, authors decided that the quality of the data as a whole would not be better even increasing the sample numbers. Further studies taking into consideration of such aspects as, altitude, location, ethnicity, main occupation and economic conditions of individual households of the villagers will definitely enhance the understanding of the issue. This will be necessary to also understand the penetration of the whole program in the village. But this will be another task and will be dealt in the future.

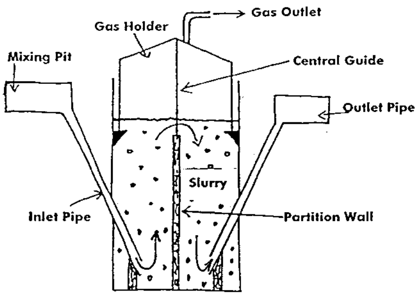

Figure A Floating Drum Plant

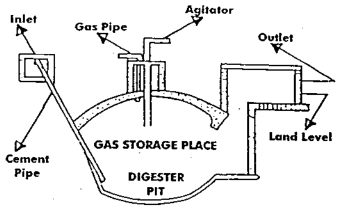

Figure B Fixed Dome Plant

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