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APPLICATION OF BIOGAS TECHNOLOGY IN NEPAL: PROBLEMS AND PROSPECTS

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PREFACE

This paper was prepared for, and presented at, the Seminar on 'Rural Energy and Related Technologies' held in Kathmandu from 26 to 28 March, 1991, in collaboration with the Agricultural Development Bank of Nepal and the Water and Energy Commission Secretariate of His Majesty's Government of Nepal.

This paper assesses the efforts made in biogas technology in Nepal and highlights areas for future action in order to achieve a significantly higher use of this technology in meeting domestic energy needs.

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Introduction

Shortage of energy is a serious constraint to the achievement of sustainable development. Predominant dependance (95%) upon traditional energy sources such as fuelwood, agricultural residue, and animal wastes characterises the energy scenario of Nepal. Among traditional energy sources, fuelwood constitutes 75 per cent while dung and agricultural residue share 11 and 8.5 per cent respectively. Poorly managed forests have to shoulder this immense burden to meet the increasing demand for energy caused by both the rising population and the lack of development of alternative energy resources.

It is ironic that Nepal, endowed with one of the largest hydropower potentials in the world, has so far used less than one per cent of its existing potential. Thus, the search for and production of alternative options to meet energy needs is of paramount importance.

One of the alternative sources of energy for cooking in the rural areas is biogas. Nepalese agriculture is dominated by a mixed farming system in which crop and livestock husbandry are combined. This necessitates that every household maintains a few animals. The livestock population in Nepal is estimated to consist of 3.4 million cows, 3.6 million oxen, and 4.2 million buffaloes. The daily average production of manure is 10kg per animal. Thus, theoretically, the total production of manure is estimated to be 112 million kilogramme per day. This will necessitate the establishment of 1.8 million family-size biogas digesters. Practically, it is difficult to collect all the dung, and, assuming the use of only 60 per cent of the total production of dung, the potential number of biogas digesters required would then be about one million.

The time involved in collecting fuelwood or making dung cakes is enormous, and if farm families are relieved of this operation they could use the spare time for other productive and income-generating activities. To achieve this, it would be necessary to provide fuel for cooking and illumination to each rural household at a cheap rate.

It has been known that, as the dung passes through biogas digesters, the resultant slurry is enriched with nutrients. Thus, theoretically , the slurry would yield a higher quantity of nitrogen, phosphorous, and potash than the actual dung. Unfortunately, because of a shortage of fuelwood in the Nepalese *Terai*, most of the fresh dung is converted into dung cakes for cooking and thus the agricultural land is deprived of traditional farmyard manure.

It is thus seen that biogas technology has enormous potential for meeting the demand of fuel for more than a million households in Nepal. Tangibly, it could replace the use of some petroleum products as well. It will also relieve rural women of the hazardous task of fuelwood burning and of physical hardships caused by several hours of travel each day in search of fuelwood. Biogas technology, therefore, assures wide ranging socioeconomic benefits for the prosperity and the quality of life of rural households. As rural households switch to biogas for cooking, their predominant dependency on fuelwood for cooking will gradually decline and this will certainly ease the burden on the depleting forests. There is also a potential for employment generation during the construction and establishment of these plants and their subsequent maintenance.

History and Development of Biogas Technology in Nepal

Biogas technology application in Nepal began in the mid-50s with the development of a micro-model digester (made of an oil drum) by Father B.R. Saubolle. Thereafter, some groups, through their own initiative, built a few biogas plants in the capital city, Kathmandu.

Genuine interest in biogas development came during the energy crisis in 1973, and the "Energy Research and Development Group" under Tribhuvan University was established in 1975. Biogas received further impetus during the Agricultural Year (1975/76) with a subsidised loan from the Agricultural Development Bank. As many as 196 of these plants were built by private contractors under the supervision of the Department of Agriculture. The design of biogas plants which are composed of floating steel drums for storage was directly transferred from India. Some private contractors and Development Consulting Services of the United Mission to Nepal popularised the plant at that time.

In 1977, Biogas and Agricultural Equipment Development (Pvt. Ltd.) was established as a specialised company by means of a joint investment from the Agricultural Development Bank, Nepal Fuel Corporation (Presently TCN), and the United Mission to Nepal. The company aims to establish service centres in strategic places in the country to construct and provide services for operation and maintenance, to train local manpower in the construction and maintenance of biogas plants, to provide support services to beneficiaries, to conduct problem-oriented research and development, and to make biogas accessories and appliances. However, the company attempts to cover all the areas feasible for biogas plant utilisation from its 17 offices. The biogas plants built by the company carry a five to six year guarantee for operation and maintenance. Since there is no separate grant aid from the Government for the extension, promotion, training, and R & D of biogas, these expenses are passed on to the farmers, resulting in the increased cost of biogas plants. The Water and Energy Commission under the Ministry of Water Resources has also been involved in biogas planning and development from the Seventh Five Year Plan onwards.

Design of Biogas Digestors

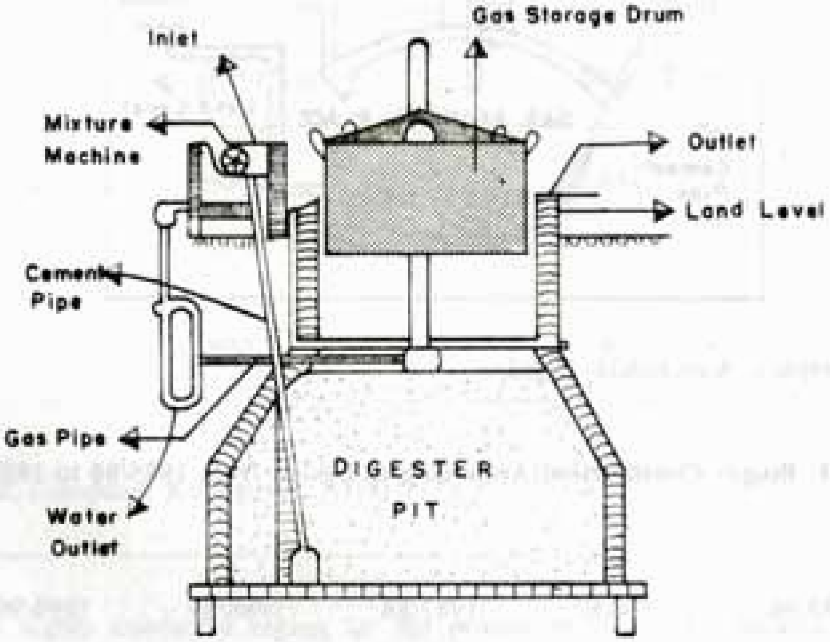
Two types of biogas digestor have been promoted in Nepal. They are:

- o the Floating Steel Drum Type and
- o the Fixed Concrete Dome Type

The Floating Steel Drum Type

This design is composed of a steel drum and a masonary structure and was popular in the initial stage of development, since it was directly borrowed from India when alternative designs were not available. With the availability of the dome type biogas digestor there has been a tendency to discourage the use of the drum type, except in the case of large plants. The major disadvantages of the steel drum type are that the metal corrodes easily, there is difficulty in transportation, and it is hard to insulate in winter. A sketch of the drum type *gobar* gas plant is shown in Figure 1.

Figure 1: Drum Design Gobar Gas Plant



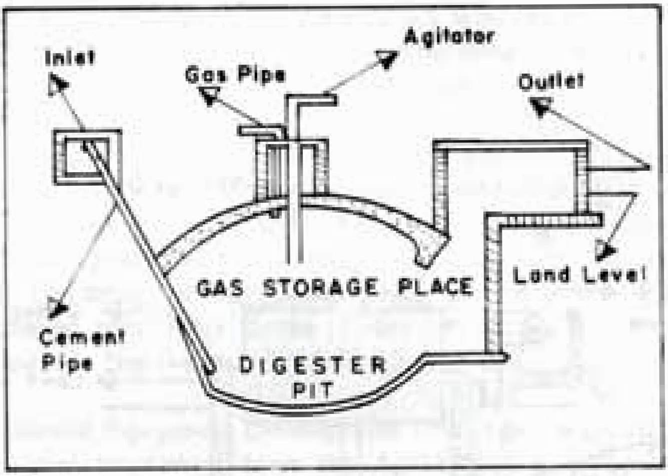
Source: Biogas Company, Kathmandu, Nepal.

Fixed Concrete Dome Design

This design (see Figure 2 below) has its masonary work mainly underground and uses mostly local materials (sand-stone, bricks, and cement). It is easier to insulate in the colder months. The maintenance cost is also minimum. The only constraint in the construction of this design is the transportation of cement to hilly areas which are not accessible by road. Therefore, the Biogas Company is experimenting with a fibre glass dome which is easy to transport to the hills. However it is relatively expensive in comparison to the concrete dome design. This design is now much more popular in Nepal.

The Biogas Company now exclusively promotes the dome type biogas plant. Table 1 indicates that over the last five years from 1985/86 to 1989/90, the Biogas Company has established only six drum types whereas 3,848 dome type biogas plants have been constructed. The floating drum design seems to have been absolutely discouraged.

Figure 2: Dome Design Gobar Gas Plant



Source: Biogas Company, Kathmandu, Nepal.

Table 1: Biogas Construction According to Design from 1985/86 to 1989/90

Design	1985/86	1986/87	1987/88	1988/89	1989/90	Total
Dome	271	401	676	1108	1391	3848
Drum	6	-	-	-	-	6
Total	277	401	676	1108	1391	3854

Source: Biogas Company, Kathmandu, Nepal.

The Present Distribution Pattern of Biogas Plants in Nepal

Geographical Distribution

A total of 5,739 biogas plants were installed in Nepal from 1974/75 to 1989/90 (see Figure 3 and Table 2). About 75 per cent of the total, i.e. 4,280 plants, were installed in the *Terai*, out of which 80 per cent, i.e. 3,438, are of the dome type. Similarly, about 25 per cent of the total, i.e. 1,459 plants, out of which 94 per cent, i.e. 1,369, are of the dome type, were installed in the hills. District-wise distribution of installed plants is also shown on the map of Nepal (Figure 4).

Table 2: Geographical Distribution of Biogas Plants in Nepal from 1974/75 to 1989/90

Region	Biogas Plant Type		Total
	Dome Type	Drum Type	
Terai	3438	842	4280
Hills	1369	90	1459
Nepal	4807	932	5739

Source: Biogas Company, Kathmandu, Nepal.

The *Terai* is a highly conducive region for the promotion of biogas, because of the favourable temperature range for the production of methanogenic bacteria responsible for biogas production (see Case Study A). In the hilly regions in winter, as altitude increases, the production of biogas diminishes because of the low temperature. The production of biogas is inversely related to the period of lower temperature. It should be kept in mind that biogas installation is equally useful in the mid-hills of Nepal. However, in winter months, depending upon the temperature, the production of biogas is low. The Swargdwari Biogas Plant is located at an altitude of 7,500ft in Pyuthan District and has been working satisfactorily (see Case Study B). Therefore, one should not rule out the feasibility of biogas in the hills, just because, for a few months, depending upon the altitude and duration of cooler months, the production of biogas is low. One may need to supplement with fuelwood during these low production period while substituting the fuelwood with biogas in cooking for most of the year.

Distribution According to Capacity or Size

In the fixed dome design, the size of the biogas plant in common demand is 10m,* followed by 15 and $20m^3$ plants. Figure 5 indicates the distribution of biogas plants according to size.

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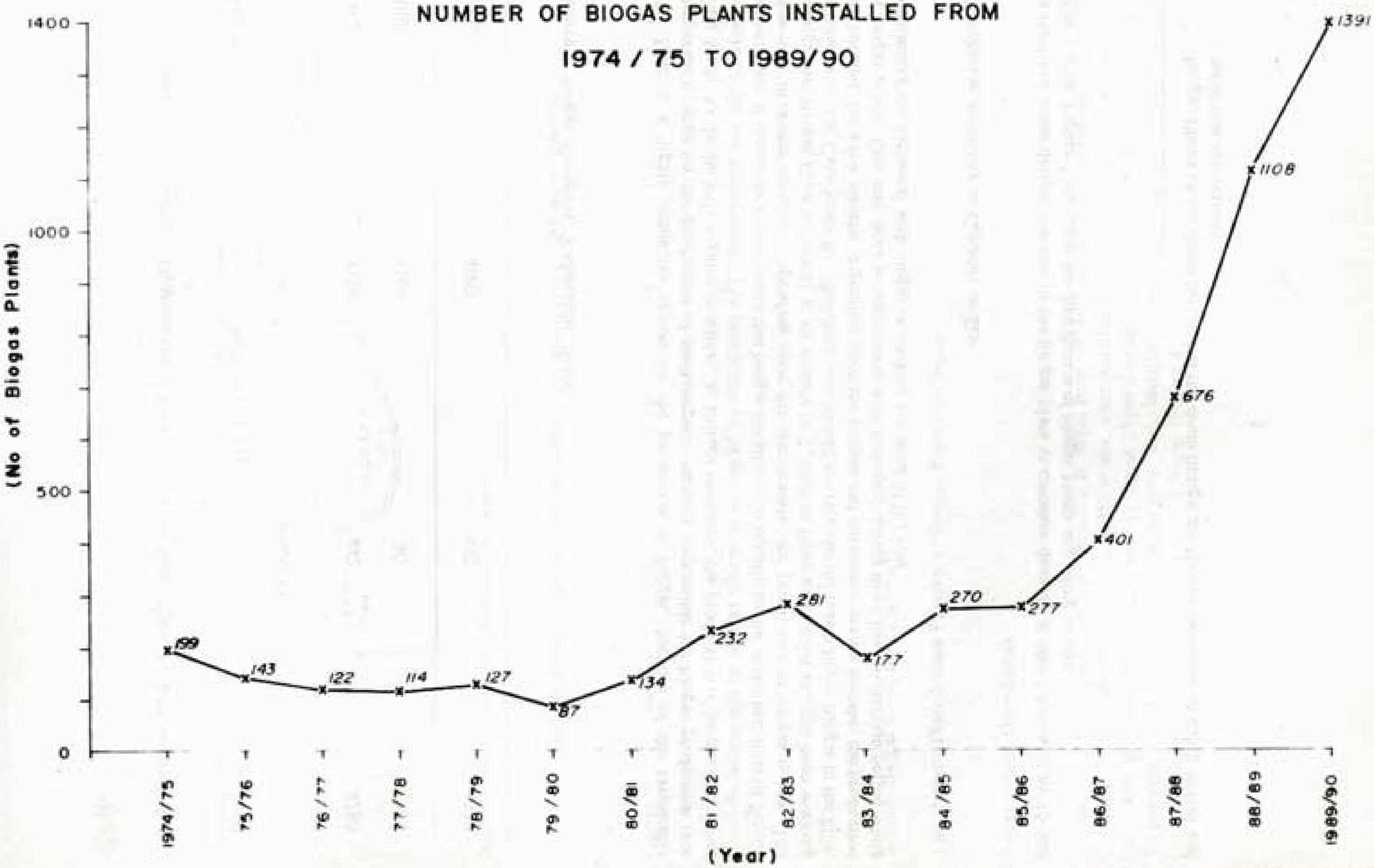
* Biogas Plants of the dome design and the drum design are always measured in cubic metres and cubic feet respectively.

NUMBER OF BIOGAS PLANTS INSTALLED FROM 1974 / 75 TO 1989/90



Source: Biogas Company Kathmandu, Nepal

DISTRICT-WISE BIOGAS PLANT INSTALLATION IN NEPAL

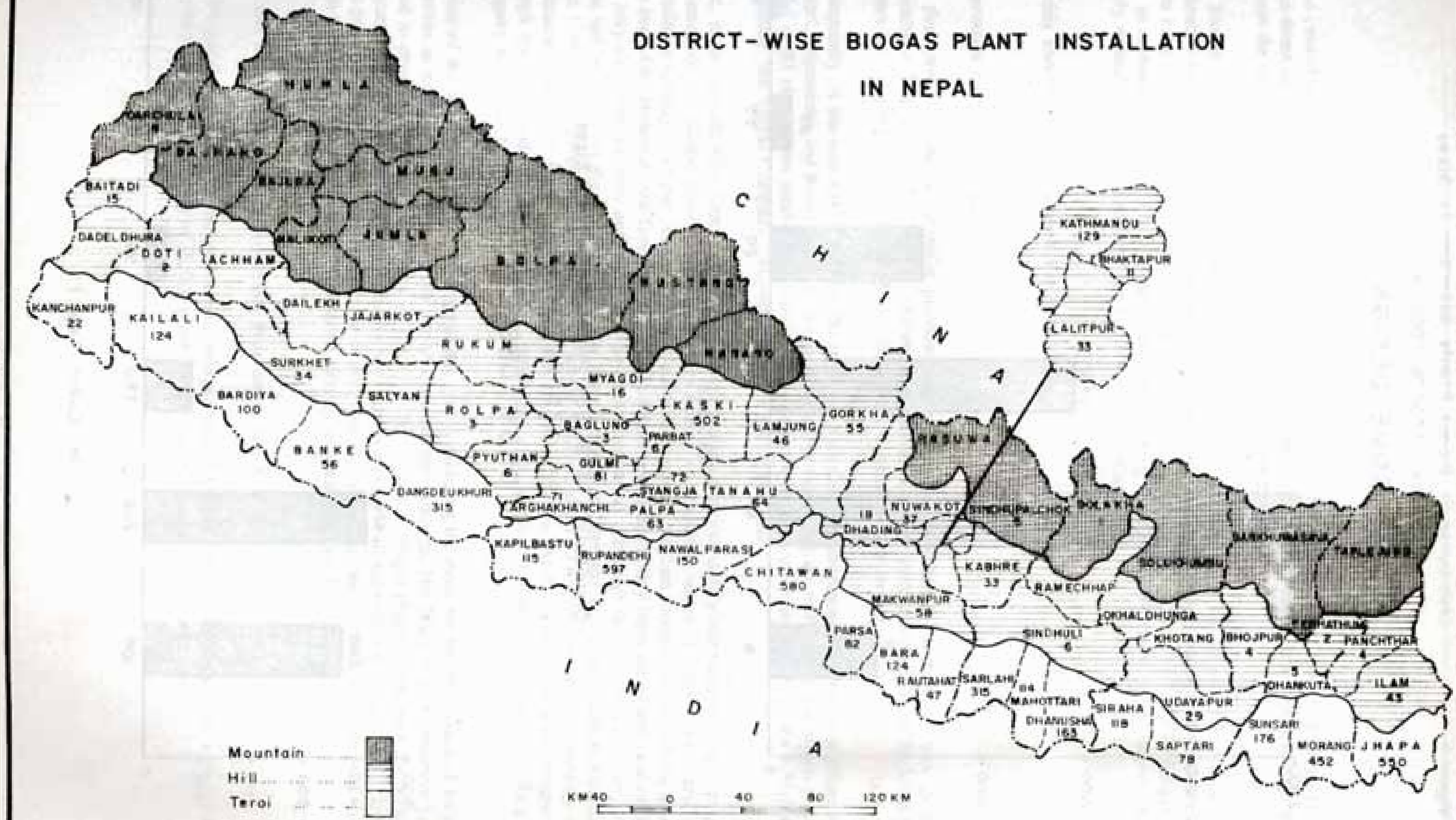


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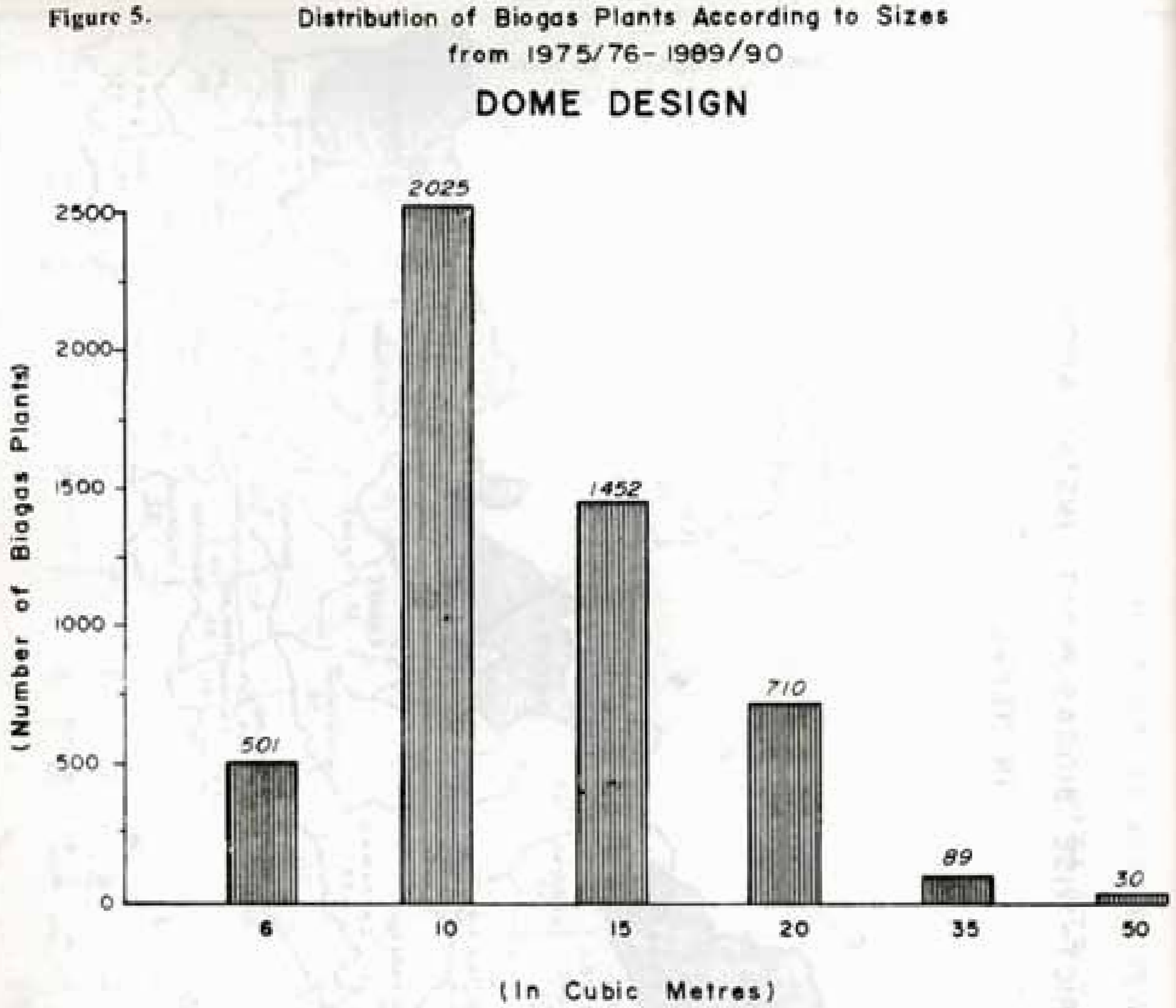
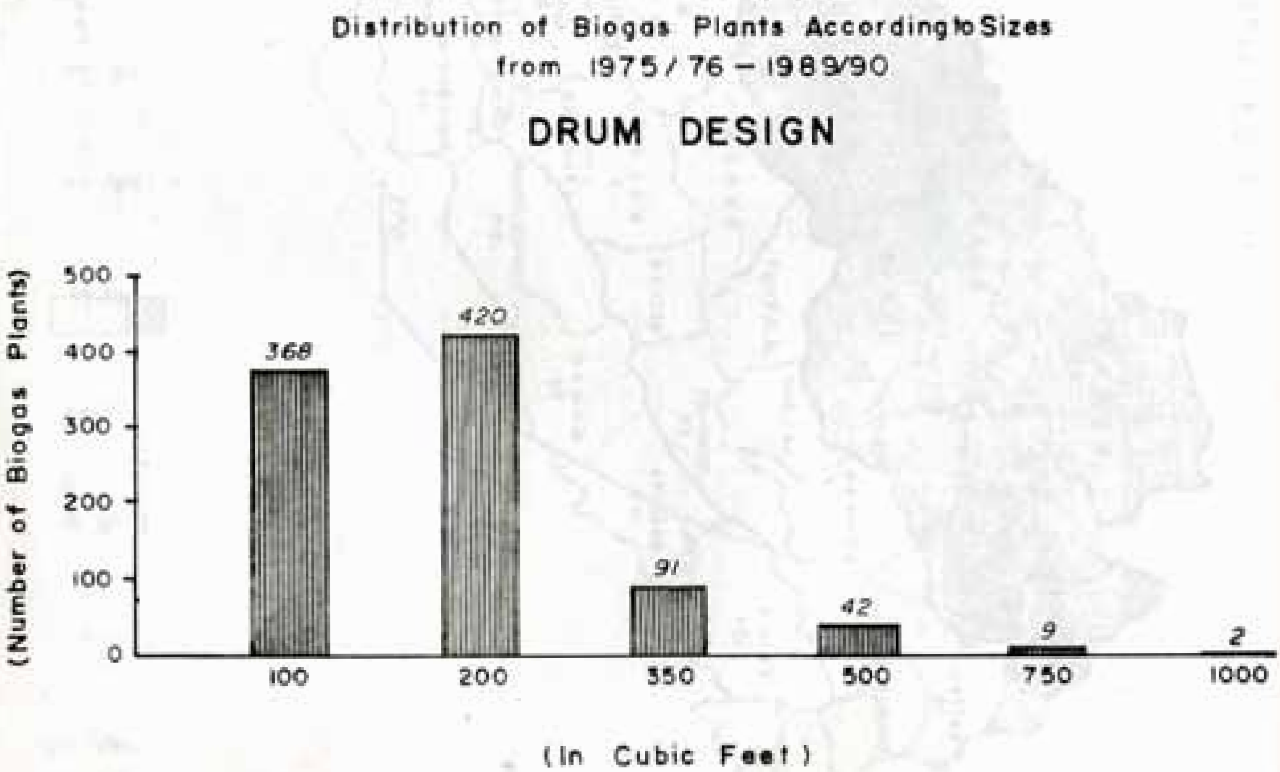
Figure 5.





Source: Biogas Company, Kathmandu, Nepal

In the case of the floating drum design, the most popular size is 200ft^3 followed by 100ft^3. Both the 10m^3 of the dome type and the 200ft^3 size of the drum type require four to six head of cattle for operation and to meet the cooking needs of a household with seven to nine members.

The Biogas Company has also promoted the attachment of latrines to the biogas plant. In Siswa and Lekhnath villages of Kaski District, a total of 195 biogas plants were established, out of which 142 biogas plants have latrines attached to them (see Case Study C). This has increased the production of biogas as well as manure and has become a good method of exploring the value of night soil which otherwise is mostly wasted. It has also improved the sanitation of the village.

Subsidy and Biogas Programmes for Five Years

Government Subsidy to Biogas

The first time that the Government provided subsidies to promote biogas installments was in the Agricultural Year (1974/75). The Government had granted a six per cent interest subsidy on loans to farmers from the Agricultural Development Bank for the installation of biogas plants.

Subsequently, in the year 1982/83, under the Intensive Rice Crop Development Programme in Dhanusa, Sunsari, Rupendehi, and Banke districts, the Government provided a grant of Rs 5,500 per biogas plant. A total of 82 plants were established in those four districts with a government subsidy of Rs 4,51,000. Altogether, the Biogas Company installed 281 plants during that year.

Later, in the Seventh Five Year Plan, the Government made a serious policy commitment to encourage the installation of biogas plants in the country by setting an ambitious target of 4,000 plants, and by providing a subsidy of 25 per cent in the construction cost and 50 per cent interest subsidy on the loans from the ADB. However, the Government actually implemented this policy from the fourth year of the plan only and continued only until the end of Seventh Plan period. Although the subsidy was given only in the last two years of the Seventh Five Year Plan, the Biogas Company was able to almost meet the target (3862 plants were installed). The Government provided about 13.43 million rupees as subsidy on construction cost and 7.5 per cent interest subsidy on the bank loans. At the same time the Government, through the Water and Energy Commission, provided a grant of about 1.7 million rupees to the Biogas Company for research and training.

In view of the success of the biogas programme, and considering the need for the protection of forest resources as well as for reduction in the import of petroleum products, His Majesty's Government had agreed to provide a 50 per cent subsidy on the construction cost of biogas plants to promote the biogas programme. But, in 1990/91, the new interim government withdrew all subsidies on biogas. This change in its policy has brought about a big setback in the promotion of biogas and also has abrogated the trust of the people who were assured of the interest subsidy on their previous loans for biogas.

Cost and Benefit Estimation of the Biogas Programme over Five Years

The Biogas Company has estimated the total subsidy needed for the biogas programme, for a period of five years for the construction of 25,000 plants in the country, under two assumptions.

Assumptions:

(A) 25% subsidy on capital cost and
50% subsidy on bank interest rate

(B) 50% subsidy on capital cost only

It is also assumed that 50 per cent of the plants would be of 10m³ or of a lower capacity and 50 per cent would be of 15m³ or of a higher capacity. For estimation purposes, only two sizes i.e., 10m³ and 15m³ are taken into account.

Sizes or Capacity (m³)	Per Unit Capital Cost (Rs)	Subsidy/per plant (Rs)			
		A			B
		25% of Capital	50% Interest Subsidy (7.5%)	Total	50% of Capital cost
10	20132	5033	4527	9560	10066
15	25961	6490	5841	12331	12980

Source: Biogas Company, Kathmandu, Nepal

Table 3 shows that the installation of 25,000 biogas plants over a period of five years would require a government subsidy of Rs 273.6 million under assumption A and Rs 288 million under assumption B.

Table 4 presents the net additional plant nutrients and their values from the biogas slurry over the pure dung. Here it is assumed that all the dung is applied to the field as farmyard manure. The total additional plant nutrients in the form of Nitrogen (N), Phosphorous (P), and Potash (K) are 32,175 tons, 24,862 tons, and 8,775 tons respectively over a period of five years. The net value of all these nutrients comes to about Rs 628 million.

Table 5 presents the net additional plant nutrients in the Biogas slurry and their values under the assumption that all the dung will be converted into dung cakes for cooking and will lose all its nutrients, apart from some potash. In this table the full nutrients, both nitrogen and phosphorous, are considered to be additional benefits, apart from the potash, and their values are estimated.

Table 3: Projection of Biogas Plant Installation and Subsidies' Estimation for Five Years

(in million Rupees)

Years	10 Cubic Metres					15 Cubic Metres					Grand Total A's (5+10)	Grand Total of B's (6+11)
	No.	A			B	No.	A			B		
		25% Capital	50% Interest	Total (3+4)	50% Capital		25% Capital	50% Interest	Total (8+9)	50% Capital		
1	2	3	4	5	6	7	8	9	10	11	12	13
1	1500	7.5	6.8	14.3	15.1	1500	9.7	8.8	18.5	19.5	32.8	34.6
2	2000	10.1	9.1	19.2	20.1	2000	13.0	11.7	24.7	26.0	43.9	46.1
3	2500	12.6	11.3	23.9	25.2	2500	16.2	14.6	30.8	32.4	54.7	57.6
4	3000	15.1	13.6	28.7	30.2	3000	19.5	17.5	37.0	38.9	65.7	69.1
5	3500	17.6	15.8	33.4	35.2	3500	22.7	20.4	43.1	45.4	76.6	80.6
Total	12500	62.9	56.6	119.5	125.8	12500	81.1	73.0	154.1	162.2	273.6	288.0

Source: Calculated by the authors.

Table 4: Biogas Enriched Nutrients' Slurry and their Values

Years	No. of Biogas Plants	Annual Dung Need Cumul-ative Amount ('000 ton)	Animal Dung			Biogas Slurry			Addition Nutrients			Values of Nutrients (million Rs)			Total Value of Nutrients (million Rs)
			N	P (Tons)	K	N	P (Tons)	K	N	P (Tons)	K	N	P (Tons)	K	
1	3000	135	675	337.5	675	2160	1485	1080	1485	1147.5	405	15.86	12.25	0.89	29.0
2	4000	315	1575	787.5	1575	5040	3465	2520	3465	2677.5	945	37.00	28.60	2.07	67.67
3	5000	540	2700	1350	2700	8640	5940	4320	5940	4590	1620	63.44	49.02	3.55	116.01
4	6000	810	4050	2025	4050	12960	8919	6480	8910	6885	2430	95.16	73.53	5.32	174.01
5	7000	1125	5625	2812.5	5625	18000	12375	9000	12375	9562.5	3375	132.16	102.13	7.39	241.68
Total	25000	2925	14625	7312.5	14625	468000	32175	23400	32175	24862.5	8775	343.62	265.53	19.22	628.37

Source: Calculated by the authors.

Dung Requirement : 10 Cubic Metre Plant = 18 tons/year
15 Cubic Metre Plant = 27 tons/year

Nutrients :

	Dung (in per cent)	Biogas Slurry
N	0.5	1.6
P	0.25	1.1
K	0.5	0.8

Price : N Rs. 10680/ton
P Rs. 10680/ton
K Rs. 2190/ton

Table 5: Total Nutrients and Values of Biogas Slurry Except Potash

Year	No. of Plants	Total Nutrients of Biogas Slurry N (in metric tons)	P	Value in Rupees N (in million rupees)	P	Total
1	3000	2160	1484	23.07	15.86	38.93
2	4000	5040	3465	53.83	37.00	90.83
3	5000	8640	5940	92.27	63.44	155.71
4	6000	12960	8910	138.41	95.16	233.57
5	7000	18000	12375	192.24	132.16	324.40
Total	25000	46800	32174	499.82	343.62	843.44

Source: Calculated by the authors.

The total additional plant nutrients in the form of N and P are estimated to be 46,800 tons and 32,174 tons respectively over a period of five years with a value of Rs 843 million.

Table 6 presents the estimation of total biogas production under optimum conditions and subsequently the total fuelwood saved in cooking due to substitution of fuelwood with biogas. The value of the fuelwood is then estimated. The total amount of biogas produced over five years from 25 thousand biogas plants would be about 70 million cubic metres of methane gas (equivalent to 0.25 million metric tons of fuelwood), worth Rs 241.4 million.

Table 7 presents the estimation of total value from the replaced fuelwood and additional plant nutrients. The total value of the fuelwood + (slurry - dung) comes to about 870.8 million rupees while the total value of fuelwood + (slurry - potash), comes to about 1,084.8 million rupees.

Table 6: Expected Production of the Biogas, the Amount of Fuelwood Saving and their Values

Year	10 Cubic Metre			15 Cubic Metre			Grand	Fuel Wood	Fuel Wood
	No.	Per Unit Optimum Gas Production Annually m^3	Total Gas Production ('000 m^3)	No.	Per Unit Optimum Gas Production Annually m^3	Total Gas Production ('000 m^3)	Total of Gas Production ('000m^3)	Saved (Tons)	Values (million Rs)
1	1500	892.0	1338	1500	1402	2103	3441	11940	11.3
2	2000	892.0	3122	2000	1402	4907	8029	27860	26.8
3	2500	892.0	5352	2500	1402	8412	13764	47761	45.4
4	3000	892.0	8028	3000	1402	11917	19945	69209	65.7
5	3500	892.0	11150	3500	1402	16824	27974	97070	92.2
Total	12500		28990	12500		44163	70153	253840	241.4

Source: Calculated by the authors.

Note: One cubic metre of biogas = 3.47 kg of fuelwood
Fuelwood Price is Rs 950/ton

Table 7: Estimation of Total Value from Replaced Fuelwood and Additional Plant Nutrients

Years	No. of Plants	Fuelwood Values in million (Rs)	Nutrient Values		Total Values (million Rs)	
			Slurry-Dung million (Rs)	Slurry - K million (Rs)		
1	2	3	4	5	6=(3+4)	7=(3+5)
1	3000	11.3	29.0	38.9	40.3	50.2
2	4000	26.8	67.0	90.8	94.5	117.6
3	5000	45.4	116.0	155.7	161.4	201.1
4	6000	65.7	174.0	233.6	239.7	299.3
5	7000	92.2	241.7	324.4	334.9	416.6
Total	25000	241.4	628.4	843.4	843.4	1084.8

Source: Calculated by the authors.

Table 8 presents the benefits of the biogas programme after deducting the government subsidy. The difference between government subsidies under situations A and B (see page 9) is not much. The benefit of the biogas programme for five years comes to about 800 million rupees after deducting the government subsidy. The total benefit comes to three times the total government subsidy. The lifespan of a biogas plant is about 25 years. With an annual net benefit of 800 million rupees a year, the total projected benefits over 25 years would be about 20 billion rupees.

Table 8: Net Benefit of the Biogas Programme
(in million Rs)

	Total Benefit	Government Subsidy		Net Benefit Difference	
		A	B	A	B
1	50.2	32.8	34.6	17.4	5.6
2	117.6	43.8	46.1	73.8	1.5
3	201.1	54.7	57.6	146.4	143.5
4	299.3	65.7	69.1	233.6	230.2
5	416.6	76.6	80.7	340.0	335.9
Total	1084.8	273.6	288.1	811.2	796.7

Source: Calculated by the authors.

Table 9 presents examples of government grants and subsidies. The transport subsidies for fertiliser amounts 300 million rupees for 1990/91. The biogas subsidy requirement is about 25 million rupees for that year. This means that approximately one-twelfth of the government subsidy on fertiliser would have contributed a continuous stream of benefits to the economy for several years.

Table 9. Examples of Government Grants and Subsidies in 1990/91

Items	Amount (in million Rs)
Transport Subsidy on Fertiliser	300.0
Transport Subsidy on Foodgrains	50.0
Petroleum Exploration	93.5
Natural Gas Exploration	3.3
Rural Energy Development through ADB/N	2.0
Community Forestry Programme	116.4
Biogas (a) Actual	0.0
(b) Requirement (50% subsidy on capital cost for 2,200 plants and the training cost)	25.0

Source: Ministry of Finance, HMG, 2047.

The analysis presented above provides strong and convincing arguments for government subsidies of up to 50 per cent of the total capital cost of biogas installations. This would provide a substantial incentive to farmers to install biogas plants because their own initial costs and the amount loaned from the banks would only be about half of the normal costs. At the household level, the cost-benefit analysis of a 10m3 biogas plant indicates that biogas technology is economically viable (see Appendix Tables 1-4) even without subsidy. However, a subsidy would make the proposition of installment very attractive to farmers.

In spite of the positive Net Present Value and 1.38 B/C ratio of biogas investments, there are no immediate cash returns from biogas investment, compared to investments in livestock (milch animals) and other components, for example. There is, however, indirect income generation. The time saved from fuelwood collection, and the burning of cattle dung for cooking do not need cash investments, and therefore, farmers with scarce resources are reluctant to invest in biogas. Besides, rural people have many other priorities to be met. Such national and social benefit programmes receive impetus only when sufficient government interventions are made, either through subsidies or cost reduction.

Subsidies to Biogas in India

The Central Government of India provides a subsidy of approximately 25 to 35 per cent on the cost of plant installation for general category users and 45 to 56 per cent for weaker sections of the community.

In addition to the Central Government's subsidies, the State Governments also make further subsidies available bringing the subsidy on biogas installation up to 70 or 75 per cent. The strong political commitment shown, through the granting of subsidies, has resulted in a substantial number of biogas installations in India. During the Seventh Five Year Plan period (1985-90) biogas installations exceeded the targets set for each year (see Table 10). The Government has set an ambitious target of installing 12 million biogas plants at an annual rate of 800,000, by the year 2001 A.D.

Table 10. Biogas Installation Targets and Achievements in India

Year	Target of Biogas Plants	Achievements
1985-86	1,50,000	1,90,222
1986-87	1,50,000	2,00,833
1987-88	1,20,000	1,73,659
1988-89	1,50,000	1,67,124
1989-90	1,60,000	1,60,000 (expected)

Source: Khandelwal, 1990.

Why Give Subsidies to Medium and Large Farmers?

Often it is argued that only well-to-do farmers can install biogas because they have the required number of cattle to start a biogas plant and so government subsidies go to the rich. This argument could also be used for fertiliser and other commodities that are subsidised. What one should consider here is that biogas has many advantages. It promotes the stall-feeding of cattle, reduces fuelwood requirements by replacing fuelwood in the cooking process, thus decreasing pressure on the forests, adds more plant nutrients to the soil, and improves sanitation by promoting the construction of latrines which can be attached to biogas plants. Thus, the overall benefits to the economy are much more than those accruing from other types of subsidy, from which the benefits are only short-term (for example fertiliser). The environmental impact of this programme is positive, because biogas slurry provides organic manure which helps to improve the texture as well as the structure of the soil, whereas inorganic fertiliser has negative environmental consequences along with bringing about a decline in soil quality.

Employment Generation through Biogas

The other tangible benefit of biogas installation is the creation of employment through this programme. Table 11 indicates that, for the installation of 25,000 biogas plants, the amount of unskilled and semi-skilled labouring time required would be about 1.44 million mandays in five years. The value of these mandays is approximately 50 million rupees. In addition about 1,000 skilled technicians would be needed on a full time basis anually.

Table 11. Employment Estimates of Biogas Programme

Years	10 Cubic metres			15 cubic metres			Grand Total of Labour	Values ('000 Rs)
	No.	Labour Need Per Plant	Total Labour Need	No.	Labour Need Per Plant	Total Labour Need		
1	1500	45	67500	1500	70	105000	172500	6.04
2	2000	45	90000	2000	70	140000	230000	8.05
3	2500	45	112500	2500	70	175000	287500	102.22
4	3000	45	135000	3000	70	210000	345000	120.75
5	3500	45	157500	3500	70	245000	402500	140.87
		12500	562500	12500		875000	1437500	503.12

Source : Calculated by the authors.
Note: Labour rate - Rs 35/man

Operational Mechanism for Implementation of the Biogas Programme

After the establishment of a Biogas Company in 1977, the biogas programme was organised more systematically with assistance from the ADB/N. Over 13 years, the company established a reasonable infrastructure within which to promote the biogas programme throughout the country. The company is the sole agency conducting extension and training activities for the biogas programme. The overhead costs of the Biogas Company have thus increased, and this increase is being borne by the farmers, making biogas installations more expensive.

Realising the high overhead cost, the Biogas Company planned to reduce the number of regular staff engaged in construction. Biogas plant construction, being a seasonal activity, is carried out only during six months of the year. Therefore, in 1985, the company launched a local masons' training programme with 30 participants for two months. The programme covered the construction and maintenance of biogas plants, and those receiving this training were placed on contract by the company to install biogas, but not kept as regular employees. They also acted as extension workers to motivate potential buyers in their localities. These local masons also helped in the maintenance and operation of biogas plants, carrying a six to seven year company guarantee.

The company has now adopted a policy of privatisation; this means that the construction and maintenance of biogas will be contracted out to private firms and individuals. These individuals are given the necessary training by the company. This means that the direct involvement of the company will be in the construction of larger biogas plants (more than $15m^3$) and the smaller ones will be contracted out to private firms. The company will provide supervision and monitoring to ensure that biogas plants are installed properly.

The Biogas Company expects to remain the lead agency in the development and dissemination of biogas in the country, by providing support to private individuals and firms engaged in the promotion of biogas. It plans to enlarge its activities in research and development to reduce the cost of plants and find alternative uses for biogas and slurry. The feasibility of producing electricity from biogas slurry is being examined as well as the use of slurry for animal feed. Thus, given a government favourable policy, the combined efforts of private sector, the Biogas Company, the Agricultural Development Bank, and the United Mission to Nepal could contribute significantly to the development of biogas in Nepal.

Problems and Prospects: Issues for Discussion

1. The Government does not have a consistent policy for the promotion of biogas to meet energy needs. This is reflected in the ad hoc nature of its subsidy policy. Therefore, it is now high time that the Government made a firm policy commitment in this area, in particular, and towards the development of renewable energy resources, in general.

2. There is no specific department or ministry responsible for promoting the development of renewable energy resources. At present, several departments and ministries are engaged in promoting different energy technologies but their efforts are not coordinated rendering it hard to identify one institution to plan and implement renewable energy policies. Since activities are uncoordinated and isolated, there is no systematic future plan or direction. It is important to make a specific department in the government responsible for the development of renewable energy resources.

3. The initial installation cost of existing biogas designs is high and beyond the reach of the majority of rural families in Nepal. Research into more cost-effective designs is essential if biogas is to be accessible for poor households as well.

4. Low gas production during the winter months, particularly in the colder hilly regions, has been a constraint to the promotion of biogas in the hills and mountains. Research is needed into methods of maintaining higher temperatures in the digester pit, so that optimum gas production can be ensured throughout the year.

5. There is very little publicity, particularly of the audio-visual kind, and a better extension and dissemination programme is essential.

6. There is an insufficiency of trained manpower to build, supervise, and repair biogas digesters. Training at different levels is essential.

7. Construction materials such as cement, G.I. Pipes, biogas lamps, and other appliances are unavailable in some parts of the country. They are also difficult to transport to the remote hilly areas. Transportation subsidies will be necessary if biogas plant installation in inaccessible areas

is to be promoted. Here again, a definite government policy is needed to assess the amount of subsidy required.

8. Community biogas plant construction has not been successful in many places, but why it failed is unknown. Can such community biogas plants be promoted to enable poor householders, who cannot afford and maintain a small plant, to derive the benefits?

9. The Agricultural Development Bank has already taken a lead in the promotion of biogas. Other commercial banks should be encouraged to participate in the promotion of renewable energy resources.

CASE A: A Popular Family Biogas Plant in Chitwan

In 1989, Ram Prasad Kafle, a resident of Swauli Bazaar in Bharatpur Municipality installed a $10m^3$ fixed dome design biogas plant with the technical assistance from the Biogas Company and financing from the ADB/N. He also received a 25 per cent subsidy on the capital investment through the ADB/N, and was assured of 50 per cent interest subsidies (7.5%) over several installments of credit repayment from six to seven years. But, because of the sudden withdrawal of interest by the Government in 1990/91 he did not receive the interest subsidy this year. Naturally, he was angry about the ad hoc manner in which the government policy was changed. Frequent changes in government policy are unlikely to instil confidence in the Government on the part of small farmers.

Mr. Kafle has seven members in his family and owns two buffaloes, including one in lactation. Prior to the establishment of the biogas plant, he used fuelwood for cooking and electricity for lighting. He used to buy fuelwood from street vendors, who collected firewood from the nearby forests. He estimated that his fuelwood requirement annually was equivalent to two full-grown sal wood trees. The nearby forest, as the time passed receded farther and farther away.

Mr. Kafle puts about 30kg of dung into the biogas digester every day. He has stall-fed his buffaloes so as not to lose the dung. He strongly recommends biogas plant owners to stall-feed their animals which could help them operate a biogas plant even with few animal heads.

Mr. Kafle has also attached a latrine to the biogas digester pit to enhance biogas production. He is, however, hesitant to speak openly about this to many of his orthodox friends and relatives, but he is quite comfortable about discussing this with outside visitors.

After installing the biogas plant, Mr. Kafle discontinued using fuelwood for cooking. The gas produced is sufficient for cooking the family meals. The slurry is used to prepare compost with the addition of refuse from the sheds, kitchen waste, and waste matter. Organic manure production has increased on his farm and its application on the vegetable garden has shown promising results. He described his experience with caulilflower seedlings; the application of slurry had improved the crop tremendously.

A satisfied biogas plant owner, Mr. Kafle strongly recommends his other farmer friends to install biogas plants and claims that a great deal of fuelwood saving can be accomplished through biogas if this programme is spread throughout the country.

He also advocates the attachment of latrines to the digester pit. By doing so, one can save the cost of constructing soak pit and septic tank separately and enhance the production of gas as well as slurry.

CASE B: Swargadwari Biogas Plant: A Case at Higher Altitude

Swargadwari is a religious place located at an altitude of 7,500 ft (approx) in Pyuthan District. Thousands of pilgrims visit Swargadwari temple on special occasions, particularly during the full moon of Baisakh and Kartik. This temple is managed and supervised by *Mathadhish* Narmananda Giri.

With the pursuasion of the Agricultural Development Bank and the Biogas Company, a 10m³ fixed dome biogas plant was installed in *Baisakh* 2045. The full cost of installation was subsidised by the Agricultural Development Bank. Bhingari, the nearest marketing centre from Swargadwari in Pyuthan, is accessible by a dirt road from Dang, but only in the dry season. The temple of Swargadwari is located about six to seven hours walk from Bhingari. Hence, almost all the construction materials; cement, sands, and stone were carried by porters from the Bhingari area. Therefore, the cost exceeded by 40 per cent the normal cost of installation.

The *Mathadhish* of the temple manages a herd of 200 cows. The prescribed quantity of cattle dung is 60kg to be mixed with 60 litres of water daily. About 40 to 50 saints and hermits stay there during most of the year. Before the installation of the biogas plant, cooking was done by fuelwood collected from the surrounding forests.

The biogas plant has the capacity to produce (optimum) 105ft^3 daily, if everything (temperature, raw materials, and moisture) is favourable for fermentation. The gas produced from the plant is used for illumination and cooking. Four lamps were installed in the *Mathadhish's* residence, cowshed, and the student hostel. Cooking was done by gas in the kitchen of the *Mathadhish* only. Gas production has varied. In the three month winter season (from *Marg* to *Magh*) gas production varied from 57 per cent to 79 per cent of optimum capacity, despite feeding the prescribed quantity of dung. The following result was based on a one time observation, and the estimation of gas production was based on the consumption of the lamps and the cooking stove.

Daily Consumption of Biogas

Items	No.	Winter	Total cft	Summer	Total
Lamps	4	9hrs	45	12 hrs	60
Stove	1	1 hr	16	1.5 hrs	24

The temperature was recorded at different times in the day for different items (see table below). It was observed that the ambient temperature (open air) was higher than the room and pond water temperature (water is used to mix with the dung). Similarly, the slurry at the bottom has a higher temperature than the slurry on top.

Time/ Temperature °C	7.30 (a.m.)	9.30 (a.m.)	11.30 (a.m.)	1.30 (p.m.)
Room Temperature	14.0	17	17	16
Ambient Temperature	13.5	18	22	19
Pond Water Temp.	11	12	15	11
Slurry Temp.(at bottom)	17	17	17	17
Slurry Temp.(on top)	10	13.5	15.5	15

In spite of the fact that the bottom slurry has a lower than ambient temperature, gas production did not decrease substantially.

The experience of Swargadwari's biogas plant has proved that biogas plant operation at higher altitudes is possible in Nepal.

CASE C: Concentration of Biogas Plants in Sisuwa and Lekhnath

The ADB Branch Office at Gagangouda of Kaski District along with the Biogas Company conducted a campaign to install biogas plants in Sishwa and Lekhnath. Gagangouda is located on the Mugling-Pokhara Highway in the southeast of Kaski District. In the area of operation, the ADB in Gagangouda, and Sisuwa and Lekhnath Village Development Committees took the lead in the installation of plants. The community is composed of *Gurungs*, *Brahmins* and *Chetris* as well as other ethnic minorities. Most of the people from these villages rely on farming for their livelihood. The villages are accessible by road all the year round, therefore transport of biogas construction materials was easy. Sisuwa and Lekhnath villages demonstrate a successful case of biogas installation with latrine attachments. Previously, the people of these villages used a Katccha latrine or used the open field, but, with the installation of biogas plants, almost all biogas plant owners now have constructed latrines attached to biogas plants. In Sisuwa and Lekhnath, a total of 195 biogas plants were established by the end of 1990 and 142 (about 73%) biogas plants have latrines attached to them.

A residesnt of Sisuwa, *Subedar* Bal Bahadur Gurung, enthuasiastically told us that his biogas plant has not only provided gas for cooking but is also used as a local fertiliser factory. The wastes and refuge, prior to the installment of biogas plants, were simply burned, but with the installation of biogas plants, Bal Bahadur collects all the waste and refuge and adds it to the biogas slurry which ultimately decomposes, increasing manure production. He owns a $10m^3$ biogas plant which produces enough manure to supply nutrients for his one hectare plot of land. Thus, he has no need of chemical fertilisers.

The experiences of Sisuwa and Lekhnath provide us with good examples of successful efforts towards self-sustaining development with extensive and comprehensive biogas installations at the village level.

Sanitation has been improved, by attaching latrines to biogas plants, fuelwood has been replaced by biogas for cooking, and the production and quality of farm manure have increased simultaneously. Thus, Sisuwa and Lekhnath have provided a successful example for other villages to follow.

ANNEXES

Annex Table 1: Economic Evaluation of Biogas Technology
Net Discounted Benefit at r = 13%

YEAR	TOTAL REVENUE (NRs)	DISCOUNTED BENEFIT (NRs)	TOTAL COST	DISCOUNTED COST (NRs)	NET DISOUNTED BENEFIT (NRs)
1	2816	2492	5363	4746	-2254
2	2958	2316	4723	3699	-1383
3	3106	2152	4104	2844	-692
4	3261	2064	3504	2149	-85
5	3424	1858	2921	1585	273
6	3595	1727	2353	1130	597
7	3774	1604	1800	765	839
8	3962	1490	1355	510	980
9	4160	1385	1277	418	967
10	4368	1287	1209	356	931
11	4586	1195	1151	300	895
12	4815	1111	1102	254	857
13	5056	1032	1061	216	816
14	5309	959	1028	186	773
15	5574	891	1001	160	731
16	5852	828	981	139	689
17	6145	768	967	121	647
18	6452	715	957	106	909
19	6774	664	956	94	570
20	7113	832	957	83	749
Total		27370		19861	7509

Source: Pokhrel 1990.

NPV = Discounted Benefit - Discounted Cost
= 27370 - 19861 = 7509

Benefit Cost Ratio = $\frac{\text{Discounted Benefit}}{\text{Discounted Cost}}$

$= \frac{\text{Rs. } 27370}{\text{Rs. } 19861} = 1.38$

The B/C Ratio is greater than 1, hence the biogas technology is economically viable.

Annex Table 3: Total Cost for Biogas Operation and Maintenance for 10 cubic metre Capacity Plant

YEAR	OPERATING COST (NRs)	INTEREST PAYMENT (15%) (NRs)	DEPRECIATION (10%) (NRs)	TOTAL COST (NRs)
0	0	0	0	0
1	271	3055	2037	5363
2	285	2605	1833	4723
3	299	2155	1650	4104
4	314	1705	1485	3504
5	330	1255	1336	2921
6	346	805	1202	2353
7	363	355	1082	1800
8	381		974	1355
9	400		977	1277
10	420		789	1209
11	441		710	1151
12	463		639	1102
13	486		575	10
14	510		518	1028
15	535		466	1001
16	562		419	981
17	590		377	967
18	619		338	957
19	650		305	956
20	682		275	957

Source: Pokhrel 1990.

Annex Table 4: Estimated Average Capital Cost for Biogas Plant Construction fro 10 Cubic Metre Capacity Plant

YEAR	CAPITAL EXPENDITURE (NRs)	INTEREST PAYMENT (15%) (NRs)	ANNUAL DEPRECIATION (10%) (NRs)	VALUE OF CAPITAL STOCK (NRs)
0	20369	0		
1	17369	3055	2037	20369
2	14369	2605	1833	18332
3	11369	2155	1650	16499
4	8369	1705	1485	14849
5	5369	1255	1336	13364
6	2369	805	1202	12028
7	0	355	1082	18025
8			974	9742
9			877	8768
10			789	7891
11			710	7102
12			639	6392
13			575	5753
14			518	5178
15			466	4660
16			419	4194
17			377	3775
18			338	3397
19			305	3057
20			275	2751
Total		11935	17888	2476

Source: Pokhrel 1990.

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