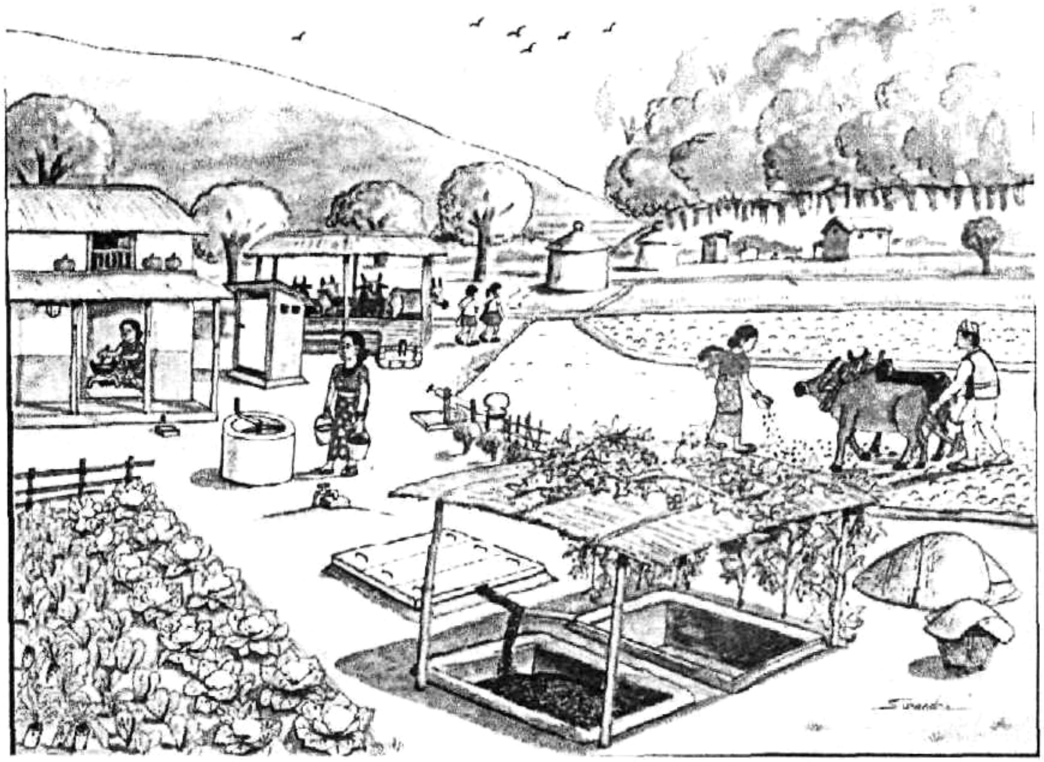
AN INTERGRATED ENVIRONMENT IMPACT ASSESSMENT



FINAL REPORT

June 2002

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PREFACE

The present study was conceived as an Integrated Environment Impact Assessment (IE1A) of BSP. The basic objective of the study was to quantify, as far as possible, the impacts of biogas programme as a whole due to the installation and use of biogas for cooking and for lighting to a certain extent.

The results of the study are intended to serve as a basis for providing recommendations for the fourth phase of BSP. The study, therefore, aimed to assess the impacts of BSP III in accordance with the Terms of References (TOR) prepared jointly by Nepalese-Netherlands team of experts.

The study was based upon the TOR, feedbacks from the Held survey, review of relevant works carried out by BSP and consultation of available documents concerning the study.

I would like to express my sincere gratitude to the members of the TOR Committee, namely Mr. D. van der Berg, Mr. P. van Ginnekcn, Dr. K. B. Karki (Local Expert), Mr. P. Laban. Mr. A. Pijpers (Chairman), Mr. A. Pradhan (Local Expert), Dr. K. Rijal (Local Expert) and Mr. A. KolhulT tor their valuable contribution in the study. Likewise, 1 acknowledge the inputs of the Study learn, which was composed of Prof. Jagan Nath Shrestha (expert in Energy and Climate Change), Dr. Amrit Bahadur Karki (expert in Health and Socio-economics) and Mr. Binod Sharma (expert in Agriculture and Sustainable Land Use) and sincerely thank them for their efforts to present (he report in this shape. Similarly, my sincere thanks are due to Dr. Jan Brouwers, NRM Sector Manager. SNV/Nepal and Mr. Felix ter Heedge, Renewable Energy Advisor of SNV/Nepal for their precious comments, cooperation and advice in this study and to Mr. Arjun Bhadra Khanal, Statistician and Mr. Netra Prasad Mainalee. Data Analyst.

I also would like to express my sincere thanks to Student Partnership Worldwide, Kathmandu particularly Mr. Mohan Parajulee, all supervisors and enumerators whose contribution in data collection and data analysis has assisted the Study Team.

Last but not the least, 1 express my sincere gratitude to the biogas and non-biogas farmers who contributed a lot by providing us the useful information in the process of data collection.

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20 June 2002

ABBREVIATION

ADB/N	-	Agricultural Development Bank of Nepal
AEPC	-	Alternative Energy Promotion Centre
Bari	-	Upland/Dryland Cultivation
BGMs	-	Biogas Households
BGL	-	Biogas Lamp
BGP	-	Biogas Plant
BGS	-	Biogas Stove
BSP	-	Biogas Support Programme
CDR	-	Central Development Region
CES	-	Centre for Energy Studies
CMS	-	Consolidated Management Services Nepal (P.) Ltd.
DDC	-	District Development Committee
EDK	-	Eastern Development Region
FAO	-	Food and Agriculture Organization of the United Nations
FYM	-	Farm Yard Manure
GHG	-	Greenhouse Gas
GWC	-	Global Warning Commitment
HHs	-	Households
HMG/N	-	His Majesty's Government of Nepal
IEIA	-	Internal Environmental Impact Assessment
IOE	-	Institute of Engineering
KfW	-	Kreditanstalt for Wiederaufau
Khet	-	Lowland under Paddy Cultivation
LPG	-	Liquified Petroleum Gas
MER	-	Netherlands Committee for EIA's
MOST	-	Ministry of Science and Technology
MWDR	-	Mid-western Development Region
N.A.	-	Not Available
NTFP	-	Non-timber Forest Products
PIC	-	Products of Incomplete Combustion
R13C	-	Reinforced Brick Concrete
RCC	-	Reinforced Cement Concrete
SEP	-	Slurry Extension Programme
SEPP	-	Slurry Extension Pilot Programme
SNV	-	Netherlands Development Organization/Nepal
TOR	-	Terms of References
TSP	-	Total Suspended Particle
UNEP	-	United Nations Environmental Development
VDC	-	Village Development Committee
WDR	-	Western Development Region
WECS	-	Water and Energy Commission Secretarial

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EXECUTIVE SUMMARY

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01. Background and Objectivity of the Study

The Government of Nepal and the Government of the Netherlands are working together in implementing the Biogas Support Programme (BSP) in Nepal. The BSP represents a working partnership between the Government of Nepal, the Netherlands Government (DGIS), the German Financial Cooperation through the German Development Bank (KfW), the Agricultural Development Bank of Nepal (ADB/N), the Netherlands Development Organization (SNV), the private biogas sector of Nepal and the farmers of Nepal, who are the ultimate beneficiaries of the programme. The Alternative Energy Promotion Centre (AEPC) is Nepal's Government Agency that promotes and coordinates all small-scale renewable energy initiatives in the country and BSP is one of the renewable energy programmes of AEPC.

The objective of BSP is to promote the wide scale use of biogas as a substitute for fuel wood, agricultural residue, animal dung and fossil fuels (kerosene/LPG) that is presently used for cooking and lighting ne eds in rural households.

The present study was conceived as an integrated environment impact assessment (IEIA) of BSP phase III (BSP III). The basic objective of the study was to quantify, as far as possible, the impacts of BSP III as a result of the installation and use of biogas for cooking and for lighting to a certain extent. The results of the study will then serve as a basis for providing recommendations for the fourth phase of BSP. The study, thus, aims to assess the impacts of BSP 111 in the following areas:

- Energy situation, particularly the energy obtained from bio-gas plants primarily for cooking and to a lesser extent for lighting;
- Environmental situation, in particular: sustainable land use, forest resources, and the contribution of the greenhouse gasses (carbon dioxide, methane, and nitrous oxide) to climate change; and
- Health and socio-economic situation of the households, including gender relations.

Present study dealing with integrated environmental impact assessment (IEIA) will be helpful to clearly understand and define the positive as well as the negative impacts of biogas technology in Nepal. Thus, the study will be useful with respect to clarifying interrelations between thematic fields; spelling out underlying causes of the impacts; offering an opportunity of balancing and prioritizing of the impacts; and contributing an opportunity of a financial-economic evaluation of the impacts.

02. Approach and Methodology

The study is based primarily on the results of an extensive households survey and is supplemented by the review of relevant literature. A total of 19 districts covering 4 development regions of the country were chosen for sampling. Out of the 19 districts, 10 districts comprise of Hills and 9 of Terai. Altogether 1,200 respondents comprising of 600 biogas households (111 Is) were selected from BSP computerized database, while the same number of non-biogas III Is (600) were sampled in the field. Out of 600 HHs, 278 HI Is (46%) were in the Terai and the rest 322 1 Ills (54%) were in the Hills.

03. Main Findings of the Study

The principal findings of the study have been presented under different sub-headings as follows:

03.1 Impact on Energy Use

1. **Number of Operational Biogas Plants:** Out of the total 600-biogas plant installed households, the biogas plants are operational in 584 HHs 997.3%) at present. In te rest 16 Hhs (2.7%), they were found to be non-operational.

2. **Reasons for Non-operation:** The reasons for non-operation are known for only 8 BGHs. Among these 8 BGHs, 5 cited appliance failure, 2 cited civil structure damage and 1 cited no feeding as the probable cause for non-operation of the BGPs.

3. **Average Biogas Stoves per Plant:** The average biogas stoves per plant in case of Terai is 1.76 and 1.23 in case of Hills. Majority of the BGHs (75.2%) in Terai have 2 biogas stoves per plant, whereas most of he BGHs (73.9%) in Hills have just a single biogas stove per plant.

4. **Average Biogas Lamps per Plant:** The average biogas lamp per plant is 0.14 for both Terai as well as the Hills.

5. **Frequency of Dung Feeding:** Majority of the total surveyed BGHs feed their plants once a day (46.5%) or twice a day (45.9%) In case of Terai most of th BGHs (51%) feed twice a day, whereas in case of the Hills the majority of the BGHs (46%) feed once a day.

6. **Quantity of available Dung:** The overall average quantity of dung available per day per BGP is 33.85 kg and the similar figures for Terai and the Hills are 41.71 kg and 27.21 kg respectively.

7. **Average Size of Biogas Plant:** the overall average size of a biogas plant is 7.12 m^3. However, the average biogas plant size in Terai is 7.85 m^3. In case of the Hills, majority of the plants are of the size of 6 m^3 (53.2%) followed by those of 8 m^3 (23.6%). But in Terai, majority of he plants are of the size of 8 m^3 (41.4%) followed by those of 6 m^3 (31.3%).

8. **Feeding Capacity of Biogas Plants:** The recommended dung feeding per day is 58.87 kg for Terai and 38.94 kg for Hills. However, the survey results indicate that the actual feeding per day is 41.71 kg in case of Terai and 27.21 kg in case of Hills, which means there is dung deficiency of 17.16 kg and 11.73 kg in case of Terai and Hills respectively. The available data, hence, indicate that the feeding percentage in case of Terai and Hills is 70.85 percent and 69.88 percent, respectively.

9. **Gas Production:** Assuming the conditions to be favourable, in case of the Terai, it can be expected that about 1680 liters of biogas is daily produced per palnt during summer and about 1180 liters during winter. Similarly, in case of the Hills it can be expected that the daily production of biogas is about 1080 liters during summer and 750 liters during winter.

10. **Gas Consumption:** The total gas consumed per plant per day for Terai varies between 1235-1385 liters in summer and betw een 1225-1335 liters in winter. The corresponding values for the Hills, however, do not vary seasonally and remain constant at around 905-1015 liters. A large portion of the gas (above 95% of total gs produced) is used in cooking purpose whereas insignificant amount of gas is consumed in lightening purpose.

11. **Excess or Deficiency of Gas Produced:** The production and consumption figures suggest that during summers, both in the Terai and the Hills, the production of biogas far exceeds the consumption rate. In case of Terai the excess production varies from 295-445 liters per day

whereas in the Hills the production exceeds from 65 - 175 liters per day. However, during winter the biogas production does not seem to be able to fulfill the consumption rate. There seems to be a deficiency of 45 - 155 liters of gas in a day in the Terai and of 155 - 265 liters per day in the Hills.

12. **Change in Use of Fuelwood:** In Terai, there has been a decrease of 3.39 kg fuel wood per household (BGH) per day in summer and 7.55 kg fuelwood per household per day in winter. The corresponding Figures for the Hills are 5.54 kg and 6.47 kg in summer and in winter respectively. At national level 490 tonnes of fuel-wood is being replaced daily at present, which is a saving of about Rs. 790,000 daily. Once the BSP III targets are achieved there would be a daily saving of 570 tonnes of fuel-wood, which at present rates would worth Rs. 920,000. Similarly, when all (he technically feasible biogas plants will be installed, these plants will le ad to the saving of 7410 tonnes of fuel-wood per day. This saving of fuel-wood is worth Rs. 11.93 million at current prices.

13. **Change in Use of Agricultural Residues as Fuel:** In Terai, there has been a decrease of agricultural residue by 2.7 kg daily per household in both seasons which is a decrease of 30 percent from the previous use pattern. Even though there is a more pronounced decrease in the Hills during summer (1.4 kg daily per household), the use of agricultural residue has shown an increase by 0.14 kg per day per household during winter.

14. **Change in Use of Dung as Fuel:** In Terai, there has been a decrease in use of dung as fuel by 20.4 liters per household per day in summer and by 2 1.5 liters in winter. This is a decrease of 77.3% and 71.7% in summer and in winter respectively. In the Hills there has been a decrease by 17.9 liters daily per household in both seasons, which is a decrease of 99.4 % from the previous use pattern.

15. **Change in Use of Kerosene:** After the introduction of biogas plants the consumption of kerosene has been reduced by 0.30 liters and 0.33 liters per day per household in Terai in summer and winter respectively. Similarly, the BGHs in the Hills have experienced a decrease by 0.36 liters per day per household in summer and 0.37 liters in winter. At national level 29,240 liters of kerosene is being replaced daily at present, which is a saving of about Rs. 550,000 daily. Once the BSP **III** targets are achieved, there would be a daily saving of 34,000 liters of kerosene, which at present rates would worth about Rs. 640,000. Similarly, when all the technically feasible biogas plants will be installed, these plants will lead to the saving of 442,000 liters of per day. This saving of kerosene is worth Rs. 8.28 million at current prices.

16. **Change in Use of LPG:** The consumption of LPG in BGHs of Terai has reduced by 1.0 cylinder per household per year in summer and by 0.9 cylinders in winter. The scenario in case of the Hills is opposite as it shows an annual increase in LPG consumption by 2 cylinders per household. However, as the households using LPG is negligible (1% overall) compared to other fuel sources, the change in consumption pattern of LPG does not have significant implications in financial saving or in Greenhouse gas emission at present.

17. **Change in Cooking** Efficiency: Prior to the installation of the biogas plants, majority of the households were dependent upon the traditional cooking stoves (96.7%) followed by the kerosene stoves (21.3%). At present, the biogas stoves have substituted the traditional stoves and the kerosene stoves to a great extent. Now only 54.2 percent households are using traditional mud stoves and only 12.8 percent are using kerosene stoves.

03.2 Impact on Health Situation

1. **Latrine Construction and Motivation:** Significant number of biogas HHs (90%) has built their own toilet compared to non-biogas HHs (60%). About 60 percent biogas HHs has

attached their toilets with BGP. 20 percent of the biogas HHs had septic tank while 29 percent of the non-biogas HHs had attached their toilet with sewerage. The percentage of self-motivated HHs to build toilet are remarkably more in non-biogas HHs (89.1%) than biogas (61.7%). Biogas companies appears to have played influencing role in building the toilet in biogas HHs, as 27.7 percent of (he IIII were motivated by its effort. Statistical analysis has revealed significant difference between the two study groups in above variables.

2. **Reduction in Kitchen Smoke:** 85 percent biogas III Is perceived a remarkable decrease in smoke after they have had the biogas plants. However, 9 percent still realised a decrease in smoke only to *some extent*, while the rest 6 percent did not observe reduction in the amount of smoke even after BGP installation. This may be attributed to the technical defects in some plants or insufficiency of gas produced.

3. **Possession of Kitchen Garden:** 76.5 percent sampled biogas HHs had kitchen garden, while in case of non-biogas HHs, the figure was 2.6 percent less than the former. The difference between two study groups is statistically insignificant.

4. **Eye Infection:** The comparative study on the presence of signs and symptoms of eye infection in biogas and non-biogas HHs indicated that the percent of respondents perceiving positive effect was 3.7 percent more in non-biogas HHs than biogas HHs, Similarly, the percentage of *increased symptomatic eye injection* for the last three years was found 11 percent higher in non-biogas than biogas group. The difference between two study groups is statistically insignificant.

5. **Respiratory Diseases:** The under examination result showed that 92 percent of biogas HH did not have any respiratory diseases, whereas the figure was 88 percent in case of non-biogas HHs. This indicates that the presence of respiratory diseases was found 4 percent more in non-adopter of biogas than the adopter. The difference is statistically-significant. Regarding the status *of decreased cough* for the last three years, the difference in the HHs with biogas was found more than 20 percent in comparison to HHs without BGP. This difference between by groups is statistically significant. This clearly reflects the positive role rendered by biogas technology in improving family's health, particularly of women who have to face the drudgery of cooking.

6. **Diarrhoeal Episodes:** In terms of diarrhoeal disease under examination, no difference was perceived between biogas HHs and non-biogas HHs, while the *'increased diarrhoea'* for the last three years in non-biogas HHs was reported to be around 15 percent higher than that of biogas HHs. However, this difference is statistically insignificant.

7. **Dysentery:** In terms of the dysentery disease under examination, the installation of BGP might be of some significance as 11 percent non-biogas HHs reported dysentery compared to 5 percent in biogas HHs. This difference is statistically significant. Regarding the status of dysentery for the last three years, the study did not reveal any significant difference between the two study groups. However, it should be noted that dysenteric episodes might not necessarily be related with biogas, it may also depend upon the general cleanliness.

8. **Tapeworm Infestation:** In case of tapeworm infestation for the last three years, the difference in the percentage of '*increased tapeworm infection"* in non-biogas HHs was found, about 11 percent more than the biogas III Is. Similarly, the percentage of biogas HHs stating *'decreased tapeworm infection'* was found 8 percent higher than non-biogas HHs. The differences are statistically insignificant.

9. **Burned Case:** None of biogas HHs reported an increase in the burned cases for the last three years, while as many as 78 percent of non-biogas HHs were exposed to this problem. Similarly, the difference in the decrease in this case in the Biogas I Ills was reported to exceed

by 22 percent compared to non-biogas HHs. Further analysis of data showed that there is a high danger of burning cases in the households without biogas plant.

10. **Safety Measure of Biogas ove r Fuelwood:** Majority of biogas Mils (95.5%) reported a very high degree of safety on the use of biogas stove after they have had the biogas plants.

11. **Mosquito Breeding:** About 70 percent of biogas HHs reported that mosquito breeding was increased as a res ult of biogas installation. The principal reasons for mosquito proliferation may be attributed to the dampness on the upper part of the outlet of biogas plant. Furthermore, if firewood is burnt inside the kitchen, the smoke produced from it drives out mosquito outside from the kitchen, while in clear illumination of biogas lamp or electric bulb, there is every risk of mosquito attack.

03.3 Impact on Agriculture and Sustainable Land Use

1. **Land Holding:** The average biogas user households possessed about 37 percent more land than the non-biogas households. Majority of the biogas households owned 0.5 to 2.0 ha. of Khet land, while most of the non-biogas households owned less than 0.5 ha. of Khet land.

2. **Major Crops:** Rice is the dominant crop in the summer, wheat in winter and pulses in the spring season. No perceptible change was observed in the cultivation of crop as a result of biogas use. More farmers in the biogas area however, seemed to cultivate rice, wheat and mustard than those in the non-biogas households. No appreciable difference in crop yields as a result of biogas plant installation was observed.

3. **Fertilizer** Use: Households in the biogas area were already using more fertilizers of all types than those in the non-biogas area. In the biogas area, uses of FYM and compost declined after the installation of the plants and the uses of liquid and composted biogas slurry increased considerably. Due to the use of bio-slurry, the use of chemical fertilizer was found reduced by about 9 percent.

4. **Yield Rate:** Plant nutrients made available through the increased availability and slurry compost together amounted to 28.9 kg of nitrogen, 27.5 kg of phosphorus, and 13.3 kg of potash per household in the biogas area. About 10 percent increase in maize yield and 18 percent increase in cabbage yield were obtained in farmer's field experimental plots with the application of digested slurry at the rates of 10 and 20 metric tons per hectare, respectively.

5. **Slurry Application:** Fanners preferred to use the slurry for the production of their crops in the following order: maize (30%), paddy (23%), wheat (16%) and vegetables (16%).

6. **Effect of Slurry:** More than 50 percent of the biogas users were not aware of the effect of slurry on the incidence of plants diseases and some 16 percent reported increased incidence of diseases. Similarly, about 6 percent farmers reported increased weed infestation in their crop as a result of the use of biogas slurry. It necessitates conducting a research in this regard.

7. **Use of Crop Residue:** Although most of the crop residues in both area as well as in the before and after situation in the biogas area were used to feed their animals, quite a considerable proportion was also used as a fuel for cooking. However, after the installation of the biogas plants, the proportion used for cooking decreased with a corresponding increase in the amount used for compost making.

8. **Cattle Holding:** On an average, biogas households already had more animals (mainly cattle and buffalos) than those in the non-biogas area. No significant change in the pattern of holding was observed after the installation of biogas plants.

9. **Cattle Feeding:** After the installation of biogas plants, the tendency of free grazing of animals appeared to decrease with a corresponding increase in partial and complete stall-feeding practices.

10. **Condition of Cattle Shed:** The condition of cattle sheds improved significantly after the installation of biogas plants. The number of respondents who reported having smooth concrete floor in their sheds increased by about 10 percent after the plant installation. Similarly, those who had constructed urine collection pits increased by about 8 percent.

11. **Fodder Collection:** While fodder collection from the forests remained about the same, collection from own production increased slightly (about 3 percent) after the installation of biogas plants.

12. **Water Consumption:** On an average, water consumption by the cattle was reported to increase by about 4 liters per day per household after the installation of biogas plants. This, agrees, in general, with the increased demand done to the increased tendency to stall feed the cattle in the after biogas situation.

13. **Milk Production:** Slightly greater quantity of milk production per household per day was reported in the biogas households than in the non-biogas households, but no change was detected between the before and after situation in the biogas households.

14. **Fuelwood Consumption:** After the installation of the biogas plants, daily consumption of fuel wood was found to be reduced by more than 50 percent. The equivalent forest area protected by this amounts to about 36.680 hectares in the Hills and 59,734 hectares in the Terai**.**

15. **Fuelwood Collection:** Most of the households had the habit of collecting large dry branches as well as small dry twigs of trees along with the leaves from the forest floor for fuelwood. The collection of large branches reduced sharply after the installation of biogas plants. The collection of other types of wood use for fuel also reduced significantly.

16. **NTFP Collection:** About 50 percent of the communities interviewed reported increased collection of non-timber forest products (N1TP) and 15 to 21 percent reported decreased collection. Due to the complicated nature of the factors involved, the communities could not relate the increase or decrease to the use of biogas.

17. **Encroachment of Forest:** 61 percent of the respondents at the community level reported decreasing trend of encroachment of agriculture into the forestland. The use of biogas was seen as an important factor among others, responsible for this tendency.

18. **Types of Cultivated Land:** Khet[1] land cultivation type is found to have increased both in the Hills and in the Terai. But, whereas the increase in the Hills has occurred through the conversion of the Bari[2] land, similar increases in the Terai have occurred mainly at the expense of the forest lands.

03.4 Impact on Climate Change

1. **Carbon Emission Saved from the Reduction of Fuelwood: In** case of Terai, there has been a reduction of 1419 g -C and 3160 g -C equivalent of Carbon emission per day per household in summer and in winter respectively. Similarly, in case of the Hills there has been a reduction

[1] Khet means wetland for paddy cultivation
[2] Bari means upland/dry land cultivation

of 2319 g -C and 2708 g -C equivalent of Carbon emission per day per household in summer and in winter respectively.

2. **Carbon Emission Saved from the Reduction of Use of Agricultural Residues as Fuel:** In Terai, there has been a reduction of 1398 g-C equivalent of Carbon per day per household in both seasons. Similarly, in the Hills during summer there has been a reduction of 725 g -C equivalent of Carbon per day per household. However, during winters the Hills experience an increase in Carbon emission from agricultural residues by 207 g-C equivalent of Carbon per day per household.

3. **Carbon Emission Saved from the Reduction of Use of Dung as Fuel:** In Terai there has been a reduction of 6818 and 7186 g -C equivalent of Carbon per day per household during summer and winter respectively. Similarly, in the Hills there has been a reduction of 5982 g - C equivalent of Carbon per day per household in both seasons.

4. **Carbon Emission Saved from the Reduction of Kerosene:** In Terai, there has been a reduction of 253 and 278 g *~C* equivalent of Carbon per day per household during summer and winter respectively Similarly, the Hills have experienced a reduction of 304 and 312 g -C equivalent of Carbon per day per household in summer and in winter respectively.

5. **Carbon Dioxide Emission Reduction at National Level:** At present 738 million-gram equivalent of Carbon dioxide emission is being reduced everyday at the national level due to the replacement of conventional fuels by the biogas plants. Once the BSP III targets are achieved, the biogas plants have a potential of saving about 859 million-gram equivalent of Carbon dioxide emission per day. Similarly, when all the technically feasible biogas plants will be installed, these plants will lead to the daily saving of 11,170 million-gram equivalent of Carbon dioxide emission.

03.5 Impact on Socio-Economic Conditions

1. **Ethnicity of the Biogas HHs:** Among the sampled biogas households, there was the dominance of Brahmin and Chhetri compared to other ethnic groups. The combined percentage of Brahmin (53.2%) and Chhetri (17.8%) comprised of 71 percent in the sampled **biogas HHs.**

2. **Average Family Size and Sex of Household Head:** Average size of biogas family is found slightly larger than that of non-users. In case of sampled biogas HHs, males HHs owned 91 percent plants, while only 9 percent females had their ownership. In case of non-biogas sampled HHs, the percentage of female-headed households was found slightly higher (i.e. 14% more) than the biogas HHs.

3. **Occupation and Education Level of the Household Head:** Agriculture was found to be the main occupation of the sampled households followed by service, business and industry. 78.4 percent of biogas household head has practiced agriculture, while the figure was about 6.0 percent lower (72.5%) in case of non-users of biogas. The household head undertaking business was 5.6 percent more in case of non-users HHs (10.0%) than the users HHs (4.4%). The illiterate household head was 4.2 percent higher (20.6%) in case of non-biogas HHs than biogas HHs (16.2%). As regards literacy percentage (both with or without formal education), the same difference was found between biogas and non-biogas households indicating that percentage of the former is 4.4 percent higher than the latter.

4. **Cattle Population and Land Holding:** On an average Biogas HHs own more cattle, buffalo and goats/sheep than Non-biogas HHs. There seems a decreasing trend of livestock after plant installation. Similarly, biogas HHs owned more land than the non-biogas ones. The average Biogas HHs in the hills is a medium farmer, while it is small farmer in case of non- biogas Mils. The biogas HHs in Terai is rated as small farmer whereas it is only the marginal farmer

in case of non-biogas HHs. It seems clear that the biogas III is one step forward compared to Non-biogas HHs so far as possession of landholding is concerned.

5. **Income of the Biogas Household:** The average annual income of biogas households from different source ranges from Ks 77,000 to Ks 86,000. which is fairly higher than the average national household income of the country (around Ks 42,000).

6. **Types of Houses:** The percentage of thatched roof possessed by non-biogas HHs to more than 6 percent compared to biogas households. The difference is statistically significant. In case of corrugated and tile/slated roof, it was almost equal in both the cases. The biogas HHs possessed 4 per cent more RCC/RBC roof than non-users of biogas indicating insignificant difference between the two study groups. It appears that biogas HHs seem slightly well off compared to non-biogas HHs so far as improved type of houses are concerned.

7. **Access to Electricity:** 71 percent of biogas lilts had access to electricity in their houses compared to 67.4 percent in case of non-biogas HHs. However, the difference is statistically insignificant.

8. **Means of Media Available at Home:** 3.2 percent of biogas HHs did not possess any means of media, while the figure in case of non-biogas Mils was 23.3 percent. This difference is statistically significant. With regard to the possession of TV, a significant difference was observed between biogas and non-biogas users. On the other hand, non-biogas HHs were found to possess significantly higher percentage of radio than biogas HHs. The percentage of biogas HHs owning both TV and radio was found to be 41.5 percent, while the figure was negligible (0.2%) in case of non-biogas HHs.

9. **Means of Transportation Available at Home:** Regarding means of transport, 57.7 percent of biogas HHs and 60.8 percent of non-biogas III is did not possess any means of transportation. Bicycle was found to be main means of transport for both biogas and non-biogas HHs, which they possessed almost in equal percentage. Biogas III is had 3.2 percent more motorcycle (4.5%) than non-biogas HHs (1.3%). This difference is statistically significant. Only a few percent of the sampled HHs possessed tractor.

10. **Person Generally Feeding the Plants:** Amongst the persons generally feeding the plant, male head's share amounts to 22.4 percent and female head almost double than male (44.7%). Specifically, the contribution of adult women oilier than female HHs head of the household (e.g. daughter-in-law) to is 18.7 percent. If we combine the work of female (female head, other adult women and daughter), we can conclude that in biogas HHs, females' contribution amounts to about two-thirds compared to male members so far as responsibility of feeding the digester is concerned. The servant has to play some role in this matter (6.2%) whereas the contribution of the daughter and the son is negligible.

11. **Utilization of Saved Time After UGP Installation:** About 46 percent of the biogas HHs used the time saved as a result of biogas installation in productive purposes. 37 percent spent their saved time in entertainment and 13 percent engaging themselves in social services. Only 3 percent utilized the saved time in adult education. They pointed out that they utilized the saved lime by taking rest, cleaning their house, regularizing household affairs and taking care of the children.

03.6 Recommendations

Following recommendations have been derived from the study. It is recommended to implement them during the Fourth phase of BSP that starts in 2003.

1. It is recommended to determine the nutrient contents of different forms of bio-slurry (i.e., digested slurry, slurry compost, etc.) with appropriate sample collection and standard analytical methods.

2. The responses of crops to the application of different forms of slurry should be determined by systematic field trials with adequate number of replications.

3. The exact cause for the increase of mosquito population due to introduction of biogas should be investigated with necessary solution for the control of mosquito.

4. Appropriate research should be carried on health and hygienic aspects of latrine-attached biogas plants by conducting pathogenic test on fresh and digested shiny as well as slurry compost.

5. Improvement in diseases as a result of biogas introduction may not necessarily be related to biogas but it may depend upon several factors associated with health improvement. Therefore, while designing research in this area, it is recommended to take such factors into consideration.

6. A comparative study between the users and non-users of biogas should be done to determine the economic differences in their annual income.

7. It is recommended to carry out regular study to assess the role of gender in biogas related activities such as women's role in decision-making, their participation in management etc.

8. It is recommended to carry out a direct measurement of the fuels used in certain sampled HHs using standard measuring units. In order to obtain seasonal and regional variations, these observations should be carried out in both summer and winter and in both Terai and the Hills.

9. To assess the accurate figures for CO2, CH_4 and NO_2 emission reduction and also for detecting methane leakage from the biogas plants, it is recommended to carry out a direct, measurement for these emissions using appropriate effective measuring equipment.

CHAPTER I
INTRODUCTION

CHAPTER I
INTRODUCTION

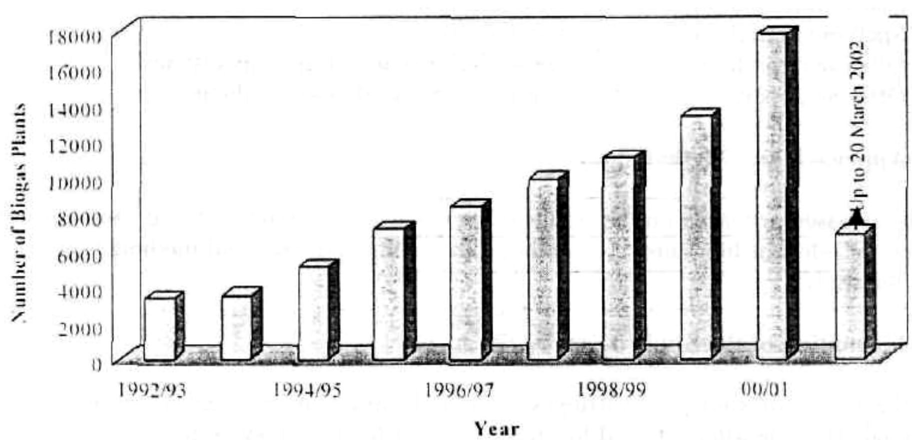
1.1 Background

The Government of Nepal and the Government of the Netherlands are working together in implementing the Biogas Support Programme (BSP) in Nepal. The BSP represents a working partnership between the Government of Nepal, the Netherlands Government (DGIS), the German Financial Cooperation through the German Development Bank (KfW), the Agricultural Development Bank of Nepal (ADB/N), the Netherlands Development Organization (SNV), the private biogas sector of Nepal and the farmers of Nepal, who are the ultimate beneficiaries of the programme. The Alternative Energy Promotion Centre (AEPC) is Nepal's Government Agency that promotes and coordinates all small-scale renewable energy initiatives in the country and BSP is one of the renewable energy programmes of AEPC.

The objective of BSP is to promote the wide scale use of biogas as a substitute for fuel wood. agricultural residues, animal dung and fossil fuels (kerosene/LPG) that is presently used for cooking and lighting needs in rural households.

The BSP started in July 1992 with the first phase. Presently, implementation of the third phase 1997 - 2002 is carried out and construction of 50,000 biogas plants was celebrated on November 1, 2000[1]. It is worth nothing that by 20 May 2002, a total of 86,400 plants, have been installed in 65 districts of the country (.see Figure 1.1). Out of these 86,400 plants, 38,570 (44.67%) were installed in Terai and the rest 47.830 (55.4%) in accessible hills and remote hills. The fourth phase of BSP will start in 2003.

Figure 1.1 Installation of Biogas Plant in Nepal under BSP Programme from 1992/93 to May 20, 2002



Internal as well as .external missions have executed a number of evaluations of BSP so far. The conclusions of these evaluations are rather positive. The biogas plants provide several benefits to the household, the settlement and the nation, such as: improvement of the health situation of women and decline in physical workload of women. A potential negative impact might be the leakage of methane, which is one of the greenhouse gases.
Ministry of Science and Technology (MOST) and SNV were of the opinion that it is required to

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[1] Mrs. Kapai Devi Tharuni of Khanar VDC. Ward No. 4 of Sunsari district, was awarded a prize (for being the 50.000th biogas plant owner) by the late Crown Prince Dipendra Bir Bikram Shah Dev on 1 November 2000 amid a special function (BNRM. No. 67 October-December 2000).

quantify as far as possible and substantiate the impacts of BSP through executing an integrated environmental impact assessment (IEIA). Therefore, the independent Netherlands Commission for Environmental Impact Assessment was requested by AEPC to draft the Terms of Reference (TOR), which formed the basis for this study (see Appendix I). A joint Nepalese-Netherlands working group of the Commission was requested to prepare an advice for TOR for the execution of IEIA. The composition of the members of TOR Committee as well as the Study Team is given in Appendix II. It is planned to use the results of the IEIA as an important input for the evaluation study of BSP's Phase IV.

1.2 Objective and Scope

The present study was conceived as an integrated environment impact assessment (IEIA) of BSP phase III (BSP III). The basic objective of the study is to quantify, as far as possible, the impacts of BSP III as a result of the installation and use of biogas for cooking and for lighting to a certain extent.

The results of the study will then serve as a basis for providing recommendations for the fourth phase of BSP. The study aims to assess the impacts of DSP III in the following areas:

- Energy situation, particularly the energy obtained from biogas plants primarily for cooking and to a lesser extent for lighting;
- Environmental situation^ in particular: sustainable land use, forest resources and contribution/reduction of the greenhouse gasses (carbon dioxide, methane, and nitrous oxide) responsible for climate change; and
- Health and socio-economic situation of the households, including gender relations.

In fact, present study dealing with IEIA will be helpful to clearly understand and define the followings:

- Present a complete overview of the positive as well as the negative impacts;
- Clarify interrelations between thematic fields;
- Spell out underlying causes of the impacts;
- Offer an opportunity of balancing and prioritizing of the impacts; and
- Offer an opportunity of a financial-economic evaluation of the impacts.

1.3 Approach and Methodology

The study is based primarily on the results of an extensive households survey and is supplemented by the review of relevant literature. Accordingly, following approach and methodology were adopted to conduct the study. .

1.3.1 Formation of the Study Team

As per the nature of study, SNV/Biogas Support Programme engaged a multidisciplinary team of professionals (here-in-after referred to Study Team) who have done similar type of work in the past (see Appendix II). Furthermore, Student Partnership Worldwide (SPW), Kathmandu was entrusted with the responsibility of data collection from the field. Hence SWP appointed a Coordinator (Mr. Mohan Parajulee) along with 16 data collectors (enumerators) and 3 supervisors for this purpose (see Appendix III).

1.3.2 Sampling Technique

Out of the 65 biogas installed districts of Nepal, initially 16 districts were envisaged for sampling purpose. The sampling districts in Hills and Terai were chosen based on the high/low biogas penetration looking into its technical potentialities (High potential but low penetration and high potential and high penetration). As it was not possible to survey few biogas plants because of security problem, other 3 districts were added to make the total sampling districts up to 19.

VDCs were sampled from each sampled district based upon high number of plants constructed in cluster. Individual biogas household was sampled from the VDC by random sampling method depending upon the information obtained from the BSP computerized database. Non-biogas HHs was identified by the field survey team on the spot, nearest to the sampled biogas HHs taking into consideration the similarity of socio-economic conditions of biogas HHs.

Altogether 1,200 respondents comprising of 600 biogas households (HHs) and the same number of non-biogas HHs (600) were planned to be sampled in the study for carrying out the statistical analysis.

The spatial location of the sampled districts is shown in Map I, whereas Table 1.1 presents the detail of sampling of the randomly selected biogas households in accordance with Development Regions.

Table 1.1 -Sampling of Biogas Households

Development Region	Sampling District	Frequency	Percent
Eastern Development Region (EDR)	- Jhapa (T)	28	4.7
	- Dhankuta(H)	30	5.0
	- Saptari (T)	10	1.7
Subtotal of EDR		**68**	**11.4**
Central Development Region (CDR)	- Sarlahi (T)	41	6.8
	- Kavre (H)	46	7.7
	- Makawanpur (H)	44	7.3
	- Chitwan (T)	48	8.0
	- Dhading (H)	5	0.8
	- Nuwakot (H)	8	1.3
	- Kathmandu (H)	5	0.8
Subtotal of CDR		**197**	**32.7**
Western Development Region (WDR)	- Nawalparasi (T)	30	5.0
	- Tanahu (H)	39	6.5
	- Kaski(H)	46	7.7
	- Syanja(H)	55	9.2
	- Palpa(H)	44	7.3
	- Rupandehi (T)	20	
	- Kapilbastu (T)	29	4.0
Subtotal of WDR		**263**	**43.9**
Mid Western Development Region (MWDR)	- **Banke (T)**	17	2.8
	- **Damu (T)**	55	9.2
Subtotal of MWDR		**72**	**12.0**
GRAND TOTAL		**600**	**100**

H = Hills, T = Terai

It is obvious from Table I.I that out of the 19 districts chosen for sampling. 10 districts comprise of Mills and 9 of Terai. Out of the 600 sampled biogas HHs, 322 (54%) falls in the Hills and the rest 278 (46%) in the Terai indicating that percentage of sampling in Hills exceeded by 8 percent compared to Terai. Such sampling difference between Hills and Terai seems well justified as the construction record of biogas plants until May 20, 2001 indicates that in Hills, the installation is 24 percent higher than that of Terai (Sec. 1.1. Background). Above table also shows that the distribution of sample in EDR and MWDR is 1 1.4 and 12.0 percent, while it is 32.7 percent in CDR and 43.8 percent in WDR.

1.3.3 Age of the Sampled Biogas Plants

Age of the sampled biogas plants or plant construction year is given in Table 1.2

Table 1.2-Age of the Sampled Biogas Plants

S.N.	Year of Completion	Frequency	Percentage
1.	2049	1	0.2
2.	2050	2	0.3
3.	2051	28	4.7
4.	2052	29	4.8
5.	2053	53	8.8
6.	2054	104	17.3
7.	2055	92	15.3
8.	2056	117	19.5
9.	2057	165	27.5
10	2058	9	1.5
Total		**600**	**100.0**

Table 1.2 shows that above 80 percent of the sampled biogas plants were commissioned from B.S. 2054 to 2057 indicating that they were 5 to 8 years old. Realizing the life span of a biogas plants ranging between 20 to 30 years depending upon repair and maintenance, the selection of the age of the sampled plants seems well justified.

1.3.4 Tools of Data Collection

Based upon TOR and as well as relevant works carried out by BSP in the past and literature review, the working team of professionals formulated the tools for data collection. Following categories of structured questionnaires and checklists were prepared for administrating to the targeted households.

A. Questionnaire for Biogas HHs
B. Questionnaire for Non-biogas HHs
C. Checklists for Community Level

A complete set of final questionnaire and checklists (A, B and C) has been attached to this report as Appendix IV.

1.3.5 Training mid Pre-testing of Questionnaire

Guided by IEIA Consultants, the SPW conduced a three days workshop (13 to 15 June 2001) during which the field survey team was thoroughly trained and oriented towards biogas technology and data collection methodology. Prior to field mobilization, the questionnaires and checklist were pre-tested at the field based upon the feedback of (he training and were further refined and finalized. -

1.3.6 Field Survey

After necessary reorientation, the field survey enumerators (12) were divided into six groups and mobilized in the field for 45 days to accomplish the task of data collection. The three supervisors appointed by SPW closely supervised their fieldwork and SPW coordinator checked the quality of data collection and monitored the data collection activity.

The questionnaires A and B were mainly administered to the HH head his/her spouse together. With the help of community level checklists (Questionnaire C), the field survey team conducted Focus Group Discussions (FGD) with altogether 60 communities in selected VDCs. The participation of farmers, Government official, NGO representative, social worker, schoolteacher, health worker etc was sought in FGD so organized. The main theme of the discussion was focused on the impact of biogas on environmental and ecological aspects. The qualitative information thus derived from FGD has been integrated in this report wherever applicable.

1.3.7 Analysis and Interpretation of Data

All data collected from the field was processed through EPI INFO and SPSS programme by SPW staff (Mr. Netra Mainalee) for analysis. The processed data were verified by the members of the Study Team and were analyzed with help of SPSS expert.

1.3.8 General Procedures about Hypothesis Testing for Statistical Analysis[1]

Null Hypothesis (H_0): $P_1 = P_2$, that is there is no significant difference in the percentage of the components between HHs *with*- and *without* biogas plants.

Alternative Hypothesis (H_1): P_1 ? P_2 that is there is significant difference in the percentage of the components between HHs *with*- and *without* biogas plants.

Test Statistic (Z): Under null hypothesis (H_o) the test statistic is the Z-test for the difference of proportions. Accordingly,

$$Z = \frac{p_1 - p_2}{\sqrt{\hat{P} \times \hat{Q} \, (1/n_1 + 1/n_2)}} \qquad (1)$$

Where, p_1 and p_2 are the sample fraction (percentage) of the components of the variable in the HHs *with*- and *without* biogas plants respectively. Similarly, ii| and n_2 are the corresponding sample sizes, and P is the overall proportion given by the formula:

$$\hat{P} = \frac{n_1 \times p_1 + n_2 \times p_2}{n_1 + n_2} \qquad (2)$$

$$\hat{Q} = 1 - \hat{P} \qquad (3)$$

Level of Significance (a): The hypothesis testing is done at 0.05 level of significance.

Critical Value (Z_a): The computed value of Z obtained from the above formula is compared against the critical value of Z_{α}, which is 1.96 at 0.05 level of significance.

Decision: The critical value of Z at 0.05 level of significance is 1.96. Thus any value of Z that is less than 1.96 is considered as "**Not Significant (NS)"** and the value of Z that is above 1.96 is considered as **"Significant".**

In the case of NS we accept null hypothesis and conclude that the difference is not significant, that is, both groups exhibit the same character. In other words, they are identical groups.

In the case of Significant we do hot accept null hypothesis and conclude that the difference is significant, that is, both groups do not exhibit the same character. In other words, they are distinct groups.

After analysis it is found in some cases (variables) that all the components differ significantly between HHs *with*- and *without* biogas plants. In some cases, partial components are found to differ significantly leaving other insignificant (NS). Likewise, in other cases it is found that none of the

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[1] Hypothesis Testing for the difference of proportion (percentage) of the components between HHs with- and without biogas plants.

components differ significantly, i.e., there is no significant difference between HHs *with-* and *without* biogas. From the table attached herewith we can see the values of Test Statistic (Z), the decision variable computed from the above-mentioned formula.

As per the hypothesis testing for statistical analysis presented above, the data presented in Chapter IV (Impacts on the Health Situation) and Chapter VII (Impacts on Socio-economic Conditions) were subjected to statistical analysis and the outcome is presented in Appendix V.

1.4 Limitations of Study

As said earlier, data were sampled for 16 districts in the beginning but due to the prevailing security situation in the country, it was not possible to visit some plants. Hence other 3 districts were again sampled in order to recovering missing samples (30 households).

Although TOR has suggested taking sample on Hills and Terai basis, the team visualized that sampling based on biogas penetration could be even more representative than just the Hills/Terai distribution. So, sampling was done on the basis of penetration (Sec. 1.3.2 Sampling Technique).

Because of lack of equipment and laboratory, some points raised in TOR could not be covered in this study. The measurement of NO^ and methane emissions could not be carried out due to the lack of equipment. Also the measurement of CO2 emission was based on secondary data because of the same reason.

The calculations regarding gas production and consumption, dung availability and fuel consumption pattern were all based on the responses of the surveyed HHs and no direct measures for the afore-mentioned parameters were attempted during this survey.

1.5 Structure of the Report

This report has been divided into eight chapters. Chapter I deals with the introduction, background and methodology adopted for conducting the study. Review of literature on relevant subjects dealt with in the report has been presented in Chapter II. The findings on the impact on energy use and health situation are discussed in Chapter III and Chapter IV respectively. Chapter V focuses on the impact about agricultural and sustainable land use. Similarly, the impact on climate change mid socio-economic conditions of the sampled households have been discussed in Chapter VI and Chapter VII, while Chapter VIII concludes with the presentation of conclusion and recommendations of the study.

CHAPTER II
LITERATURE REVIEW

Map I - Spatial Location of the Sample Districts

CHAPTER II
LITERATURE REVIEW

2.1 Biogas in Relation to Productivity and Crop Production

In Nepal, biogas was included for the first lime in the government programme in 1975/76, which was observed as "Agriculture Year". The emphasis was then laid to promote the technology mainly for its utility in returning more of the nutrients to soil in the form of the organic manure. With the passage of time, the technology is now valued more for its energy rather than manure.

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

The main function of the biogas plants is the production of gas to be used primarily for cooking and to a certain extent for lighting in rural households. Although theoretically well recognized, the effects and impacts of the slurry on agricultural production and the environment have not yet been fully examined in practical terms. Consequently, while literature abounds on the energy aspects of biogas. very tittle research and studies have been conducted on its environmental and agricultural aspects. This fact has now been well recognized and in recent years, increased awareness has been created about the need to conduct systematic studies on these aspects as well. Recognizing this need, BSP initiated a Slurry Extension Pilot Programme (SEPP) in 1995, which subsequently developed into a lull-fledged Slurry Extension Programme (SEP) in 1997. Since the initiation of SEPP and SEP, several periodic evaluation studies have been conducted, the major findings of which are summarized below.

Karki and Gurung (1996) found that all farmers, since the initiation of these programmes, stalled storing the slurry in compost pits. They report that the farmers use, on an average, 3.6 kg. dry materials per day lo absorb the moisture in the slurry as well as for the purpose of composting. Rice straw was used as composting material in the Terai whereas those in the Hilly regions consisted of weeds, grasses and wasted fodder. Farmers were well aware of the superior fertilizing value of the slurry in comparison to Farm Yard Manure (FYM). Due to the limited availability of composting material and in consideration lo the economic value of production, farmers tended to use higher rates of compost for vegetables (36 lo 60 t/ha) and only a moderate rate (6 to 15 t/ha) for the cereals. The authors recommend conducting research to study different composting materials for obtaining optimum nutritional enrichment of the slurry, and agronomic studies about its effects on various crops. They also suggest the need lo improve the methods of extension and provision of training, especially catering to the needs and requirements of the female members of the society.

During a midterm evaluation study of Slurry Extension Programme (SEP), the consultants found man}' positive effects of the programme. Notably, the target farmers selected by SEP had adopted the practice of mixing cattle urine in the biogas plants and had improved their cattle sheds; significantly increased stall feeding of their cattle; matched their cattle holdings with the size of the plants; tended to protect the compost pits from direct sun and from water logging; regularly composted the slurry and mixed the compost in the soil immediately after transporting it lo the fields; and were generally aware of the beneficial effects of the slurry compost. Somewhat surprisingly, however, many of the target farmers were found to have built considerably smaller compost pits than recommended, reportedly due to lack of sufficient land.

The study recommends institutional restructuring and strengthening providing better extension services lo the farmers.

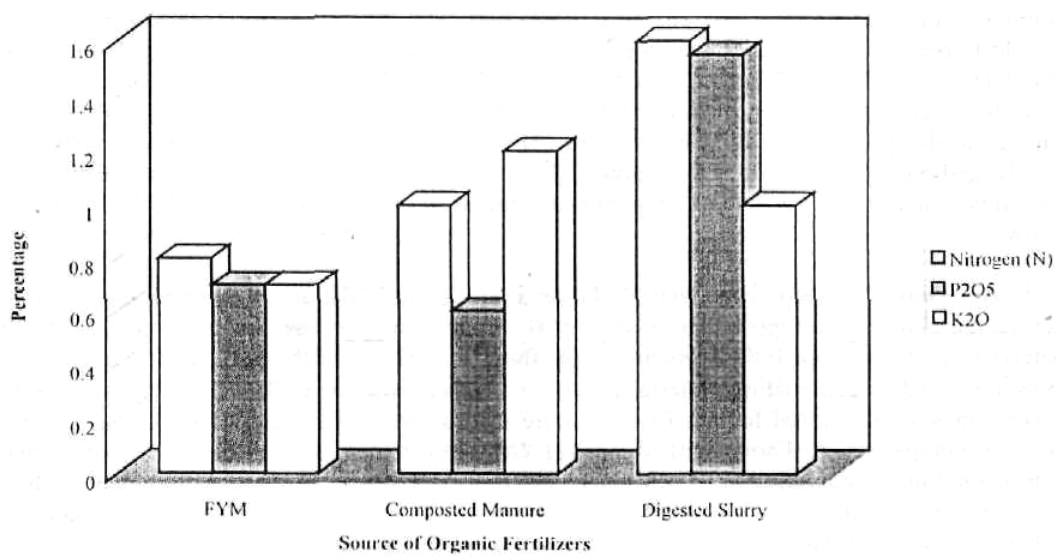
In spite of the lack of documentation on the effects of slurry on crops, it is well recognized as one of the strongest reasons for the success of biogas in Nepal as suggested Mans and Opdam who state that "the digested cow dung provides a better fertilizer than raw dung and there is no competition for its use. In fact, the biogas plant can be regarded as a fertilizer factory producing joint outputs (gas and fertilizer)".

Table 2.1 and Figure 2.1 show a typical analysis result obtained form a study conducted in India, which clearly shows the superior fertilizing value of the digested slurry (Gupta, 1991).

Table 2.1 - Nutrients Available in FYM, Composted Manure and Digested Slurry

Nutrients	FVM		Composted Manure		Digested Slurry	
	Rang (%)	Average (%)	Range (%)	Average (%)	Range (%)	Average (%)
Nitrogen (N)	0.5 to 1.0	0.8	0.5 to 1.5	1.0	1.4 to 1.8	1.60
P_2O_5	0.5 to 0.8	0,7	0.4 to 0.8	0.6	1.1 to2.0	1.55
K_2O	0.5 to 0.8	0.7	0.5 to 1.9	1.2	0.8 to 1.2	1.00

Figure 2.1 Available Nutrients in FYM. Composted Manure and Digested Slurry



The results of a similar study conducted in Nepal to compare the chemical characteristics and nutrients contents of different forms of bio gas slurry are presented in Table 2.2.

Table 2.2 clearly illustrates the marked enrichment of composted slurry in comparison to other forms in terms of their nutrient contents (Bajracharya, 1997). However, remarkably low contents of N, P and K have been reported for fresh dung and fresh slurry. This is a somewhat unexpected finding and needs further verification through a much more detailed and comprehensive research and analysis. During personal communications with the author of the laboratory analysis and other experts it was suspected that the anomalous results were obtained due to inadequate methods of sample collection.

Table 2.2 - Average Compositions of Different Forms of Slurry

Form	pH	Moisture (%)	Total N (%)	O.M (%)	C: N Ration	P_2O_5 (%)	K_2O (%)	Remarks
Composted Slurry	7.82	65.02	1.31 3.75	25.07 71.70	11.00 11.00	1.18 3.37	0.88 2.52	Wet basis Dry basis
Sun-dried Slurry	7.44	40.66	1.73 2.92	24.53 41.46	8.00 8.00	0.69 1.17	0.68 1.15	Wet basis Dry basis
Fresh Slurry	7.16	93.07	0.06 0.87	4.55 65.66	44.00 44.00	0.04 0.58	0.06 0.87	Wet basis Dry basis
Fresh Dung	8.11	8 1.25	0.30 1.60	15.47 82.46	30.00 30.00	0.78 4.16	0.42 2.24	Wet basis Dry basis

As pointed out earlier, during the officially declared "Agriculture Year" in 1975/76, the installation and use of biogas as an alternative form of energy and the slurry an a fertilizer WJIS actively promoted by the Department Agriculture and other government agencies. A lot of effort was made to popularize biogas on a national-wide scale. During that period and a couple of more sears to follow, various researchers conducted a series of simple field experiments lo lest the fertilizing value of the slurry.

Maskey (1978), and Bhattarai et. al. (1978) conducted experiments to study the effects of biogas slurry on wheat yields in comparison lo chemical fertilizers and other locally available manures. Maskey (1978) also tested the slurry on paddy, cauliflower, tomato, French beans, wheat and maize. Bhattarai (1978) tested the effects of slurry on wheat yields under irrigated and rain fed conditions at Bhairahawa and Khumaltar. After an in-depth study of these and other research results, Gurung (1997) concludes that "the manurial value of biogas slurry in Nepal provide a confusing array of signals on the superiority of biogas slurry over other organic manures." The research results in this area have so far been inconclusive. It appears that after this initial spate of interest, research in this direction abruptly ceased to exist.

Realizing a gap in research, the Alternative Energy Promotion Centre (AEPC) implemented a research programme in 2001 to study the influence of bio-slurry application on maize and cabbage in Lalitpur district. The result of the experimentation has revealed the supremacy of organic manure in all forms viz. FYM, slurry compost and liquid slurry over the inorganic fertilizer. The increment in the yield of cabbage due to application of slurry compost (20 t/ha) was 28 percent higher than the control. In case of maize, an application of 10 tons of slurry compost per hectare produced 23 percent more yield than the control (AEPC, 2001).

2.2 Biogas in Relation to Forestry i

The important benefit of biogas, in broader sense, is the conservation of environment due to saving of the forest. The saving of forest improves the environment by diminishing the number of natural calamities such as soil erosion. floods, landslides, etc. The heavy reliance on fuel wood has caused not only irreparable damage to the sustainability of agriculture and ecosystems in Nepal but has also increased the workload of 78 percent of rural women and a large number of children, mostly girls, who have lo allocate 20 percent of their work lime for fuelwood collection (WECS, 1995).

Practically no quantitative data on the effect of biogas on forest resources exists. However, several researchers have conducted case studies and made some calculations based on theoretical assumptions. Ghimire (2001) estimates that installation of 1.3 million biogas plants (total potential of Nepal) would save about four million tons of firewood per year. The FAO/CMS Training Manual (1996) sites the findings of a case study conducted in 1994 at two VDCs by Mr. Binod P. Devkota, Forest Officer, as follows:

- The number of animal heads kept by -*A* fanning family decreased utter installation of a biogas plants, compared to non-adopters:
- Biogas technology led to the adoption of stall feeding practices which reduced the pressure on nearby forest and pasture land by animals grazing there; and
- Biogas replaced SO to 85 percent firewood consumption of a family.

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

2.3 Reduction of Workload of Women

Comprehensive studies *on* women's workload in different parts of Nepal conclude that a day's work consists of 9 to 11 hours. A study by US!' conducted in 1992 estimates that almost 75 percent of biogas households spent more time collecting firewood in 1988 than in 1993. Two-third of them spent about six hours a day (Britt, 1994). Van Vliet and van Nes (1993) studied the effect of biogas on the women's workload in Rupandehi district in Nepal. They concluded that the reduction in workload of women as a result of installing biogas plants amounts to a minimum of 2 hours and maximum of 7 hours per family per day. When pressed with the labour shortage for such works in a family, it is the female children who have to forego their schooling.

A study of 100 biogas households corned out by EastConsult in 1994 in 16 districts of Nepal has shown a net saving on workload of 3.06 hours/hh/day as a result of installing a biogas plant. Similarly, Devpart (2000) conducted a detailed study in the average time allocation for different biogas related activities before and after installation of biogas plant. The results of this study indicated that on an average a household saves 2.38 hours/day.

2.4 Biogas is in Relation to Health and Hygiene

In the developing countries, health *and* hygiene of the women who have lo undergo drudgery of cooking with firewood are greatly affected. It is known that the obnoxious smoke produced from firewood burning contains harmful substance such as Carbon Monoxide, Benzopyrene, which increases in-house pollution. Thus, due to inhalation of the smoke, the housewives have been suffering from various types of diseases such as Acute Respiratory Infection, eye trouble and heart problem (Hurst, C and Barnett. A. 1990).

It has been reported that in some case older women, who were not longer able lo cook of firewood-began to cook again when biogas was introduced. Cooling, working and reading in the clear and bright light of biogas lamp is quite comfortable compared to kerosene lamp that causes pollution.

With support from AI'PC IUJDLSA conducted a gender related study in Kaski and Tanahu in April/May 2002. The respondents reported significant percentage of reduction on cough, eye infection and headache after biogas installation. The female respondents perceived more reduction in such diseases than their male counterparts.

2.5 Biogas in Relation to Pathogens and Sanitation

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

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

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

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

CHAPTER III
IMPACTS ON ENERGY USE

CHAPTER III

IMPACTS ON ENERGY USE

There is no denying to the indispensable role energy plays in running the wheels of the economy of any country and more importantly in the lives and livelihoods of its people. In ease of Nepal, the energy consumption scenario is characterized by the predominance of the traditional biomass fuels such as fuel-wood, crop residues and animal dung. The available statistics indicate that these biomass fuels contribute lo more than 90 percent of the total energy requirement of the country (I IMG/CBS 1998). Fuel-wood being the principal energy source among these biomass fuels, its demand far exceeds the sustainable supply (Rijal 1998). The overt impact of this situation is manifested in the increasing pressure on the already depleting forest resources of the country. As fuel-wood is becoming scarce and lime spent for its collection is increasing, the cases of transition within biomass fuel sources, i.e. shift from fuel-wood to crop residues and animal dung, are also evident. The use of crop residues and animal dung as fuel sources has manifold disadvantages. First of all, they are inferior fuels with greater Greenhouse Commitments (Smith el. al. 2000) and .secondly, their use as fuels restricts their use as fertilizers thus causing significant losses in agricultural productivity. In addition, there are other socio-economic and health related adverse impacts, many *o\'* which are disproportionately suffered by the women and the destitute.

Due lo these manifold adverse impacts associated with traditional biomass fuels, there have been efforts from all sides to substitute these traditional energy sources with alternative energy sources, which arc cleaner and greener. Biogas is one such alternative energy source, which is viable especially in the rural areas.

This chapter aims at analysing the impacts biogas plants have had on energy use. The following parameters were selected in order to come to significant conclusions regarding the energy use:

- Operational status of the biogas plants;
- Average biogas stoves/ lamps per biogas plant;
- Dung availability and frequency of feeding;
- Average plant size;
- Feeding capacity;
- Gas production and consumption;
- Change in use of traditional biomass fuels (fuel-wood / agricultural residues / animal dung) and fossil fuels (Kerosene/I.PG);
- Cooking efficiency; and
- Replacement of conventional fuels by biogas at national level.

3.1 Number of Operational Biogas Plants

Status of sampled biogas plants has been presented in Table 3.1.

Table 3.1-Status of Biogas Plants

Biogas Plants Surveyed	Operating	Non-operating	Non-operating since last since I to 60 days		
			1-5	6-30	31-60
600	584 (97.3 %)	16(2.7%)	5	6	5

Note: Figures in parentheses are the percentage figures of the total

Table 3.1 shows that out of the total 600-biogas plants installed households (BGH), 584 (97.3 %) mentioned that their plants are operational as of the date of the survey. Among the 16 (2.7 %) BGHs, which mentioned their plants to be non-operational, 5 stated that their plants have been non-operational since last 1 to 5 days. Similarly, 6 said that they arc non-operational since last 6 to 30 days and 5 since last 31 to 60 days.

The reasons for non-operation of the sampled plants have been elucidated in Table 3.2.

Table 3.2 - Reasons for Non-operation

Reasons	BGPs Non-operating at Present		BGPs that had been Non-operational in the Past	
	No of Cases	**%**	**No of Cases**	**%**
No feeding	1	6.2	11	11.8
Appliance failure	5	31.3	43	46.2
Civil structure damage	2	12.5	13	14.0
Do not know	8	50.0	21	22.6
NA	-	-	5	5.4
Total	**16**	**100.0**	**93**	**100.0**

Table 3.2 shows that out of the 16 non-operating BGHs, the reasons for non-operation are known for only 8 BGHs. Among these 8 BGHs, 5 cited appliance failure. 2 cited civil structure damage and 1 cited no feeding as the probable reasons for non-operation of the BGPs. The reasons for non-operation could not be known for the rest 8 cases.

As the concrete reasons for non-operation of biogas plants could not be ascertained from the present non-operating BGHs, the data of the past non-operation have been used to understand the possible reasons for non-operation. The data suggest that in 93 (15.7 %) BGHs [1] the plant had become non-operational in the past. Among the 93 BGHs, which reported non-operation in the past, the majority, i.e., 43 BGHs (46.2 %) cited appliance failure as the reason for non-operation followed by civil structure damage (14.0 %) and no feeding (11.8 %) respectively. From this it can be inferred that the BGPs in the Hills could be more vulnerable of being non-operational as hill areas in Nepal are comparatively remoter and less accessible to repair services. This is further substantiated by the fact that the percentage of BGHs, which have a history of non-operation, was found to be higher in the Hills (21.4 %) than the Terai (15.8 %).

3.2 Average Biogas Stoves / Lamps per Biogas Plant

The survey result presented in Table 3.3 indicates the popularity of biogas in cooking in all regions. However, the data suggest that the level of popularity is more so in Terai compared to the Hills.

Table 3.3 shows that majority (75.2 %) of the BGHs in Terai have 2 biogas stoves per plant, whereas most of the BGHs (73.9 %) in Mills have just a single biogas stove per plant. This is also evident from the average biogas stoves per plant, which in case of Terai is 1.76 and 1.23 in case of Hills. There are also nominal cases, 2 in Terai and 5 in the Hills, where the households are not using biogas for cooking purposes at all. This means these households are using the biogas for lighting purpose only.

[1] The valid case for this data is 590 BGHs

Table 3.3 - Number of Biogas Stoves

No or Stoves	Terai			Hills			Total		
	No of Mils	%	Total no of Biogas stove	No of HHs	%	Total no of Biogas Stoves	No or HHs	%	Total no of Biogas Stoves
0	2	0.7	489	5	1.6	396	7	1.2	885
1	65	23.4		238	73.9		303	50.5	
2	209	75.2		79	24.5		288	48.0	
>2[1]	2	0.7		-	-		2	0.3	
Total	278	100.0		322	100.0		601)	100.0	
Avg. BGS per Plant		1.76			1.23				

Most of the BGHs were found to use the biogas produced for cooking purpose rather limn for lighting in both the Terai as well as the Hill area. According to the survey results presented in Table 3.4. only 10.4 % in Terai; 11.8 % in Hills; and 11.8 % overall BGHs are using biogas to light one or more lamps, which is an average of 0.14 lamps per household in all [he three cases.

Table 3.4 - Number of Biogas Lamps

No of Lumps	Terai			Mills			Total		
	No of HHs	%	Total no of Biogas Lamps	No of HHs	%	Total no of Biogas Lamps	No of HHs	%	Total no of Biogas Lamps
0	249	89.6	39	284	88.2	45	533	88.8	84
1	21	7.5		31	9.6		52	8.7	
2	6	2.2		7	2.2		13	2.2	
>2[2]		0.7		-			2	0.3	
Total	278	100.0		322	100.0		600	100.0	
Avg. BGL per Plant	0.14			0.14			0.14		

3.3 Users' Satisfaction

Users' satisfaction is the most important factor to judge the successful adoption of the technology, in this regards, the results of the survey revealed that around 95 percent of the sampled biogas households are satisfied with the performance of their plants. The small percentage of unsatisfied biogas users argued that in some cases, the plant is either too big or in other cases, it is too small. Evidently, if the plant is too big, it is likely to be underfed and if it is too small, it cannot meet the household requirement for fuel.

The above findings are in agreement with several studies carried out in the past, which revealed the users' satisfaction percentage ranging from 94 to 98 (NEPECON, 2001). Among other factors users' satisfaction is solely dependent upon the performance of their plants followed by quality of the after-sales-services received by them.

[1] Assuming that >2 means at least 3
[2] Assuming that >2 means at least 3

3.4 Frequency of Dung Feeding

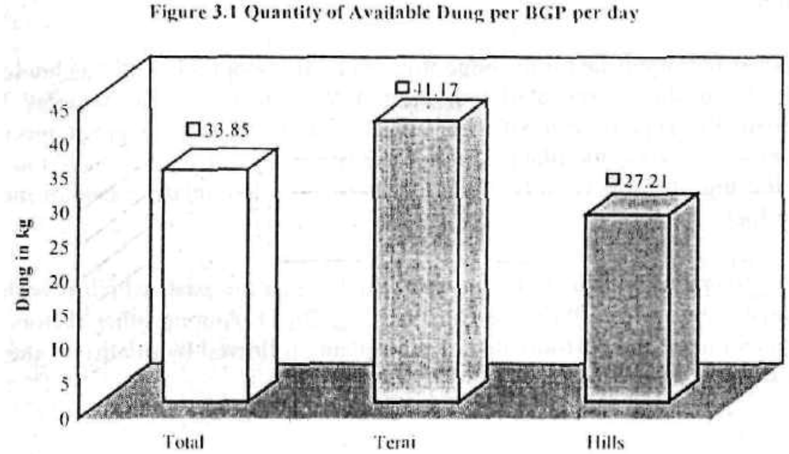
The pertinent data on frequency of dung feeding into biodigester me shown in Table 3.5.

Table 3.5 -Frequency of Dung Feeding

Frequency of Dung Feeding	Terai			Mills			Total		
	No of Plants	Dung Fed per Feeding (kg)	Total Dung Fed per day (kg)	No of Plants	Dung Fed per Feeding (kg)	Total Dung Fed per day	No or Plants	Dung Fed pet-Feeding (kg)	Total Dung Fed per day (kg)
Twice a day	135	30.57	6976.45	132	19.45	5052.96	267	25.27	12029.41
Once a day	124	32.48	4027.52	146	21.29	3108.34	270	26,43	7135.86
Every second day	3	31.67	47.49	20	29.80	298.00	23	30.04	345.49
Every third day		40.00	39.99	4	29.75	39.68	7	34.14	79.67
Twice a week	1	20.00	5.70	7	24.86	49.70	9	24.25	55.40
Weekly	-	-	-	6	27.50	23.70	6	27.50	23.52
Total	**166**	**-**	**1 1096.15**	**315**	**21.36**	**8572.38**	**581**	**-**	**19668.53**
Average quantity of available dung per BGP per day (kg)	41.71			27.21			33.85		

Table 3.5 shows that majority of the BGI Is feed their plants once a day (46.5 %) or twice a day (45.9 %). In case of Terai most of the BGHs (51%) feed twice a day whereas in case of the Hills the majority of the BGHs (46%) feed once a day. This could be due to the availability of excess dung in the Terai owing to its larger livestock population as compared to the Mills. This can further be substantiated from the fact that the average amount of dung fed into the plant per feeding in case of Terai is 3 1.5 kg as compared to 21.4 kg in case of the Mills.

Figure 3.1 Quantity of Available Dung per BGP per day



The above table also indicates that the total quantity of dung available per day in the total surveyed BGHs[1] amounts to 19668.53 kg. In Terai. the total quantity of dung available is 11096.15 kg and it is 8572.38 kg in case of the Hills. This leads to the conclusion that the overall average

[1] 581 valid cases

quantity of dung available per day per BGI 1 is 33.85 kg and the similar figures for the Terai and the Hills are 41.71 kg and 27.21 kg respectively (Figure 3.1).

3.5 Average Size of Biogas Plant

The distribution of the sizes of the surveyed biogas plants is given in Table 3.6.

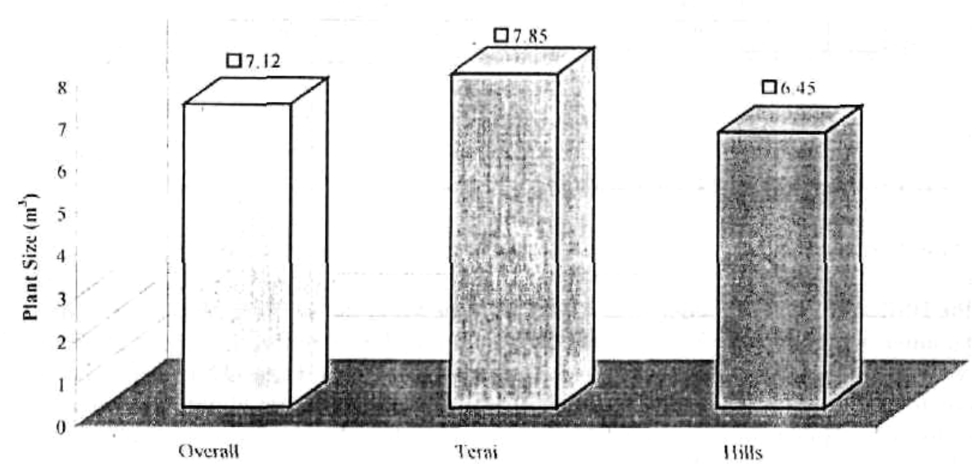
It can be seen from Table 3.6 that among the 600 sampled biogas households, about 54 percent of the plants are located in Terai and the rest 46 percent in the Hills. Regarding size distribution, about 43 percent of the sampled plants consists of 6 m^3 followed by 8 m^3 which comprises 32 percent. Likewise, 10 m^3 size consists of 14 percent and 4 m^3 10 percent, while the percentage of 15 m^3 size of plant seems very low or negligible.

Table 3.6 - Distribution of the Size of Surveyed Biogas Plants

Size in m^3	Terai		Hills		Overall	
	No of Biogas Plants	%	No of Biogas Plants	%	No of Biogas Plants	% of Total
4	9	3.2	50	15.5	59	9.9
6	87	31.3	171	53.2	258	43.0
8	1 15	41.4	76	23.6	191	31.8
10	60	21.6	24	7.4	84	14.0
15	7	2.5	1	0.3	8	1.3
Total	**278**	**100.0**	**322**	**100.0**	**600**	**100.0**
% of BGP	47		53		100	
Average plant size (m3)	7.85		6.49		7.12	

From the above table, it can be deduced that the overall average size of a biogas plant is 7.12 m^3 However, the average plant size varies regionally to some extent from the overall average. The average biogas plant size in Terai is 7.85 m^3 and in case of the Hills it is 6.49 m^3 (Figure 3.2). In case of Terai majority of the biogas plants are of $8m^3$ size (41%) followed by $6m^3$ plants. However, the situation is reverse in the Hills as majority of the plants (53%) arc of $6m''^{1}$ size followed by those of $8m^1$ size. The main reason behind the popularity of bigger size plants in Terai than in the Hills could be the availability of greater quality of dung in the former.

Figure 3.2 Average Size of Biogas Plant



3.6 Feeding Capacity of Biogas Plants

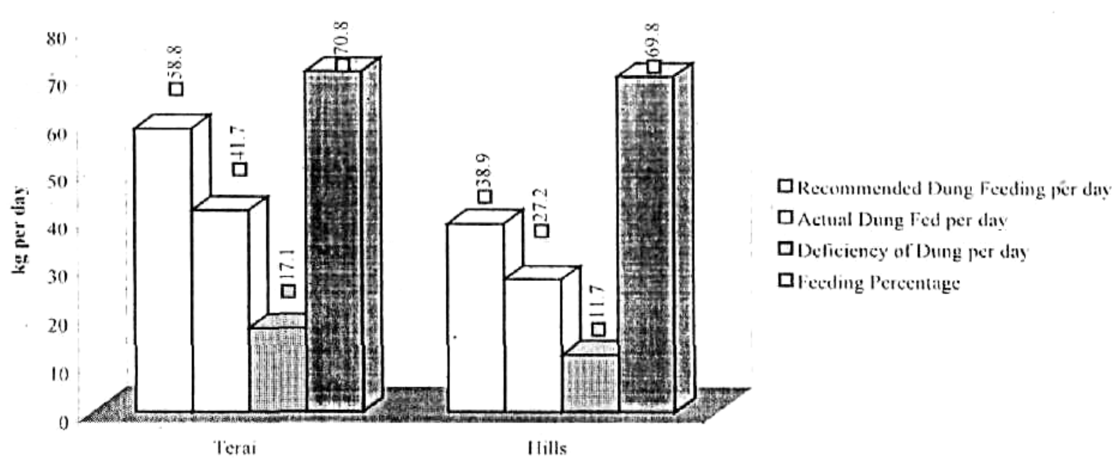
For the calculation of feeding capacity of the biogas plants, it has been assumed that a plant with a capacity of I m^1 requires 7.5 kg dung per day in Terai and 6 kg per day in Hill (BSP, 1997). Table 3.7 presents data on feeding capacity or practices adopted by the surveyed biogas HHs.

Table 3.1 - Feeding Capacity of Biogas plants

Region	Average size of Biogas Plant (m3)	Recommended Dung Feeding for an Average Sized Plant per day (kg)	Actual Dung Fed per day	Deficiency of Dung per day (kg)	Feeding Percentage (%)
Terai	7.85	38.87	41.71	17.16	70.85
Hills	6.49	38.94	27.21	11.73	69.88

Considering that the average size of the biogas plant in Terai and Hills is 7.85 m and 6.49 m" respectively (see Table 3.6 and Figure 3.2), it can be concluded that the recommended thing feeding per day is 58.87 kg for Terai and 38.94 kg for Hills. However, the survey data have indicated that the actual feeding per day is much lower than the recommended values. The survey results indicate that the actual feeding per day is 41.71 kg in case of Terai and 27.21 kg in case of Hills, which means there is dung deficiency of 17.16 kg and 11.73 kg in case of Terai and Mills respectively. The available data, hence, indicate that the feeding percentage in case of Terai and Hills is 70.85 % and 69.88 % respectively (Figure 3.3).

Figure 3.3 Feeding Capacity of Biogas Plant



3.7 Gas Productions and Consumption

3.7.1 Gas Production

As per the BSP study results, under right conditions one kilogram of dung produces 40 litres of biogas during summer and about 70 percent of the aforementioned production, i.e. about 28 litres of biogas, during winter. Since in the Terai dung fed per plant per day is about 42 kilograms, assuming the conditions to be optimum, in case of the Terai, it can be expected that about 1680 lilies of biogas is daily produced per plant during summer and about 1180 lilies during winter. Similarly, as the daily dung fed per plant in case of the Hills is about 27 kilograms, again assuming the conditions to be optimum, it can be expected that the daily production of biogas in the Hills is about 1080 lilies during summer and 750 litres timing winter.

3.7.2 Gas Consumption

lor the calculation of the daily biogas consumption rate of ;biogas stove two different scenarios have been used. For the first scenario (Scenario I) the BSP study result has been taken as a reference, which suggests that when used at full capacity, the must commonly used locally produced biogas stoves "ill consume approximately 400 litres of gas per hour. The study carried out by Devpart (2001) is the basis for the second scenario (Scenario II). The outcome of the study suggested that a biogas stove consumes a maximum of 443 litres of biogas per hour. The same study also suggested the hourly average biogas consumption by n biogas stove to be 200 lilies. However, this average figure seems to be too low. hence, ibis average figure has not been used in the assessment of the biogas consumption. One probable reason of this extremely low Mow rate could be due to the faulty calibration of the measuring instrument (the gas Mow meter).

From the present study it was observed that the daily average cooking hours per plant for Terai and the Hills is estimated to be 3 and 2.2 during summer and 2.9 and 2.2 during winter respectively. Considering these average cooking hour figures and the aforementioned scenarios, the daily biogas consumption rate has been calculated in Table 3.8.

Table 3.8 - Gas Consumption in Cooking

Region	Summer		winter	
	Scenario I	Scenario II	Scenario I	Scenario II
Terai	1 200	1350	1190	1300
Mills	8 80	990	880	990

Note: The consumption rates are in lilies per day per plant.

Similarly, in case of biogas consumption in lighting, the BSP study suggests that the widely available Ujeli lamps consume between 150 and 200 litres of biogas per hour. The study carried out by Devpart (2001) has suggested the biogas consumption rate of 166 lilies per hour in lighting, which is more or less similar to the average figure of the first. Hence, in case of biogas consumption in lighting, a constant figure of 175 litres has been considered for further calculation instead of considering two scenarios as in case of biogas consumption in cooking.

The present study also indicates that the total daily lighting hour per biogas plant for Terai and the Hills is 0.19 and 0.15. Unlike the cooking hours, the average lighting hour does not experience any seasonal variations. Assuming that 1 hour of lighting consumes 175 lilies of biogas as explained above, the total gas produced per plant per day in case of Terai is 35 litres and 25 litres in case of the Hills for all seasons. If needs to be rioted that the gas consumption in lighting is negligible as compared to the gas production in cooking, which further confirms the aforementioned observation (refer 3.2) that claims the popularity of biogas in cooking rather than in lighting.

Table 3.9 – Gas consumption in Lighting

Region	Summer	Winter
Terai	35	35
Hills	25	25

Note: The consumption rates are in litres per day per plants.

3.7.3 The Difference

Table 3.10 shows the expected biogas production rate, different scenarios of total consumption rate, inclusive of gas consumed in cooling and lightening, and the difference in production and consumption.

Table 3. 10 - Status of Gas Production and Consumption

		Terai		Hills	
		Summer	**Winter**	**Summer**	**Winter**
Production		1680	1180	1080	750
Consumption	Scenario I	1235	1225	905	905
	Scenario II	1385	1335	1015	1015
Difference (Production - Consumption)	Scenario I	445	-45	175	-155
	Scenario II	295	-155	65	-265

Note: All the figures are in litres per day per biogas plant

The above figures suggest that during summers, both in the Terai and the Hills, the production of biogas far exceeds the consumption rate. The production rates here have been calculated on the assumption that the conditions are right for biogas production, which in fact may not be so in reality, it is possible that the biogas plants produce less gas than expected production values due to the unavailability of perfectly favourable conditions. If this really is the case, there seems to be a requirement of assessing why the conditions are not favourable for maximum gas production. However, during winters the biogas production does not seem to be able to fulfill the consumption rate. This deficiency means during winters biogas alone is not able to fulfill the fuel demands, which is justified as there seems to be increase in use of other fuel sources during winter (refer 3.8-3.11).

3.8 Change in Use of Fuelwood

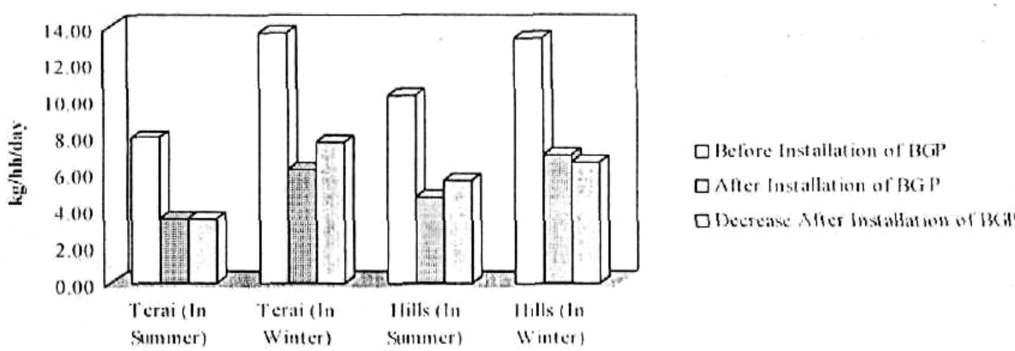
The traditional hearth, which burns fuelwood, is still the most popular mode for cooking, especially in most of the rural areas of Nepal. However, in the households with biogas plants, biogas stoves have substituted traditional mud stoves (hat burn fuelwood. As a result there has been a significant decrease in the use of fuelwood both in Terai as well as in the Mills. The survey data in this connection have been described in fable 3.11 and figure 3.4.

Table 3.11 - Comparison of the Use of Fuelwood before and after the Installation of BGP

Status	Fuelwood Used per BGH/day (in kg)			
	Terai		Hills	
	In Summer	In Winter	In Summer	In Winter
Before insinuation of BGP	7.84	13.64	10.15	13.33
After installation of BGP	3.45	6.09	4.61	6.S6
Decrease alter installation of BGP	3.39	7.55	5.54	6.47
Decrease rate (%)	43.23	55.35	54.58	48.54
	Fuelwood Used per NBG/day (in kg)			
Fuelwood consumption by an average non-biogas household	10	20	12	16

Table 3.1 1 clearly shows that, in Terai, there has been a decrease of 3.39 kg fuelwood per household (BGH) per day in summer and 7.55 kg fuelwood per household per day in winter. The corresponding figures for the Hills are 5.54 kg and 6.47 kg in summer and in winter respectively (see figure 3.4).

Figure 3.4 Change in Use of Fuelwood in BGHs



The decrease of fuel wood per household per clay by about 4[1]J % in Terai and 51 percent in the Hills is definitely a remarkable achievement. The decrease in the use of fuelwood in winter is more pronounced in case of Terai. There has been a decrease of fuelwood use per household per day by 55 percent in Terai as compared to 48 percent in the Mills. However, the scenario is reversed in summer when the decrease rate is 43 percent and 54 percent for Terai and the Hills respectively.

The query on the fuel wood consumption rate for the non-biogas households indicated that an average non-biogas household in Terai consumed about 10 kg of fuel wood in summer and 20 kg in winter. The similar figures for the Hills are estimated to be 12 kg and 16 kg in summer and winter respectively (Table 3.11), These figures indicate that the non-biogas households in Terai consume about four times more fuel wood than the biogas households. Similarly, in case of the Hills the non-biogas households have been found to consume more than twice as much fuel wood as used by the biogas households. This considerable difference in fuel wood consumption between the biogas and non-biogas households further supports the fuel wood replacement capacity of the biogas plants.

The decrease in fuelwood consumption has threefold benefit. First of all it has financial gains to the households as they can save some money, which otherwise they would have to spend in purchasing the fuelwood. Secondly, it contributes significantly in reducing the Greenhouse gases (GHGs) since the global warming commitment (GWC) of fuelwood is much higher as compared to biogas stoves. Thirdly, the decrease in the use of fuelwood also contributes to some extent in reducing the prevailing high rate of deforestation of the country thereby increasing the carbon sink. However, it needs to be noted that there is a considerable difference in reduction of GHGs if the fuelwood is produced on a sustainable basis. From the current study it cannot be ascertained whether the consumption of fuelwood has been on a sustainable basis or not. Even though the fuelwood in question has been consumed in a sustainable manner, the prevalence of thermally inefficient traditional mud stoves (refer 3.12) could result in the production of PICs. These PICs could again have further GWC. The possibility of substantial fuelwood replacement by the biogas plants, hence, can avert this phenomenon as well.

Table 3.l2 - Money Saved in Fuelwood after Installation of Biogas Plants[1]

	Money Saved per day per HH (Rs.)	
	In summer	In Winter
Terai	5.47	12.18
Hills	8.94	10.44

[1] Assuming that the price of 1 bhari of fuelwood = Rs. 63.22 and 1 bhari of fuelwood = 39.19 kg. Hence, price of 1 kg of fuelwood = Rs. 1.61 (From Q 506)

From the monetary point of view, the decrease in fuel wood consumption contributes to the daily saving of Rs. 5.47 in summer and Rs. 12.18 in winter per household {Table 3.12) in Terai. Similarly, in case of the Mills there has been a daily saving of Rs. 8.94 and Rs.10.44 per household. This is a monthly saving of about Rs. 265 in Terai and Rs. 290 in the HHs, which in rural areas can be a significant amount.

3.9 Change in Use of Agricultural Residues as Fuel

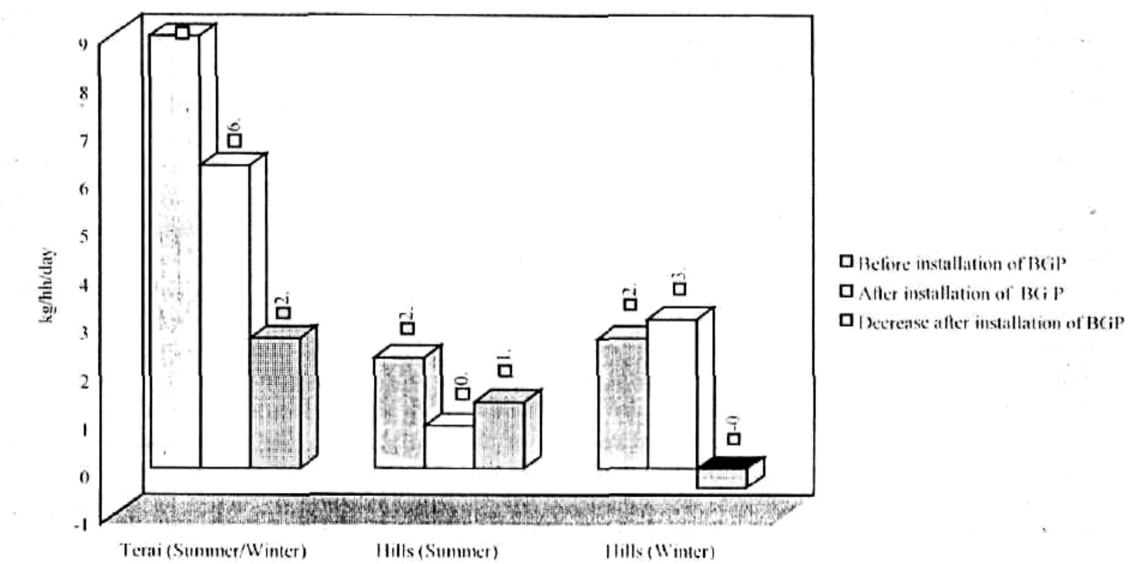
Because of the lack of easy access of other fuels as well as economic compulsions, some households in rural Nepal still are forced to use agricultural residues as fuel. However, the advent of biogas plants has succeeded in substituting this primitive fuel by more environment friendly biogas stoves. The relevant data in this connection have been presented in Table 3.13 and Figure 3.5.

Table 3.13 - Comparison of Hit Use of Agricultural Residue as Fuel

Status	Agricultural Residue Used per BGH/day (in kg)			
	Terai		Hills	
	In Summer	In Winter	In Summer	In Winter
Before installation of BGP	9.0	9.0	2.3	2.7
After installation of BGP	6.3	6. 3	0.9	3.1
Decrease after installation of BGP	2.7	2.7	1.4	Increased by 0.4
Decrease / Increase rate (%)	30.0	30.0	60.9	14.8*

* Increase rate

Figure 3.5 Change in Use of Agricultural Residues in BGHs



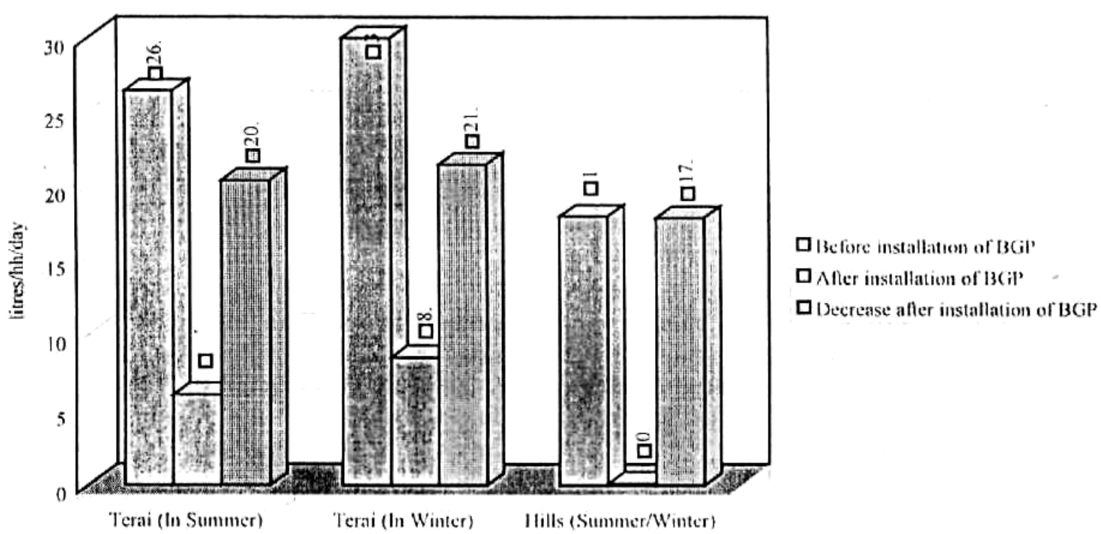
The survey results show a significant decrease in the use of agricultural residue, In Terai. ihere has been a decrease of agricultural residue by 2.7 kg daily per household, which is a decrease of 30 percent from the previous use pattern. However, even though there is a more pronounced decrease in the Mills during summer (60.9 %). the use of agricultural residue has slightly increased during w inter. The survey data indicate that there has been an increase by 0.14 kg per day per household in the Mills during winter. From the study results it has been confirmed that the feeding deficiency is more pronounced in the Hills (refer 3.6), which tends to deteriorate furl her during winters that are generally more severe in the Hills as compared to Terai. This deterioration in feeding capacity and the resulting adverse effect in gas production could be a reason people in Hills are still using agricultural residues as fuel in winters.

3.10 Change in Use of Dung its Fuel/Fertilizer

There has been the most distinct decrease in the use of dung as fuel after the installation of biogas plants. The use of available dung in feeding the biogas plants instead of using them as fuel is the main reason of this significant decrease. The data regarding comparison of the use of dung before and after the installation of BGP are presented in Table 3.14 and Figure 3.6 below.

Table 3.14 - Comparison of the Use of Dung us Fuel before andsifter the Insinuation of BGP

Status	Dung Used per HH/day (in litres)			
	Terai		Hills	
	In Slimmer	In Winter	In Summer	In Winter
Before installation of BGP	26.4	30.0	18.0	18.0
After installation of BGP	6.0	8.5	0.1	0.1
Decrease after installation of BGP	20.4	21.5	17.9	17.9
Decrease rate (%)	77.3	71.7	99.4	99.4



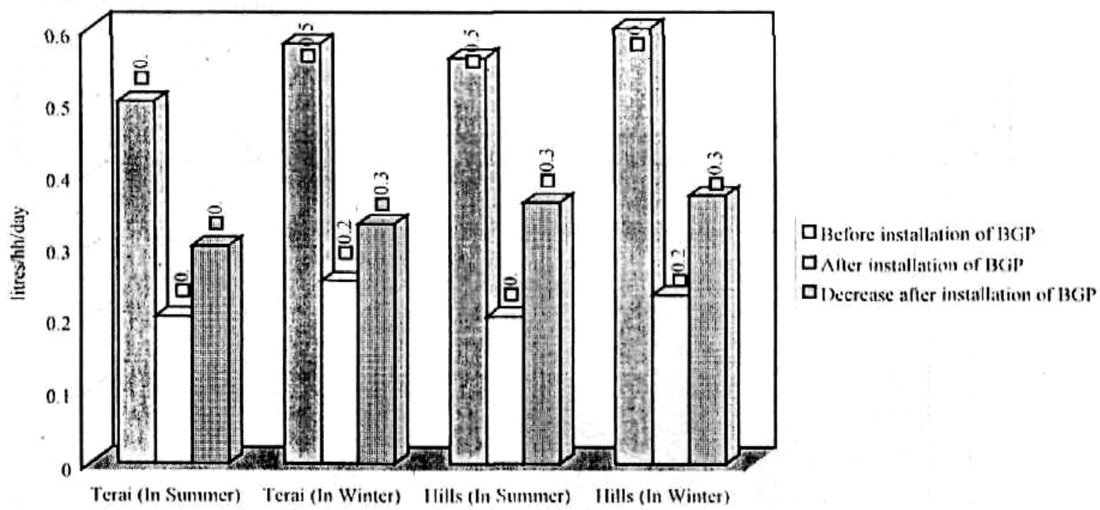
The survey results illustrate that in Terai, there has been a decrease in use of dung as fuel by 20.4 lilies per household per day in summer and by 21.5 litres in winter. This is a decrease of 77.3 % and 71.7 % in summer and in winter respectively. The decrease in the Hills is even more significant as the study indicates that there has been n decrease by 99.4 % in both seasons, which is definitely a very noteworthy decrease.

3.11 Change in Use of Kerosene/LPG

Like other fuel sources, the biogas stoves have been successful in reducing kerosene consumption as well. Table 3.15 shows change in use of kerosene and or LPG after introduction of biogas by the sampled households (sec Figure 3.7).

Table 3.15- Change in Use of Kerosene after the Installation of BGP

Status	Kerosene Used per BGH/day (in litres)			
	Terai		Hills	
	In Summer	In Winter	In Summer	In Winter
iNibre installation of BGP	0.50	0.58	0.56	0.60
After installation of BGP	0.20	0.25	0.20	0.23
Decrease after installation of BGP	0.30	0.33	0.36	0.37
Decrease rate (%)	60.0	56.9	64.3	61.7
	Kerosene Used per non-BGH / day (in litres)			
Kerosene consumption by an average non-biogas household	0.49	0.53	0.17	0.27



After the introduction of biogas plants, the consumption of kerosene has been reduced by 0.30 litres and 0.33 litres per day per household in Terai in summer and winter respectively. The decrease in kerosene consumption is even more significant in the Hills. The BGHs in the Hills have experienced a decrease by 0.36 lilies per clay per household in summer and 0.37 litres in winter. The decrease in kerosene consumption by more than 50 % in all the cases is yet another positive impact of biogas plants.

The query about the kerosene consumpt ion rate in the non-biogas households has reflected that in case of the Terai the daily consumption rates are more or less similar to those of the biogas households prior to the installation of the biogas plains. This indicates that as in case of the biogas households of Terai, even in the non-biogas households the biogas plants have a potential to replace significant consumption of kerosene. However, it is interesting to note that in case of the Hills the kerosene consumption rate in the non-biogas households is lower than the consumption rate in the biogas households. Since the kerosene consumption rates in the non-biogas households are more or less similar to the kerosene used by the biogas households even alter the installation of biogas plants, it might seem that the biogas plants do not have a potential of replacing kerosene in the Hills. But, when assessing the kerosene replaced by the biogas plants in the biogas households, which indicate even more replacement potential than in the Terai (Table 2.15), this inference proves to be false. One of the probable reason of less kerosene use in non-biogas households in the Hills could be that these households are comparatively less economically endowed than the biogas households. As kerosene can be very expensive in the Hills due to the inclusion of transportation costs, it is very possible that only a few households can a fiord to use it is fuel.

The decrease in kerosene consumption has a twofold benefits. Firstly, kerosene is comparatively a costly fuel and its reduction can result in a significant financial saving. Since kerosene is an import commodity, its reduction also contributes in reducing the foreign exchange out-flows. Secondly, kerosene is one of the high PIC emitting fuels, hence, its reduction also contributes towards decreasing the Greenhouse commitment.

Table 3.16 presents survey results about money saved in the purchase of kerosene after 13GP installation.

Table 3.16 - Money Saved in Kerosene after Installation of Hindis Plants[1]

	Money Saved per tiny per HH (Rs.)	
	In Summer	**In Winter**
Terai	5.62	6.18
Hills	6.75	6.03

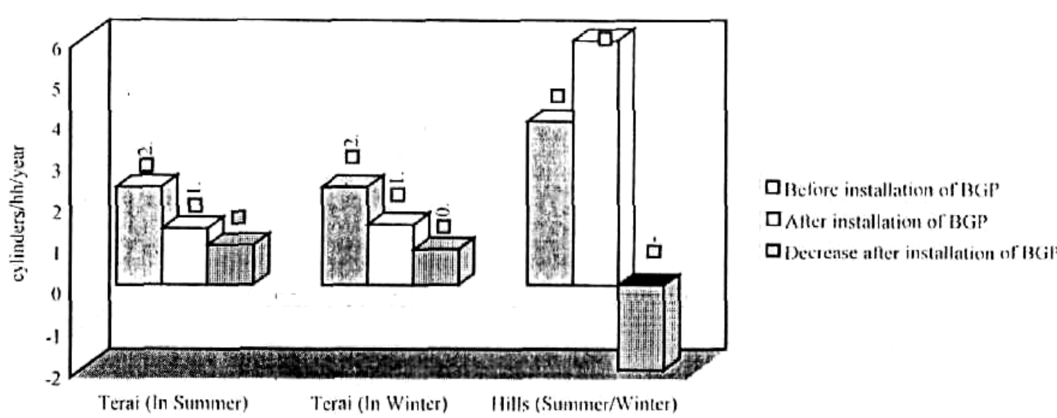
From the monetary point of view, the decrease by 0.30 litres in summer and 0.33 litres in winter in case of Terai is equivalent to the daily saving of Rs. 5.62 in .summer and Rs. 6.18 in winter per household. This is a saving of about Rs. 1 77 in a month. Similarly, in ease of the Hills the reduction in kerosene consumption contributes to the saving of Rs. 6.75 and Rs. 6.93 in summer and in winter respectively. This is n saving of approximately Rs. 205 in a month.

The installation of biogas plants has also seemed to contribute in changing the consumption of LPG gas to some extent. The data in this connection are presented in Table 3.17 and Figure 3.8 below:

Table 3.17 - Comparison of the Use of LPG before and after the Installation of BGP

Status	**LPG cylinders Used per BGH/year**			
	Terai		**Hills**	
	In Summer	**In Winter**	**In Summer**	**In Winter**
Before installation of LGP	2.4	2.4	4.0	4.0
After installation of BG P	1.4	1.5	6,0	6.0
Decrease after installation of BGP	1.0	0.9	Increased by 2.0	Increased by 20
Decrease rate (%)	41.7	37.5	Increased by 50 %	Increased by 50 %

Figure 3.8 Change in Consumption of LPG in BGHs



[1] Assuming 1 litre of kerosene costs Rs. 18.74 (From Q 506)

The reduction in LPG consumption is only evident in Terai, whereas in the Hills there has been an increase in its consumption regardless of the biogas stoves. The study reflects that the consumption of LPG in BGHs of Terai has reduced by 1.0 cylinder per household per year in summer and by 0.9 cylinders in winter. The scenario in case of the Hills is opposite as it shows an annual increase in LPG consumption by 2 cylinders per household. However, as the households using LPG is negligible (1 % overall) compared to other fuel sources, the change in consumption pattern of LPG does not have significant implications in financial saving or in Greenhouse gas emission at present.

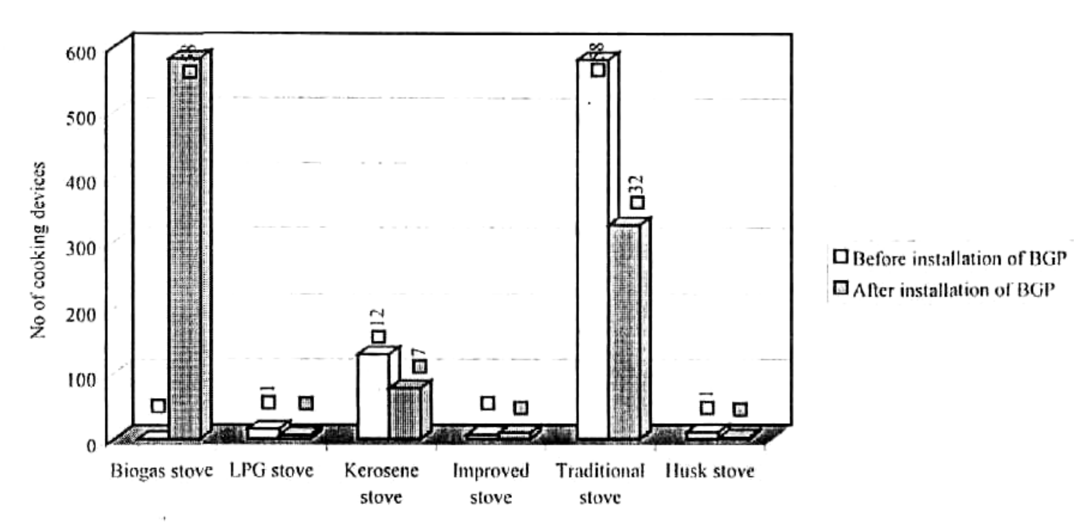
3.12 Change in Cooking Efficiency

Prior to the installation of the Biogas plants, majority of the households were dependent upon the traditional cooking stoves followed by the kerosene stoves (Table 3.18 and Figure 3.9). At present, with the installation of BGPs, the biogas stoves have substituted the traditional stoves and the kerosene stoves to he great extent.

Types of Stoves	Before the Installation of BGP		Present Status		Change in Use of Cooking Devices
	No. of Stoves	% of HH	No. of Stoves	% or HH	
Biogas stove	0	0.0	582	97.0	582
LPG stove	15	2,5	6	1.0	-9
Kerosene stove	128	21.3	77	12.8	-51
Improved stove	7	1.2	9	1.5	2
Traditional stove	580	96.7	325	54.2	-255
Husk stove	10	1.7	2	0.3	-8

The result shows that that there has been a saving of 9 LPG cylinders and 5 1 kerosene stoves per 600 households, which is a positive indicator. A decrease of LPG stoves by 60% and the kerosene stoves by almost 40 % after the installation of BGPs is an encouraging result. There has also been a slight decrease among the users of husk stove as well. This again could be taken as a positive indicator as husks could be used as a much-needed building material in the rural areas.

Figure 3.9 Change in Use of Cooking Devices in the BGHs



There has been a slight increase in the use of improved stoves from which it can be inferred that the BGP holders are familiar with other energy saving devices as well. However, it has to be noted that, due to the insignificant number of the improved stoves in the surveyed households, the comparison of BGP with an improved wood stove is not relevant. The use of traditional stoves has seen the most drastic change after the installation or BGPs. Before the installation of BGPs, 96.7 % of the households were using traditional stoves but at present only 54.2 % are found to be using them. 235 households have completely stopped the use of traditional stoves, which is a remarkable achievement. However, despite of the fact that 97.0 % of households are using biogas stoves at present, as 54.2 % households are still using the traditional stoves, it indicates that some BGHs could still be partially using these traditional stoves.

Biogas stoves have a higher efficiency of combustion than the traditional biomass stoves and the fossil fuel stoves (kerosene / LPG stoves) (Smith ct. al. 2000). As a result they contribute by far the lowest to the greenhouse gases (GHG). Studies have indicated that a biogas stove is 1.07 times more efficient than LPG stove, 1.22 times more efficient than a kerosene stove, 3.15 limes more efficient than wood burning traditional mud stove, 4.63 times more efficient than a traditional stove burning agriculture residue and 6.52 times more efficient than a traditional stove burning dung (Smith et. al. 2000). Hence, the substitution of the latter by the biogas stoves can be taken as a positive indicator of cooking efficiency. Furthermore, they are less hazardous to health with a potential of contributing towards the prevention of forest degradation, decreasing physical workload of fuel wood collection as well sis foreign currency saving when substituting fossil fuels. These facts further support the efficiency of biogas as compared to the traditional biomass and the fossil fuel stoves.

3.13 Replacement of Conventional Fuels by Biogas at National Level

The replacement of various conventional fuels after the introduction of biogas at the household level has already been dealt with in the previous paragraphs. On the basis of these household - level replacement values, the potential replacement values at the national level has been assessed for three different scenarios. The first (Scenario I) is for the present scenario with about 86,000 installed biogas plants. The second (Scenario II) focuses on the targets of the third phase of BSP, which is 100,000 biogas plants. Finally, the third (Scenario III) is a long-term scenario focusing on the future situation when the technically feasible 1.3 million biogas plants will be installed.

3.13.1 Fuelwood Replacement

The average fuel-wood saved per day per household after the introduction of the biogas is 5.7 kg. This shows that at present (Scenario I) 490 tonnes of fuel-wood is being replaced daily at the national level, which is a saving of about Rs. 790,000 daily. Once the BSP 111 targets are achieved (Scenario II), there would be a daily saving of 570 tonnes of fuel-wood, which at present rates would worth Rs. 920,000. Similarly, when all the technically feasible biogas plants will be installed (Scenario 111), these plants will lead to the saving of 7410 tonnes of fuel-wood per day. This saving of fuel-wood is worth Rs. 11.93 million at current prices.

Table 3.19- Fuelwood Replacement tit National Level

Scenarios	Amount of Fuelwood Replaced (tonnes / day)	Money Saved (Mil. Rs./day)
Scenario I	490	0.79
Scenario II	570	0.92
Scenario III	7410	11.93

3.13.2 Kerosene Replacement

The average kerosene saved per household after the introduction of the biogas is 0.34 litres per day. This shows that at present (Scenario I) 29,240 litres of kerosene is being replaced daily at the national level, which is a saving of about Rs. 550,000 daily. Once the BSP III targets are achieved (Scenario II), there would be a daily saving of 34,000 litres of kerosene, which at present rates would worth about Rs. 640,000. Similarly, when all the technically feasible biogas plants will be installed (Scenario III), these plants will lead to the saving of 442,000 litres of per day. This saving of kerosene is worth Rs. 8.28 million at current prices.

Table 3.20 - Fuelwood Replacement at National Level

Scenarios	Amount of Kerosene Replaced (tonnes / day)	Money Saved (Mil. Rs. /day)
Scenario I	29,240	0.55
Scenario II	34,000	0.64
Scenario III	442,000	8.28

CHAPTER IV
IMPACTS ON THE HEALTH SITUATION

CHAPTER IV

IMPACTS ON THE HEALTH SITUATION

Chapter II includes literature review on biogas focusing on health, hygiene, diseases and sanitation aspects. Similarly, impact of energy use due to biogas introduction has been dealt with in Chapter Three. Hence an attempt has been made here to explore and assess the achievement brought about by biogas technology on health, diseases and sanitation aspects. Undoubtedly, one of the principal causes of pollution in the household is attributed to firewood burning, which produces obnoxious smell. This is detrimental to human health, as household members especially the women, who have to undergo the drudgery of cooking, have been suffering from respiratory diseases (cough, shortness of breath, asthma, etc.), eye problem and headache since times immemorial. Similarly, cooking and lighting with kerosene also causes in-house pollution affecting human health.

Another important factor of pollution is the contamination from unmanaged faecal wastes that harbor various kinds of pathogenic germs. Similarly, many studies carried out in recent years have clearly revealed an increase in the pollution of mosquitoes after biogas installation. Thus, based upon the present study and the relevant works conducted in the past in Nepal and elsewhere, this chapter addresses overall impact of biogas on different aspects of health, hygiene, diseases and sanitation as perceived by the sampled households.

4.1 Types of Toilet

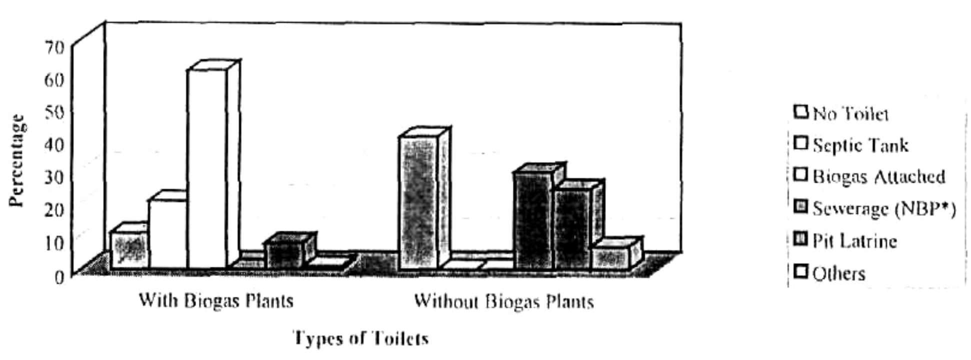
The types of latrine used by the surveyed households are shown in Table 4.1 and Figure 4.1.

Table 4.1 - Types of Toilet

S.N.	Types of Toilet	With Biogas Plants		Without Biogas Plants	
		Frequency	Percent	Frequency	Percent
1.	No Toilet	63	10.7	237	40.2
2.	Septic Tank	119	20.3	0	0.0
3.	Biogas Attached	355	60.5	0	0.0
4.	Sewerage (NBP*)	0	0.0	172	29.2
5.	Pit Latrine	45	7.7	142	24.0
6.	Others	5	0.9	39	6.6
	Total	**587**	**100.0**	**590**	**100.0**

* Households with non-biogas plants

Figure 4.1 Types of Toilets in Biogas and Non-biogas HHs



Statistical analysis revealed that there is significant difference between the two study groups (Z=11.587) as around 90 percent of the households installed biogas compared to 60 percent non-biogas Mils (fable 4.1 and Chart I). Thus the biogas HHs is likely to be more economically well off and therefore can afford to have toilet.

It is interesting to note that around 60 percent of the sampled biogas I ills have attached their toilets with the plant to solve the waste disposal problem and as a means to provide additional input for gas production. Significant percentages of non-biogas HHs (24%) were found using the pit latrine compared to biogas HHs (7.7%).

Above finding clearly shows that in many respects, households with biogas plants arc comparatively more concerned and aware of health and sanitation than non-biogas HHs. However, as the digested slurry or slurry compost prepared from latrine attached plant may harbour pathogens or parasitic worms, it is necessary that the biogas Hi Is be instructed to adopt necessary protective hygienic measures while handling the waste output.

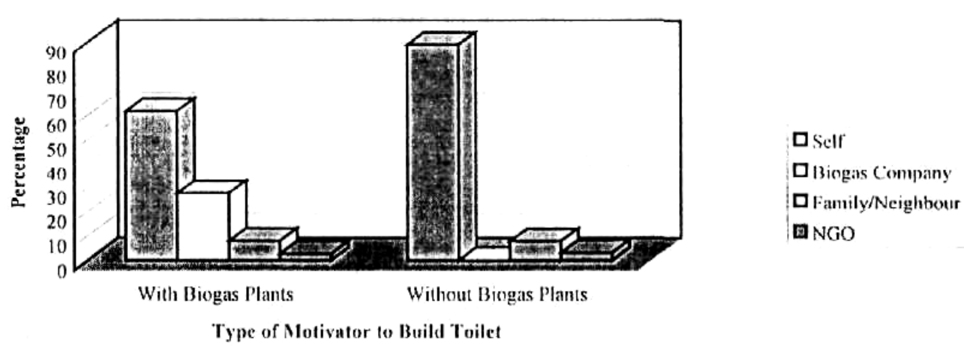
4.2. Motivation to Build a Toilet

Motivation is considered to be among the important factors for convincing the people to adopt desired innovation in llic society. Some people are self-motivated, while friends and neighbour can influence some others. In many respects companies and NGOs also play a vital role in motivation (see Table 4.2 and Figure 4.2).

Table 4.2 - Motivation to Build a Toilet

S.N.	Types of Toilet	With Biogas Plants		Without Bio	gas Plants
		Frequency	Percent	Frequency	Percent
1.	Self	321	61.7	310	89.1
2.	Biogas Company	144	27.7	0	0.0
3.	Family Members/ Neighbours	41	7.9	27	7.8
4.	NGO	14	2.7	11	3.2
	Total	520	100.0	348	100.0

Figure 4.2 Motivation to Build a Toilet



According to Table 4.2 and Figure 4.2, the percentage of self-motivated HH to build toilet are significantly higher (Z=8.864) in non-biogas HHs (89.1%) than biogas HHs (61.7%). Biogas companies appear to have played influencing role in building the toilet in biogas HHs. as 27.7 percent of the HHs were motivated by their efforts. Statistical analysis revealed that Z= 10.749, which is significant al 0.05. Only about 8 percent of both the categories of HHs seem to have motivated by family members or neighbours to build the latrine, while NOO has contributed to very less extent in (he motivation of latrine establishment.

4.3 Impact of Biogas on Various Smoke-borne Diseases

Based upon the survey o\' 100 biogas households, the impact of biogas on various smoke-borne diseases was studied by SNV/BSP (2000). It was found that there was significant improvement in the smoke-borne diseases such as eye illness, eye burn, respiratory problem, headache and diahorrea due to installation of biogas. Following important information has also been revealed from this impact study:

- 52 percent respondents told that they build toilet to attach to the plant. This has helped in enhancement of personal health and environmental sanitation;
- 23 percent respondents held the view that the frequency of visits to the hospital has been reduced and 26 percent experienced reduction in the quantity of medicine they were using in the past;
- 63 percent respondents reported that the household and its surrounding are cleaner clue to biogas installation;
- 87 percent reiterated that biogas facility enabled to reduce the number of burning cases; and
- 22 percent reported that in-house pollution due to the smell of kerosene or smoke has been reduced.

4.4 Degree of Reduction in Smoke after Biogas Plant

Before biogas installation, the people in the rural community were mostly dependant upon biomass such as firewood, agricultural residues, dung cake etc. for their domestic cooking requirements. These substances produce smoke and in poorly ventilated kitchens the amount of smoke inhaled by women and children increases. Smith et. al, (l983) has indicated that the levels of smoke in kitchens are a serious health problem, leading to respiratory and heart disease. In measurements in kitchens in Gujarat villages of India, the estimated annual dose of women cooking is 5,800 mg of Total Suspended Particles (TSP) and 3,200 mg of Benzopyrene. The Benzopyrene figure is equivalent to smoking 20 packets of cigarettes per day!

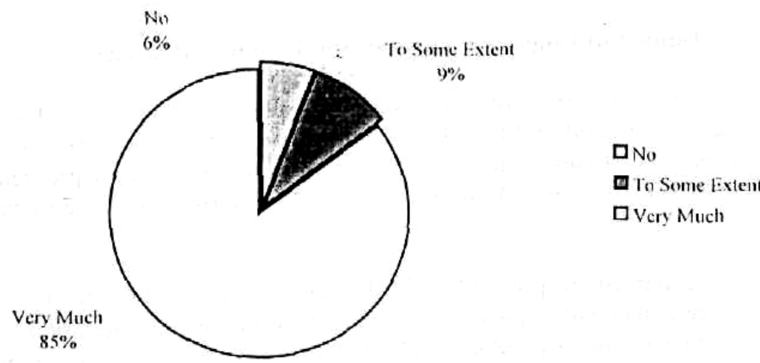
It is in above context that biogas users' viewpoints were sought in view of exploring their perception regarding the degree of reduction in the amount of kitchen smoke after installation of biogas plants (Table 4.3 and Figure 4.3).

Table 4.3 - Reduction in Smoke after Biogas Plant

S.N.	Decrease in Smoke	After Biogas Plants	
		Frequency	Percent
1.	No	34	5.8
2.	To Some Extent	52	8.9
3.	Very Much	497	85.2
	Total	**583**	**100.0**

Very large proportion of the households with biogas plants (85%) perceived a remarkable decrease in kitchen smoke after they have had the biogas plants. However, 9 percent respondents still realized the decrease in smoke *to some extent,* while the rest 5 percent did not find reduction in the amount of smoke even after biogas installation. This finding may be attributed to cither some technical defects in the plants or insufficiency of gas produced due to which they were compelled to use other sources of smoke producing fuels such as cowdung cake, straw, firewood, other agricultural residues, etc.

Figure 4.3 Perceived Reduction in Smoke after BGP



4.5 Kitchen Garden

In fact, possession of a kitchen garden is a highly desirable characteristic that enables the family to produce fresh, green and healthy vegetables. In this case, biogas families have extra advantages over non-biogas ones, as the former can use digested slurry as fertilizers besides biogas.

The composition of the households' with- and without plants possessing kitchen garden is illustrated in Table 4.4 and Figure 4.4.

Table 4.4 - Possession of Kitchen Garden

S.N.	Response	With Biogas Plants		Without Biogas Plants	
		Frequency	Percent	Frequency	Percent
1.	Yes	457	76.5	440	73.9
2.	No	140	23.5	155	26.1
	Total	597	100.0	595	100.0

Figure 4.4 Possession of Kitchen Garden by Biogas and Non-biogas HHs

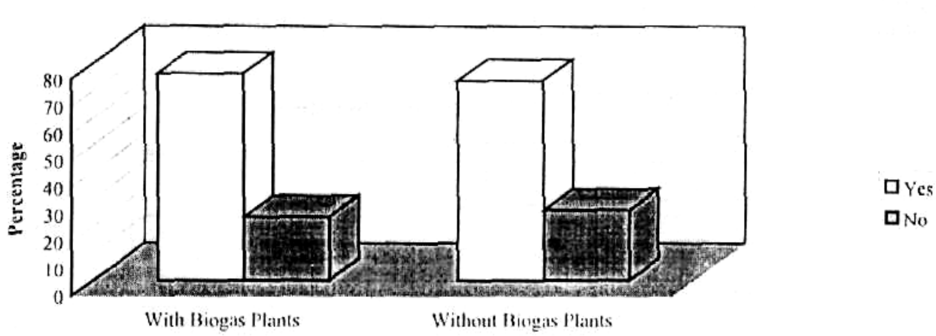


Table 4.4 and Figure 4.4 show that 76.5 percent biogas HHs possessed kitchen garden compared to 73.9 percent non-biogas Mils. Statistical analysis revealed that Z= 1.040, which is not significant at 0.05. Hence there is no significant difference between the two study groups

4.6 Reported Symptoms of Eye Infection

Exposure to kitchen smoke for prolonged time may produce symptoms like red eye, water discharge or plus discharge from the eyes, Thus, this study made an attempt to explore the reported systems of eye infection in biogas and non-biogas HHs.

Table 4.5 reveals the composition of the households with and without biogas plants under examination relating to reported symptoms of eye infection.

Table 4.5 - Reported Symptoms of Eye Infection

S.N.	Symptoms	With Biogas Plants		Without Biogas Plants	
		Frequency	Percent	Frequency	Percent
1.	Presence of Eye Infection Symptom	75	14.2	103	17.9
2.	Absence of Eye Infection Symptom	453	85.8	474	82.1
	Total	**528**	**100.0**	**577**	**100.0**

The comparative study on the presence of signs and symptoms of eye infection in biogas and non-biogas HHs indicated that the percent of respondents perceiving positive effect was 3.7 percent more in non-biogas HHs than biogas HHs. Statistical analysis revealed that Z = 1.647, which is not significant at 0.05 level. Hence there is no significant difference between two study groups.

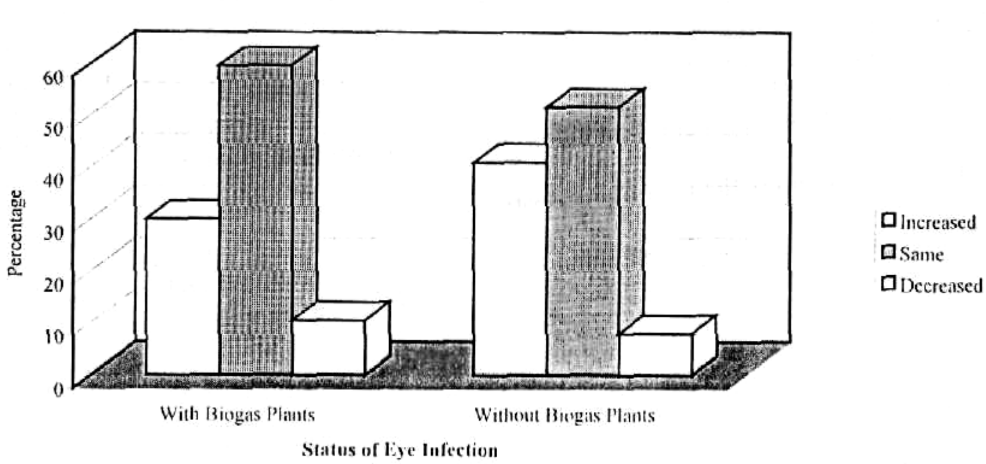
4.7 Episodes of Symptomatic Eye Infection for the Last Three Years

The data on the episodes of eye infection for last three years of the households under study with and without biogas plants are described in Table 4.6 and Figure 4.5 below.

Table 4.6 - Episodes of Eye Infection for the Lust Three Years

S.N.	Status of Infection	With Biogas Plants		Without Biogas Plants	
		Frequency	Percent	Frequency	Percent
1.	Increased	20	29.9	42	40.8
2.	Same	40	59.7	53	
3.	Decreased	7	10.4	8	7.8
	Total	**67**	**100.0**	**103**	**100.0**

Figure 4.5 Episodes of Symptomatic Eye Infection



Around 41 percent of non-biogas HHs had perceived *'increased eye infection'* within last three years, compared to 30 percent in case of biogas HHs. Statistical analysis revealed $Z=1.446$ which is not significant at 0.05. In the same manner, no significant difference was found between the two study groups perceiving *'decreased eye infection'* or *'same conditions'*. It should be noted that among other factors, the eye problem might be related also to the hygiene of the women.

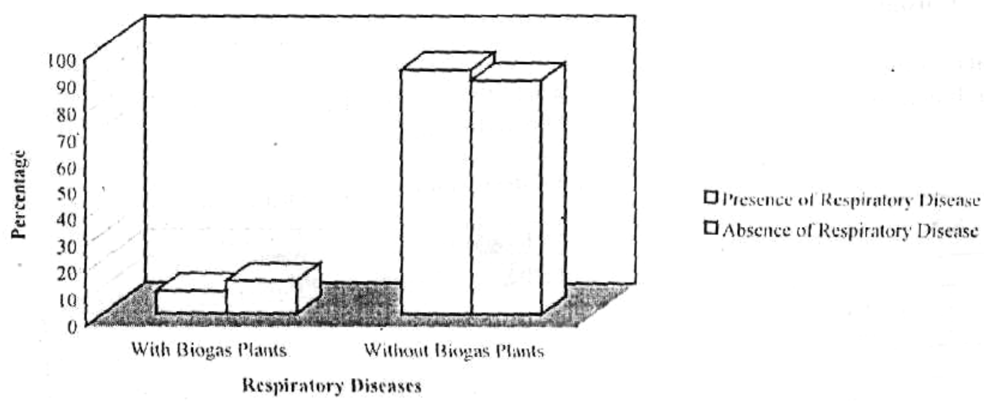
4.8 Respiratory Discuses[1]

Table 4.7 and Figure 4.6 illustrate the responses the respiratory diseases of the households under examination with and without biogas plants.

Table 4.7 - Respiratory Diseases

S.N.	Status **of Infection**	Wit It Hiogns Plants		**Without** Biopis *Hants*	
		Frequency	Percent	Frequency	**Percent**
1.	Presence of Respiratory Disease	50	**8.3**		12.2
2.	Absence of Respiratory Disease			526	87.8
Total		600	100.0		**100.0**

Figure 4.6 Presence of Respiratory Diseases in Biogas and Non-biogas HH



There seems very less difference between the biogas and non-biogas HHs stating presence and absence of the respiratory diseases. In this connection, some 91.7 percent of biogas HHs had not reported any respiratory diseases, whereas (his figure was H7.H percent in case of non-biogas tills. This means the presence of respiratory diseases was found around 3 percent higher in non-adopter of biogas than the adopter. However, statistical analysis revealed that Z= 1.199, which is not significant at 0.05 level. Hence there is no significant difference between two study groups

4.9 Status of Cough for the Last Three Years

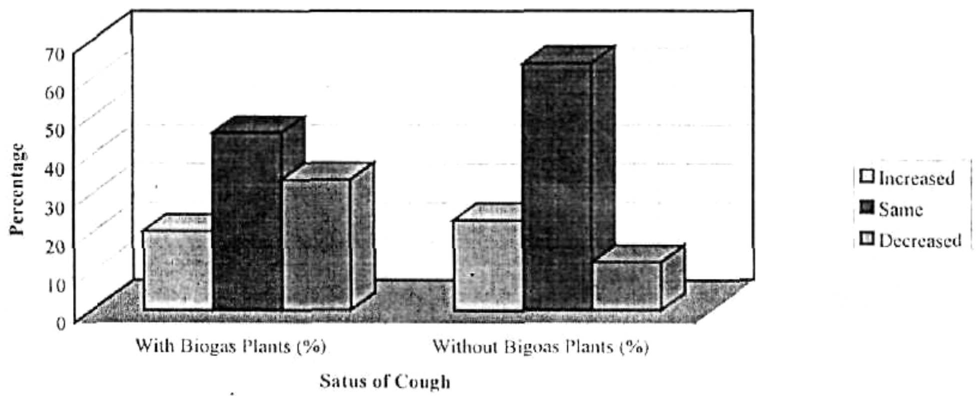
This study presents the result of survey about the status of cough in biogas and non-biogas HHs as reported by the respondents for the last three years (Table 4.8 and Figure 4.7).

[1] Includes cough, shortness of breath, asthma, etc.

Table 4.8 - Status Cough for the Lust Three Years

S.N.	Condition	With Biogas Plants (%)	Without Biogas Plants (%)
1.	Increased	20.5	23.4
2.	Same	45.8	64.1
3.	Decreased	33.7	**12.5**
	Total	**100.0**	**100.0**

Figure 4.7 Status of Cough for the Last Three Years



In biogas group, the respondents perceiving increased cough were 3 percent less in comparison to non-biogas group. This difference is not statistically significant (Z=1.202). Interestingly, the percentage of *'decreased cough'* was reported to be almost three times higher in biogas HHs than non-biogas HHs. Statistical analysis revealed Z = 8.666, which is significant at 0.05. Similarly, the percentage of respondents reporting no difference (Same) in the status of cough was 18.3 higher in non-biogas group than biogas Mils. Statistical analysis revealed that the difference between the two study groups is significant Z =6.359).

The above findings are in agreement with a recent study conducted in Kaski and Tanahu districts (RUDESA, April 2002). The study has revealed significant percentage of reduction in cough, eye infection and headache after BGP installation. The female respondents had perceived more reduction (64%) in such diseases than their male counterparts (47%).

These findings confirm the general belief as well as previous studies that biogas is quite helpful in decreasing the cough of the family members especially women who are able to cook their food in healthy atmosphere with clean and smokeless biogas.

The particulate carbon matter and toxic substances like carbon monoxide in the smoke produced by firewood can also cause allergic cough asthma, bronchitis, etc. Oilier factors like pre-existing respiratory problems and smoking habit have not been analyzed.

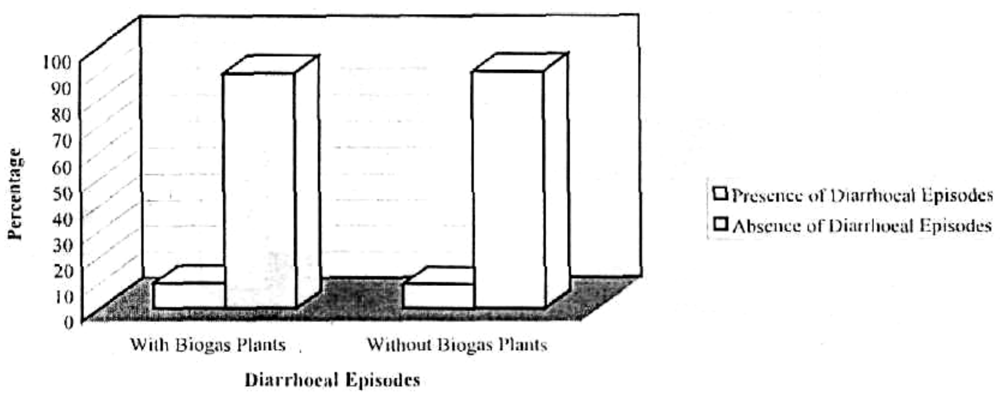
4.10 Diarrhoeal Episodes

Table 4.9 and Figure 4.8 illustrate the responses about the diarrhoeal episodes of the households under examination with-and without biogas plants.

Table 4.9 - Diarrhoeal Diseases

S.N.	Response	With Biogas Plants		Without Biogas Plants	
		Frequency	Percent	Frequency	Percent
1.	Yes	59	9.8	55	9.3
2.	No	541	90.2	539	90.7
	Total	**600**	**100.0**	**594**	**100.0**

Figure 4.8 Diarrhoeal Episodes of Biogas and Non-Biogas HHs



The data presented in Table 4.9 and Figure 4.8 imply that in terms of the diarrhoeal problems, the installation of biogas plants is not so significant at the moment as the difference between biogas HH and non-biogas was found quite negligible (0.5%). Statistical analysis revealed Z = 0.338, which is not significant at 0.05.

It appears that biogas users are more informed and aware of health and hygiene like use of toilets, cooking stove, cleanliness and safe drinking water. These all may contribute to decreased diarrhoeal episodes.

4.11 Status of Diarrhoeal Episodes for the Last Three Years

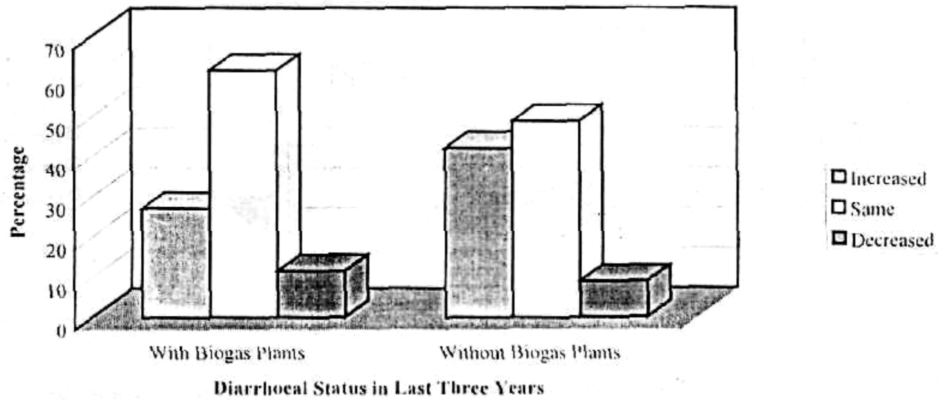
Table 4.10 and Figure 4.9 express the status of diarrhoea for the last three years of the households under study with and without biogas plants.

Table 4.10 - Condition of Diarrhoea

S.N.	Condition	With Biogas Plants		Without Biogas Plants	
		Frequency	Percent	Frequency	Percent
1.	Increased	14	27.0	19	42.2
2.	Same	32	61.5	22	48.9
3.	Decreased	6	11.5	4	8.9
	Total	**52**	**100.0**	**45**	**100.0**

27 percent of households with biogas plants reported an increment in diarrhoea, while it was 42 percent in case of non-biogas HHs. This shows that *'increased diarrhoeal'* episode in non-biogas HHs was 15.2 percent higher that that of biogas HHs. However, statistical analysis did not reveal any significant difference al 0.05 (Z=l.586). Similarly, the *'decreased diarrhoeal'* episodes exceeded by 2.6 percent in biogas HHs compared to non-biogas HHs. Again, the difference is not statistically significant (Z=0.428). Likewise, 61.5 percent of biogas HHs and 48.9 percent non-biogas HHs did not notice any difference in diarrhoeal episodes for the last three years. The difference between the two study groups in this case is not statistically significant (2=1.251).

Figure 4.9 Condition of Diarrhoea for the Last Three Years in Biogas and Non-Biogas HHs



4.12 Dysentery

Table 4.11 illustrates the responses about the dysentery of the households under examination with and without biogas plants.

Table 4.11 - Dysentery

S.N.	Dysentery	With Biogas Plants		Without Biogas Plants	
		Frequency	Percent	**Frequency**	Percent
1.	Presence of Dysentery	33	5.5	63	10,5
2.	Absence of Dysentery	567	94.5	536	89.5
	Total	**600**	**100.00**	**599**	**100.0**

94.5 percent of biogas HHs did no find any dysentery, whereas the figure was 89.5 percent for non-biogas HHs. In other words, 10.5 percent of non-biogas Ill-Is reported dysentery compared to 5.5 percent biogas HHs. Statistical analysis revealed that Z = 3.201, which is significant at 0.05[1]. It implies that in terms of the diarrhoeal problems, the installation of biogas plants has some significance.

4.13 Status of Dysentery for the Last Three Years

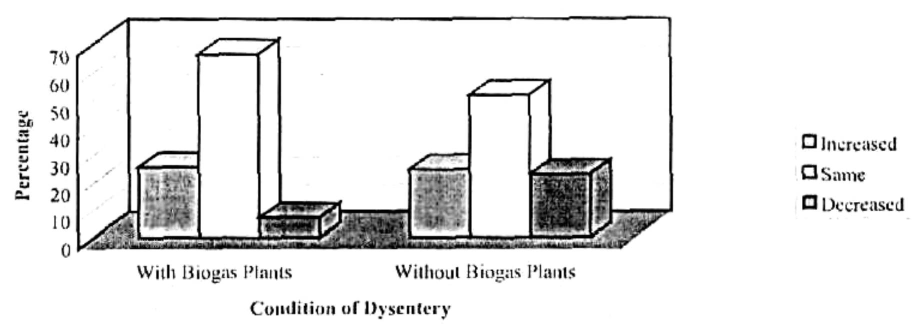
Table 4.12 and Figure 4.10 express the condition of dysentery for the last three years of the households under study with and without biogas plants.

Table 4.12 - Condition of Dysentery

S.N.	Condition	With Biogas Plains		Without Biogas Plants	
		Frequency	**Percent**	**Frequency**	**Percent**
1.	Increased	7	25.9	13	25.0
2.	Same	18	66.7	27	51.9
3.	Decreased	2	7.4	12	23.1
	Total	**27**	**100.0**	**52**	**100.0**

1 The table on the statistical analysis is given in Appendix v.

Figure 4.10 Condition of Dysentery for the Last Three Years in Biogas and Non-Biogas HHs



The study did not reveal any significant difference between biogas and non-biogas family perceiving an increase in dysenteric problem (Z=0.090). The respondents slating that the condition of dysentery has remained *'Same'* was 66.7 percent in case of biogas HHs and 52.0 percent in ease of non-biogas HHs, which is not significant (Z~l.255). Similarly, the respondents perceiving a decrease in dysentery were found to be 16.0 percent higher in non-biogas HHs than biogas HHs, which is also statistically insignificant (Z=1.730).

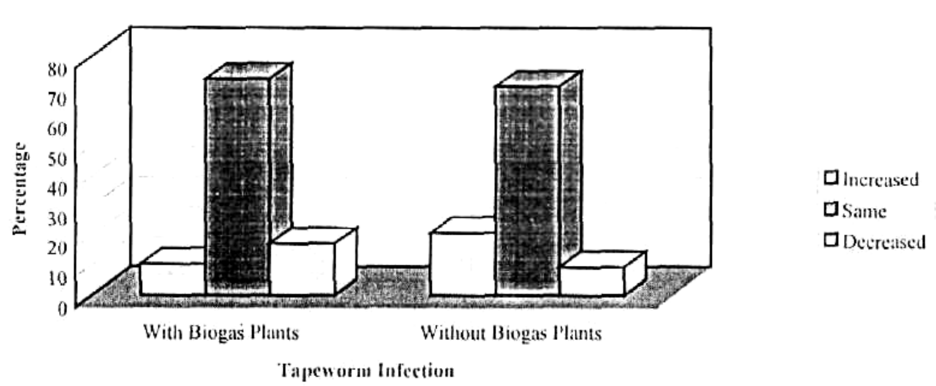
4.14 Status of Tapeworm for the Last Three Years

Table 4.13 and Figure 4.11 express the status of tapeworm for the last three years of the households under survey with and without biogas plants.

Table 4.13 - Status of Tapeworm Infection for the Lust Three Years

S.N.	Status	With Biogas Plants		Without Biogas Plants	
		Frequency	Percent	Frequency	Percent
1.	Increased	3	10.3	9	20.9
2.	Same	21	72.4	30	69.8
3.	Decreased	5	17.2	4	9.3
	Total	29	100.0	43	100.0

Figure 4.11 Condition of Tapeworm Infestation for the Last Three Years in Biogas and Non-Biogas HH



About 10 percent of biogas HHs reported an increase of tapeworm infection, while it was 21 percent in case of non-biogas HHs. However, statistical analysis revealed that the difference between two groups was insignificant (2=1.182). Likewise, the percentage of biogas ill-is staling *'decreased tapeworm infestation'* was around 8 percent higher than non-biogas HHs, Statistical analysis revealed that Z=0.999, which is not significant at 0.05. Hence there is *no* significant difference between two study groups.

4.15 Parasitical Test of Toilet Attached Slurry

Despite the hesitation and social constraint for sue of human excreta as raw materials to feed the biodigester, the users are becoming more conscious to connect their latrine with cowdung plant. The result of the biogas survey shows that around 40 percent of the installed biogas plant was connected to the latrine.

As per the TOR, it was envisioned to assess the health risks produced due to vectors/pathogens likely to be present in slurry (fresh and digested) and slurry compost and present solutions to minimize those risks for people and cattle. However, such study could not be completed due to some unavoidable reasons. In this connection it is worth to quote the work carried out by SNV/BSP (Manure Analysis Report, ATC, 1997). With support from SNV/BSP, Agricultural Technology Centre (ATC) performed parasitical test of 50 samples collected from toilet-attached biogas plants. The study revealed the presence of various parasites in about 16 percent of the samples. Thus, ova of Ascaris lumbricoides, Trichuris trichura, and Hookworm and Giardia lamblia were detected in the samples. However, the pathogens were detected in only 4 compost samples (8%) that were prepared by using the digested slurry produced from the latrine-attached biogas plant.

This being a sensitive issue, it is, therefore, suggested to carry out systematic and in-depth research in this subject in an immediate future.

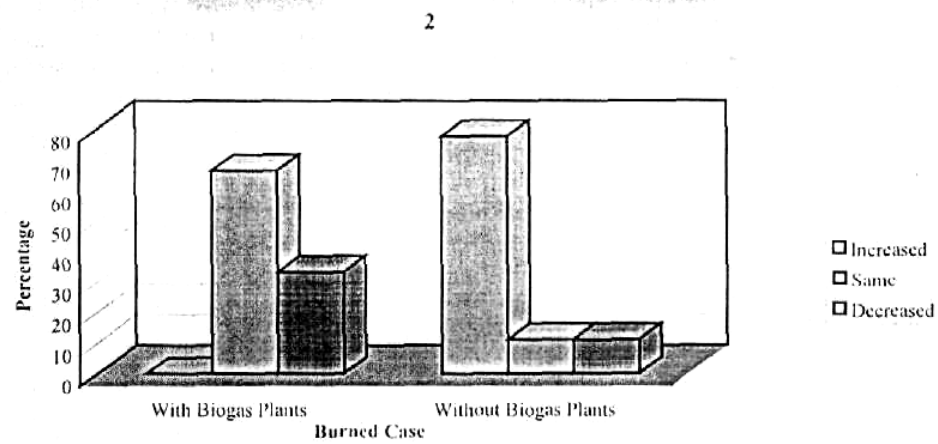
4.16 Condition of Burned Case of the Last Three Years

There is a high danger of burning cases in the households without biogas plant due to firewood burning, kerosene stove and other cooking devices. In this connection, this study attempts to reveal the status of burning case in biogas and non-biogas HHs for the last three years, as shown in Table 4.14 and Figure 4.12.

Table 4.14 - Condition of Burned Case

S.N.	Condition	With Biogas Plants		Without Biogas Plants	
		Frequency	Percent	Frequency	Percent
1.	Increased	0	0.0	7	77.8
2.	Same	2	66.7	1	11.1
3.	Decreased	1	33.3	1	11.1
	Total	**3**	**100.0**	**9**	**100.0**

None of biogas HHs reported an increase in the burned cases, while substantial percentage of respondents in non-biogas Mils (78%) disclosed such problem. Similarly, the *'decreased percentage'* of this case in biogas HHs is found to be three times more than that of non-biogas HHs. It is evident from finding that biogas has an impact to control the burning cases that takes place accidentally in the house.



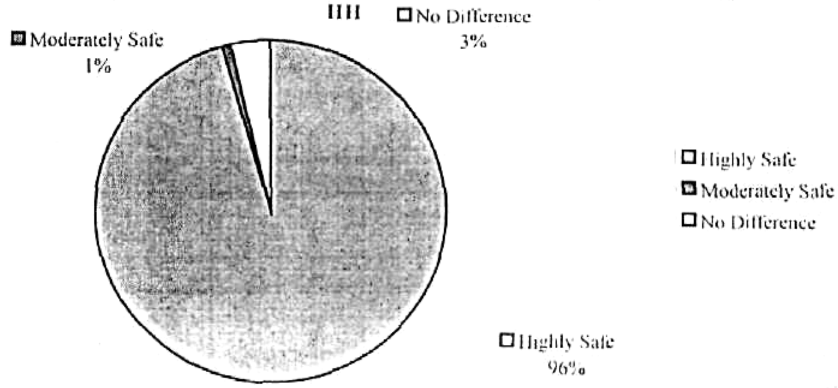
4.17 User's Perception about Safety Measure of Biogas over **Fuelwood**

Table 4.15 and Figure 4.13 show the degree of safety on the use of biogas stove over fuelwood.

Table 4.15-Safety of Biogas over Fuelwood

S.N.	Ranks of Safety	After Biogas Plants	
		Frequency	**Percent**
1.	Highly Safe	554	95.5
2.	Moderately Safe	7	1.2
3.	No Difference	9	3.3
	Total	**580**	**100.0**

Figure 4.13 Safety of Bigoas Stove over Fuelwood Stove in Biogas and Non-Biogas HH



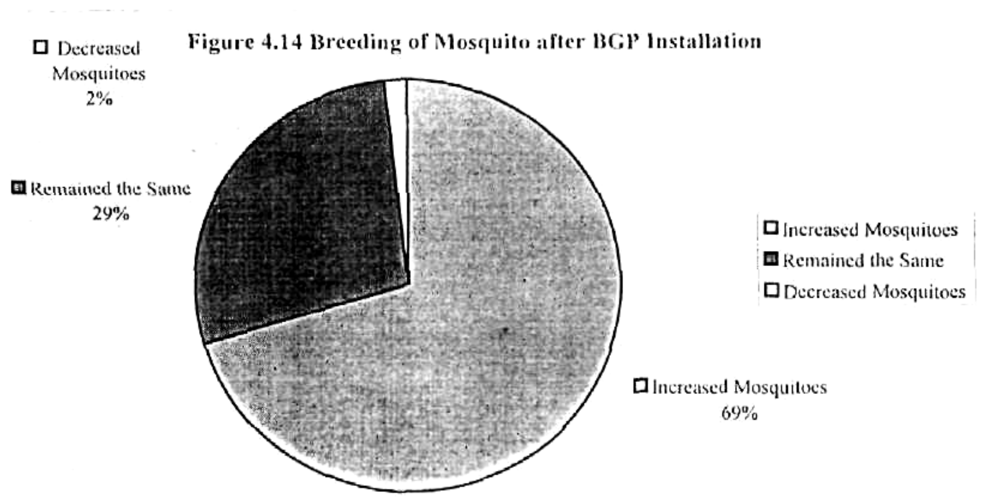
Majority of biogas HHs (95.5%) perceived a very high degree of safety on the use of biogas stove after they have had the biogas plants. Only 1.2 and 3.3 percent of the households ranked the safety of biogas stove as *moderate* and *no difference* respectively. Thus, it is clear that biogas stove is safer than kerosene stove, firewood stove and oilier available stoves. In the survey area, there is also an example of a member of non-biogas Mils being killed because of kerosene-stove burst.

4.18 Breeding of Mosquitoes

Various studies conducted in recent years have indicated that there is an increment in the population of mosquitoes after BGP installation. In this connection, the status of mosquito breeding after the introduction of biogas BGP has been revealed in Table 4.16 and Figure 4.14.

Table 4.16 - Breeding of Mosquitoes after BGP Installation

S.N.	Stilt us	Frequency	Percent
1.	Increased Mosquitoes	413	69.9
2.	Remained the Same	169	28.6
3.	Decreased Mosquitoes	9	1.5



Around 70 percent of biogas HHs reported that mosquito breeding had increased after the installation of biogas whereas 28.6 percent HHs were of the opinion that mosquito breeding remained the same and only 1.5 perceived its decrease after biogas plant. Similar findings were also revealed in course of the study reported by NEPECON (2001). The principal reasons for mosquito proliferation may be attributed to the followings:

- Observation indicates that the probable cause of mosquito breeding in biogas plant may be due to availability of moist space in the upper part of the outlet of biogas plant; and
- If firewood is burnt inside the kitchen, the smoke produced from it drives out mosquitoes. On the other hand, in clear illumination of biogas lamp or electric bulb, there is every risk of mosquito bite.

However, the above observation needs to be confirmed by appropriate research. Simultaneously, it is also essential to suggest suitable methods to the biogas HHs for the control and destruction of mosquito.

CHAPTER V
IMPACTS ON AGRICULTURE AND SUSTAINABLE LAND USE

CHAPTER V

IMPACT ON AGRICULTURE AND SUSTAINABLE LAND USE

Although the fertilizing value of the biogas slurry had been recognized ever since it was introduced in Nepal, the overall effects of biogas on the land use and agricultural system in a broader sense have so far received very little attention. Realizing this gap in knowledge and information, this study attempts to evaluate the effects of the use of biogas on the agriculture system including both crops and livestock as well as on the forest resources.

Several interesting facts relating to the land and livestock holding characteristics of the households using biogas and their impacts on crops, livestock and forest resource use have been observed from the analysis of the information obtained from this study. It was found, for instance, that almost all the biogas users were aware of the potential of the slurry to increase soil fertility but were unable to use it extensively clue to certain constraints. Attempts to assess the effects on the incidence of crop pests and diseases and weeds produced an inconclusive result, probably because of the limitation of the methodology used. Several positive impacts were observed on the livestock management practices and forest resource utilization pattern. Detailed information regarding these and other aspects of the impact assessment arc discussed in this chapter.

5.1 Land Holding Pattern

Table 5.1 gives a picture of the land holding patterns of the surveyed households with respect to size of holding and cultivated khet[1] and bari[2] hind.

Table 5.1 -Land Holding Pattern

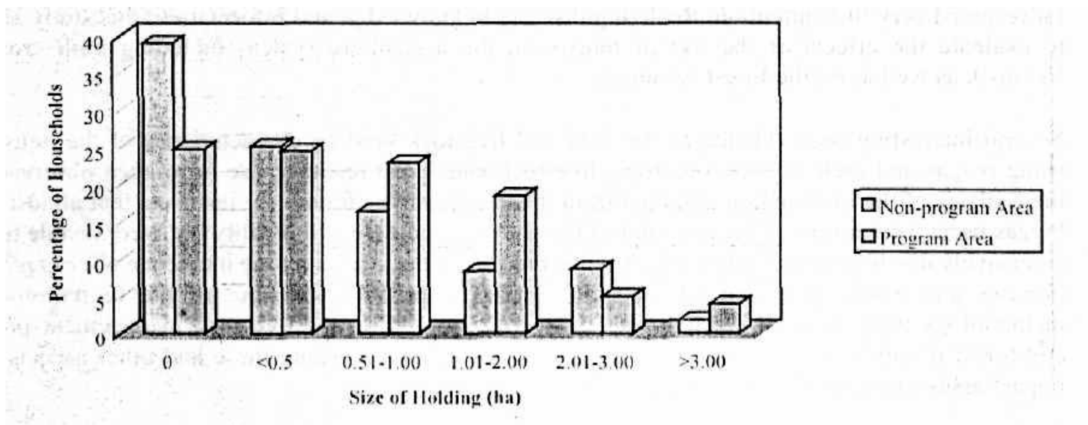
Cultivated Khet Land (ha)					Cultivated Bari Land (ha)			
Size of Holding (ha)	Non-biogas				Non-biogas		Biogas	
	Number	%	Number	%	Number	%	Number	%
0	234	30.1	149	24.8	355	59.2	331	55.2
<0.5	151	25.2	147	24.5	183	30.5	183	31.3
0.51-1.00	99	16.5	138	23.0	45	7.5	53	8.8
1.01-2.00	51	8.5	111	18.5	16	2.7	19	3.2
2.01-3.00	53	8.8	31	5.1	1	0.2	5	0.8
>3.00	11	1.8	24	4.0		0.0	4	0.7
Average size of holding	0.59 ha		0.79 ha		0.15 ha		0.22 ha	

The table shows that the average cultivated land in the Biogas area is 1.01 hectares (including khct and bari lands), whereas it is only 0.74 ha in the Non-biogas area. This means biogas households possess about 37 percent more land than Non-biogas households. Both khet and bari kinds of the households that own biogas are larger in size than those of the Non-biogas households. It is more interesting to note that the number of households cultivating 0.5 to 2.0 ha of khet land is much greater in (he Biogas area than in the Non-biogas area. On the other hand, there are more small and marginal farmers who own less than 0.5 ha of khet in the Non-biogas area. Only about 10 percent of the households cultivate more than 2.0 ha of khet land in both cases. No marked difference in the distribution of the bari land was apparent between the two groups of the surveyed households. This observation indicates that the households that own biogas plants are slightly better off than their counterparts in terms of their access to prime (khet) land.

[1] Lowland under paddy cultivation
[2] Upland cultivation

A clearer picture of the difference between the two groups of households in terms of their accesses to resources is given by Figure 5.1, which shows the khet kind holding patterns in the Biogas and Non-biogas areas.

Figure 5.1 - Khet Land Holding Pattern



An analysis of the regional distribution of land holding among the surveyed households revealed that on an average, the per household land holding size (including khet and bari lands) in the Terai tended to be more than double the size in the Hills. As shown in Table 5.2, the Biogas IIH owned more land than the Non-biogas HH in both regions (sec Chapter VII, Section 7.4.2).

Table 5.2 - Land Holding Sizes by Hill and Terai Regions
(Total average holdings in Hectares)

Region	Biogas HH	Nun-biogas HH
Hill	0.54	0.36
Terai	1.20	0.89

5.2 Agricultural System mid Production

5.2.1 Crops and Copping Patterns

Cropping patterns vary according to the climatic conditions, land form, and availability of irrigation. Since the climatic conditions and land forms are more or less similar across the whole of the Terai, the cropping pattern in this region is largely dictated by the availability of irrigation. On the other hand, due to the highly variable topographical conditions prevailing in the Hills, ail three parameters, i.e. climate, land form and irrigation availability, vary widely over short distances. This leads to a larger number and wider distribution of cropping patterns in the Hills region than in the Terai. The dominant cropping patterns occurring in the Hill and Terai regions under irrigated and rainfed conditions are listed in Table 5.3.

Table 5.3 - Major Cropping Patterns

Irrigation Status	Hills	Terai
Irrigated	Rice - Wheat Rice - Legumes Rice - Oilseeds Rice - Rice - Fallow Rice - Rice- Wheat Maize - Rice - Fallow Off season vegetables -wheat or vegetables Rice-Main Season vegetable	Rice-Rice-Wheat Rice-Rice-Fallow Rice-Wheat Rice-Fallow Rice-Winter Vegetables Rice-Oilseeds Rice-Legumes
Rainfed	Maize/Millet Maize - Mustard Maize - Winter crops Maize + Potato - Winter crops Maize - Fallow Vegetable seeds	Maize-Rice Maize-Mustard Pigeonpea Cash Crops .

Source: LRMP 1985 and authors personal observation

Cardamom, coffee, ginger, citrus, tea, and sericulture (mulberry) arc the major perennial crops of the Hills and tropical/subtropical fruit trees and crops like mango, litchi, pineapples, jackfruits, sugarcane, etc. are grown commonly in the Terai, in the sampled area, normal cropping patterns as described above were observed to be in practice.

With a view to understand the farmers[1] preferences, they were asked what crops they grew during the various seasons of the year. The resulting data arc presented in Table 5.4, Table 5.5 and Table 5.6.

Table 5.4 - Crops Grown in Summer

Crop	% of farmers		
	Biogas Area		Non-biogas Area
	Before	After	
Paddy	90.5	90.5	81
Maize	84.2	84.8	78.7
Millet	31.3	31.7	31.7
Summer vegetables	45.7	43.7	44.8
Cash crops	12	12.8	5.7
Other crops	12.5	10.7	-

Table 5.4 shows that 90 percent of the respondents in the Biogas area and 81 percent in the Non-biogas area preferred to grow paddy in the summer. In general, this response reflects the proportional availability of the khet lands where rice can be grown in the two areas. Accordingly, paddy is the most dominant crop for the summer season followed by maize. Interestingly, about 45 percent of the respondents in both areas preferred to grow vegetables, both in summer and winter. Millet was the fourth crop and was followed by assorted cash crops and other minor crops (12% each). Though particular cash crop to be grown depends on the location, the majority of the respondents specifically mentioned potato. Other cash crops, depending on the locations, comprised of sugarcane, cardamom, ginger, tomato, and a number of vegetables.

Table 5.5 - Crops Grown in Winter

Crop	% of Farmers		
	Biogas Area		Non-biogas Area
	Before	After	
Wheat	71.5	71	64
Mustard	*55.3*	54.3	47.5
Bailey	13	13.5	8.3
Winter vegetables	46.2	44.2	44.7
Cash crops	3	2.7	
Other crops	15.2	15.2	5.8

Table 5.5 shows the most dominant crop for the winter season to be wheat followed by mustard. Winter vegetables were the third crop of choice. Barley, the fourth crop in the list was preferred by only about 8 percent *o\'* the farmers in the Non-biogas area as against 45 percent engaged in cultivating the third crop, winter vegetables. The trend was similar in the biogas households although the percentage figures are slightly higher. Considerably lower percentage of respondents reported the cultivation of cash crops in the winter. This is probably due to the limitation imposed by temperature particularly in higher altitudes.

Table 5.6 - Crops Grown in Spring

Crop	% of Fanners		
	Biogas Area		Non-biogas Area
	Before	After	
Early rice	12.3	12.3	9.7
Off-season vegetables	9	9	18.3
Pulses	23.7	23	26.0
Cash crops	1	0.8	2.8
Other crops	11.2	10.8	8.8

Table 5.6 indicates different type of crops grown in the Biogas and Non-biogas area in spring. The above table shows that pulses dominated during the spring season, and early rice was reported as only a second crop of choice. Off-season vegetables were preferred by 9 percent of the respondents in the Biogas area and quite surprisingly, by 18 percent in the Non-biogas area. Correspondingly lower percentage of people in the latter area preferred early rice. No shift in crop preferences as a result of biogas plant installation was spotted whatsoever except the fact that there was more per capita khet kind capable of growing rice available in the Biogas area.

In conclusion, it seems that the role of biogas is to enhance crop production through improved soil fertility management (including replacement of chemical fertilizers to a certain extent) rather than causing a radical change in the cropping pattern.

5.2.2 Crop Production

Table 5.7 summarizes the data depicting area allocated to various crops and their productions (average per household) before and after the installation of biogas plants in the Biogas area based on the information provided by the respondents.

Table 5.7 - Average Area, Production and Yields of Crops

Crop	Area (ha)		Production (Kg)		Yield (Kg/ha)	
	Before	After	Before	After	Before	After
Faddy	0.83	0.81	2954	2954	3574	3647
Wheat	0.41	0.41	716	721	1747	1754
Maize	0.46	0.46	777	773	1676	1666
Millet	0.30	0.31	400	445	1319	1442
Vegetables	0.10	0.10	781	731	8024	7477
Fruits	0.10	0.10	l967	1248	19567	12533
Cash crops	0.50	0.49	7557	8119	14997	16598
Others[1]	0.28	0.26				

The yields were calculated from the area and production figures. The data presented in the table show no significant differences with respect to these parameters. The slight increase in the yield of rice represents only 2 percent, which is not significant. The sign ificant decrease in yield of fruits may have other reasons than the use of biogas slurry. Thus, it is difficult to establish direct correlation between biogas plant installation and crop production and the results obtained are inconclusive. In order to quantify the effect of the use of bio-slurry on crop production, it is necessary to conduct properly designed field trials with adequate number of replications. The results obtained from the household survey records only the farmers' perceptions, and from the data shown in Table 5.7. It appears that the farmers are not quite sure of the effects.

5.2.3 Crop Production Potential under Different Scenarios

A recent experiment conducted in the Lalitpur district (Karki. 2001) concludes that the use of slurry at the rate of 10 tons per hectare increased maize yield by 10 percent and 20 tons per hectare use on cabbage increased its yield by 18 percent. Slurry compost was even more effective in increasing crop yields as its application at the rate of 10 tons per hectare increased maize yield by as much as 23 percent. Considering that the average size of biogas plants installed in the Hills is 7.85 cubic meters (Chapter III, Table 3.6) and that a cubic meter of plant volume produces 3750 kg of slurry (ter Heegde, 2001), the following calculation representing the increased crop production in the Hills condition under different scenarios was made (Table 5.8):

Table 5.8 - Production Potentials

Particulars	Crop	Unit	Number of Biogas Plants			Remarks
			1	47,830	605,467	*BSP Database*
A. Annual slurry output (Tons)			24.34	1,164.063	14.735.552	*No of plants * 6.49 * 3.75*
Increase in yield	Maize	t/ha	0.58	0.58	0.58	*Slurry applied @ 10 tons/ha*
	Cabbage	t/ha	10.02	10.02	10.02	*Slurry applied @ 20 tons/ha*
Increase in production	Maize	tons	1.4!	61.576	854.662	*(A/10 *0.58)*
	Cabbage	tons	12.19	583.196	17.382.512	*(A/20 * 10.02)*

As was already mentioned above, the slurry compost was even more effective in increasing the yields and production. In fact, the slurry compost treatment was the best among all other treatments including the application of a full recommended dose of chemical fertilizers. But at the moment there is no information available as to the quantity of slurry compost ava ilable from a given quantity of slurry. Also, information of this type is not available for Terai. Clearly, these are the areas where

[1] Among the other crops, most of he respondents reported growing mustard, pulses and potato.

attention needs to be paid urgently in the lulu re.

5.3 Fertilizer Use Patterns

Fertilizer use pattern in Biogas and Non-biogas area before and after installation of biogas has been presented in Table 5.9, while changes in trendy of use of different forms of fertilizers are illustrated in Figure 5.2.

The survey results indicate that the households in (he Biogas area were accustomed to using more fertilizer of all types than those in the Non-biogas area, even before the installation of biogas plants. In the Biogas area, the use of FYM and compost declined after the installation of the plants and the use of liquid and composted biogas slurry (called slurry compost) increased considerably to fertilize the crops and vegetables. The application level of chemical fertilizers was found much higher in the Biogas area before the installation of biogas plants than in the Non-biogas area, but their use appears to have declined slightly since the liquid and slurry compost became available to replace them. Although the amount of chemical fertilizers replaced by the biogas slurry appears to be small (only 9.9% in the sampled population), this is an encouraging trend that must be actively supported through research and extension efforts. The amount of slurry compost use in the Biogas area after the installation of biogas plants appeal's to be somewhat exaggerated which needs to be confirmed with a more purposive survey.

Table 5.9-Fertilizer Use Pattern

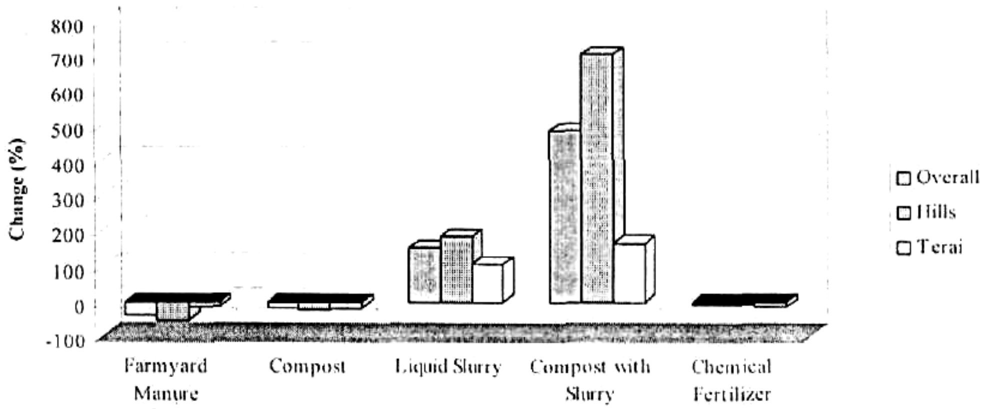
Fertilizer type	Region	Rate of use (Kg/ha/year)[1]			
		Non-biogas	Biogas		
			Before	After	Change
Farmyard Manure	*Overall*	*2975*	*3150*	*1960*	*-1190(38%)*
	Hills		3644	1709	-1935(53%)
	Terai		2595	2242	-353(14%)
Compost	*Overall*	*1015*	*1960*	*1575*	*-385(20%)*
	Hills		2320	1829	-491(21%)
	Terai		1557	129!	-266(17%)
Liquid slurry	*Overall*		*455*[2]	*1155*	*700(154%)*
	Hills		539	1525	986(183%)
	Terai		361	741	380(105%)
Compost with slurry	*Overall*		*770*	*4515*	*3745(486%)*
	Hills		868	6975	6107(704%)
	Terai		661	1 759	1098(166%)
Chemical fertilizer	*Overall*	*50*	*89*	81	*-8(9%)*
	Hills		51	46	-5 (9%)
	Terai		136	122	-14 (10%)

It is interesting to note that the reduction in the use of FYM and corresponding increase in the use of fertilizing materia ls based *on* bio-slurry is much more accentuated in the Hills than In the Terai.

[1] Average landholding per household is about 1 ha, which means that the average per household use is also equivalent to average per hectare use.

[2] While conducting the survey it was decided that the "before" situation referred lo three years before the date of survey which represented the time before the installation of biogas plants in the Biogas area. The small amount of slurry use "before" the plant installation points lo the fact that some biogas plants were already-installed and functioning more than three years before now.

Figure 5.2 - Changes in Use of Different Forms of Fertilizers After Biogas Plant Installation



The most important finding of this analysis is that at least 9 percent chemical fertilizer use is replaced by bio-slurry in the biogas households. With about 86,000 biogas plants operating now, this reduction means a saving of 774 metric tons of chemical fertilizers at present and a potential reduction of 13,500 metric tons at full development potential of about 1.5 million plants in the country.

5.4 Fertilizing Values of the Digested Slurry mid Composted Slurry

Taking the analytical values of nutrient contents of different types of fertilizing materials cited in Chapter II (Table 2.1 and Table 2.2) and the availability of liquid slurry and composted slurry in the biogas households (Table 5.9 above), a calculation was made to assess the fertilizing values of these materials available on a per household basis. While calculating the fertilizing value of the composted slurry, it was assumed that the equivalent quantity of FYM would have been used had the bio-slurry been not available. Thus, the difference in the nutrient contents between the composted slurry and FYM was taken as a factor to calculate its additional fertilizing value.

Table 5.10-Nutrient Contents mid Fertilizing Values of Digested (liquid) Slurry and Composted Slurry

	Unit	N	P2O5	K2O	Reference
A. FYM	(%)	0.8	0.7	0.7	Table 2.1 (Chapter II)
B. Digested slurry	(%)	1.6	1.55	1	Table 2.1 (Chapter II)
C. 700 ka slurry (refer to Table 5.9)	(kg)	11.2	10.85	7	(B *700/ 100)
D. Composted slurry	(%)	1.31	1.18	0.88	Table 2.2 (Chapter II)
E. Difference	(%)	0.51	0.48	0.18	(D-A)
F. 3745 kg composted slurry	(kg)	17.72	16.68	6.26	(E * 3745/ 100)
G. Total additional nutrients available per household per year	(kg)	28.92	27.53	13.26	(C + G)

Theoretically, the 700 kg increase in the use of digested biogas slurry and 3745 kg composted slurry after the installation of the biogas together amounts to an additional availability of about 29 kg of nitrogen, 28 kg of phosphorus and 13 kg of potash. Total plant nutrients available at different scenarios of biogas development, on this assumption, is presented in Table 5.1 1 below.

Table 5.11 - Plant Nutrients Available from Bio-slurry under Different Scenarios

Number of Biogas Plants	Available plant nutrients from liquid slurry and slurry compost (kg)		
	N	P_2O_5	K_20
1 Plant	28.9	27.5	m^3
86.000 Plants	2,137,500	2,062,500	997,500
1.5 Million Plants	43,350,000	41,250,000	19,950,000

5.5 Utilization of Bio-slurry

In this section, utilization of bio-slurry is discussed in the context of its effects on crop production, its application in different forms and its possible role *on* crop pes t and diseases and incidence of weeds.

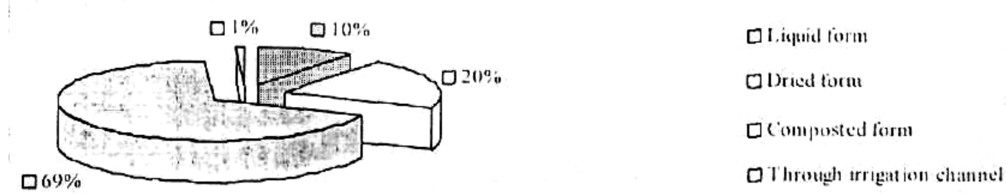
5.5.1 Use of Bio-slurry in Crop Produ ction

Information on the application of the bio-slurry in different forms, as reported by the respondents, are presented in Table 5.12 and figure 5.3.

Table 5.12 - Method of Bio-.slurry Applied

S.N.	Method of Application	Count	% of Responses
1.	hi liquid form	44	9.9
2	In dried form, not composted	92	20.6
3.	In composted form	306	68.6
4.	In liquid form through Irrigation Channel	4	0.9
	Total Responses	446	100

Figure 5.3 - Method of Slurry Application



The data presented in table 5.12 and Fig 5.3 clearly show that about 68 percent of the biogas farmers preferred using the slurry in composted form, while 20 percent used it in dried form. Only 10 percent of the respondents reported using liquid slurry directly to fertilize their crops. Only a negligible proportion (less than 1%) of the farmers reported applying the liquid slurry through irrigation channels, mostly for rice.

It is worth noting that using the slurry in liquid form is the best practice from the point of view of conservation of plant nutrients, but this practice has a limitation for wider adoptability due to the difficulty of transporting it to the fields. For this reason, the extension workers and biogas companies have encouraged the farmers to compost the liquid slurry. In fact, composting the slurry enables them to conserve plant nutrients, thereby augmenting the quality of organic fertilizer, as about 3 to 4 parts of-the organic residues can be composted with one part of slurry. Application of slurry in dried form is not normally recommended, as the nutrients (especially nitrogen) contained in it are lost, when dried in the sun.

The slurry use pattern is presented in Table 5.13 in a little more detail showing the preferences of the farmers as regards the crops and the forms in which the slurry is used.

Table 5.13 - Slurry Use Pattern By Crops and By Forms of Slurry

Crop	% of Respondents Using Slurry in				
	Liquid form	**Dried, not Composted**	**Composted**	**Through Irrigation Channels**	**Total**
Paddy	2.60	4.32	15.60	0.22	22.74
Wheat	1.82	2.12	11.82	0.00	15.76
Maize	2.15	7.16	20.76	0.30	30.37
Millet	0,61	1.44	3.42	0.07	5.54
Vegetables	2.02	3.57	10.60	0.15	16.34
Fruits	0.22	0.40	1.30	0.07	1.99
Cash crops	0	0.40	1.06	0.00	1.46
Others	0.6S	0.40	4.65	0.07	5.80
% Respondents	10.10	19.81	69.21	0.88	100

Table 5.13 shows that the biogas farmers are applying slurry in various crops, vegetables, fruits and cash crops in its different forms. The data indicates that most of the farmers prefer to use it to fertilize paddy (23%). wheat (16%), maize (30%) and vegetables (16%). Even among these four crops, maize received the highest priority.

The respondents put forth various reasons for not applying the liquid slurry in their fields (Table 5.14).

Table 5.14 - Reasons for not Using Slurry in Liquid Form

Reason	Count	% of Responses
Too wet. difficult to transport	50	27.2
New plant	47	25.5
Not aware of fertilizing value	26	14.1
Do not know application method	24	13.0
Toilet attached, too dirty to handle	18	9.8
Too little available to bother	11	6.0
No land	3	1.6
Other unspecified reasons	5	2.7
Total Responses	**184**	**100**

According to Table 5.14, 27 percent biogas farmers did not use liquid slurry, as they found it difficult to transport it to the fields in this form. About 25 percent of the respondents had new biogas plant and as yet, they did not have enough slurry for application. Fourteen percent of the respondents said that they were not aware of the fertilizing value of slurry in liquid form, while 13 percent were unaware of the method of application. Similarly, about 10 percent did not use the slurry because their plants were attached lo the latrines and they thought that the effluent was too unhygienic to handle. About 6 percent did not want to bother, as the quantity of slurry produced was too little.

5.6 Effect of Slurry on Crop Pests, Discuses and Weeds

It is generally believed that the use of raw or incompletely decomposed FYM encourages increased crop pests, diseases and weeds. Such an environment provides a favorable breeding ground for disease causing insects, pests and other organisms and a conducive atmosphere for the weed seeds to remain viable. On (he other hand il is believed that most of these undesirable objects are destroyed under the anaerobic condition prevailing during the digestion process of bio-slurry. Use of such a product would surely be much more desirable and beneficial than the traditional FYM and raw dung. Many studies in the past, (including Karki. A. 2000) have reported reduced insect, pest and weed infestations in crops due lo the use of bio-blurry.

An attempt to confirm this hypothesis through the present household survey produced an inconclusive result. This is probably due to the fact that many of the biogas plats are new and the fanners haven't had sufficient time to experience this effect in a conclusive manner. About 56 percent *oi'* the respondents said that they did not know whether the bio-slurry was better than FYM in this regard and about 25 percent did not perceive any change. Moreover, a household survey based on the opinion of the respondents may not be an appropriate loot to definitively answer this question. For this reason it is strongly recommended that a systematic research based on properly designed experimental procedures be conducted to resolve this issue,

5.7 Uses of Crop Residues

In the Nepalese farming communities, crop residues like rice and wheat straw, corn stalk, rice husk. elc are used for various purposes. A good proportion of such items are used as fuel for cooking. With the installation of biogas plants, it is expected that such materials would no longer he needed for cooking purposes and thus would be available for compost making and mulching. Table 5.15 summarizes the responses received on the question designed lo lest this hypothesis. The data obtained from the household survey regarding the uses of such crop residues is shown in the table. For the biogas households, the data has also been broken down by the I Mil and Mountain Regions.

Table 5.15 - Uses of Crop Residues

Purpose	Region	Use of Crop Residue (in %)		
			Biogas Households	
		Non-biogas Households	Before Biogas	After Biogas
Cooking	Hill		8.61	4.88
	Terai		12.28	10.62
	Total	**16.1**	**10.34**	**7.59**
Animal feed	Hill		84.59	87.4
	Terai		89.85	85.36
	Total	**83.8**	**87.07**	**86.44**
Composting	Hill		20.66	24.01
	Terai		18.97	24.7ft
	Total	**38.1**	**19.86**	**24.36**
Mulching	Hill		7.05	6.97
	Terai		7.17	7.08
	Total	**0.5**	**7.11**	**7.02**
Others	Hill		12.83	12.5
	Terai		9.49	9.52
	Total	**16.7**	**11.25**	**11.09**

These results suggest that in all cases most of the crop residues were used as animal feed. In the Non-biogas area, 83 percent of the respondents said that they used crop residues to feed their animals followed by composting (38%) and cooking (16%). About 87 percent of the households reported feeding the crop residues to the animals in the Biogas area. There was no real difference between the before and after situations in this respect. There appears to be some increase in the use of crop residues for preparing compost after the installation of the biogas plants. Only a negligible proportion of the crop residues are used in all cases for mulching purpose. About 11 to 15 percent reported using them for various other purposes, mostly to prepare FYM. A regional comparison shows an interesting fact that considerably greater proportions of the crop res idues were used as fuel for cooking in the Terai than in the Hills, even after the installation of the biogas plants. Uses for other purposes appear to be more or less similar in both regions.

5.8 Livestock Production

5.8.1 Livestock Holding Pattern

The situation on livestock holding in Biogas and Non-Biogas area is shown in Table 5.16.

Table 5.16 - Livestock Holding Pattern
(Average number of animals owned)

Animals	Non-biogas		Biogas			
			Before		After	
	Adults	Calves	Adults	Calves	Adults	Calves
Cattle	1.56	0.44	1.93	0.58	1.99	0.34
Buffalo	1.02	0.34	1.72	0.7	1.67	0.4
Pi-s	0.12	0.02	0.08	0.05	0.08	0.03
Goats/sheep	1.57	0.31	1-88	0.45	1.8	0.28

In general, the Table 5.15 shows that households in the Biogas area owned more cattle, buffalo, and goats/sheep on an average than those in the Non-biogas area. This indicates that the households that own relatively greater number of large animals (cattle and Buffalo) tend to install biogas plants in their households. In the Biogas area, some decreasing trend of livestock possession after the biogas plant installation was observed, but the differences appear to be very small (see Chapter VII, Section 7.4.1).

Table 5.17 - Cattle and Buffalo Holding Patterns in the Biogas Area

Number of Animals	Before				After			
	Cattle		Buffalo		Cattle		Buffalo	
	Number	%	Number	%	Number	%	Number	%
0	179	30.1	97	16.4	159	27.1	97	16.6
1	113	19.0	241	40.6	103	17.5	222	38.1
2	162	27.2	168	28.3	180	30.7	164	28.1
3	69	11.6	48	8.1	66	11.2	50	8.6
4	41	6.9	21	3.5	38	6.5	28	4.8
5	10	1.7	8	1.3	13	2.2	10	1.7
5+	21	3.5	10	1.7	28	4.8	12	2.1
Total	**595**	**100.0**	**593**	**100.0**	**587**	**100.0**	**583**	**100.0**

A more detailed analysis of the ownership patterns of cattle and buffalos, as depicted in Table 5.17, shows that the majority of the households in the Biogas area tended to own one to two cattle heads and/or one lo two buffalo on an average. Thus, be lore ins tallation of biogas. 46.2 percent households had possessed 1 to 2 cattle, which was increased by 2 percent after they have had biogas. In case of buffalo. 68 percent household had possessed 1 to 2 buffalo before biogas, which was decreased by 2.7 percent after biogas situation. It can be concluded from fable 5.17 that virtually there exists little difference in livestock situation before and after bio gas installation.

5.8.2 Livestock Feeding and Management Practices

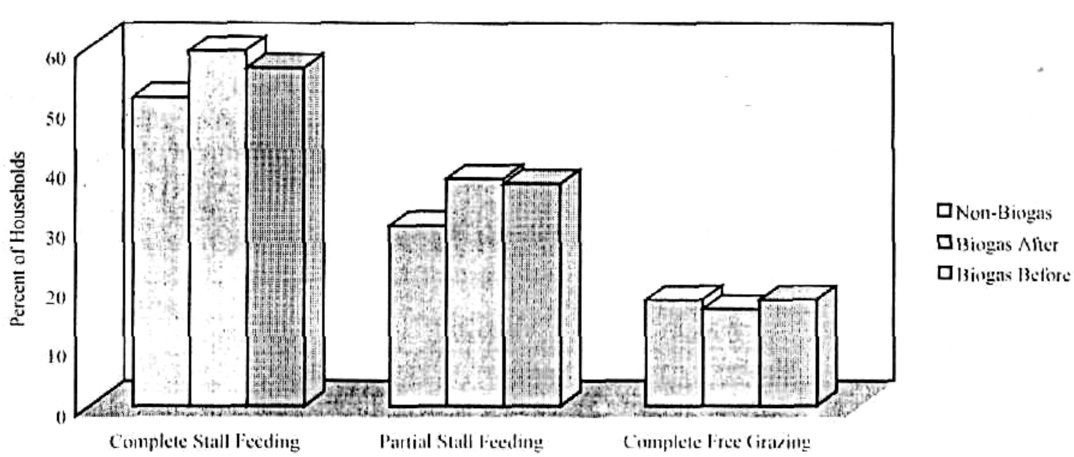
A. Feeding Practices

Table 5.18 and Figure 5.4 present a summary of the livestock feeding practices prevailing in the Non-biogas area as well as in the Biogas area both before and after installation of biogas plants.

Table 5.18 – Livestock Management Practices

Feeding Practice	%	Average No. of Animals
Non-biogas HH		
Complete stall feeding	51.7	1.83
Partial stall feeding	30.3	1.27
Complete free grazing	17.9	1.14
Biogas HH Before Plant Installation		
Complete stall feeding	56.6	2.34
Partial stall feeding	37.4	1.99
Complete free grazing	17.9	1.13
Biogas HH After Plant Installation		
Complete stall feeding	59.5	2.48
Partial stall feeding	38.2	1.74
Complete free grazing	16.3	0.91

Figure 5.4 Cattle Grazing Practices



As shown in Table 5.18 and figure 5.4, a slightly greater percentage of the households in the Biogas area pursued complete and partial stall-feeding practices than their counterparts in the Non-biogas area. This trend is also reflected in the average number of animals per household that are subjected to such practices. In the Biogas area, slight increases in complete and partial stall-feeding practices were observed after the installation of the plants with a commensurate decrease in the complete free gracing practice. The increases amounted to 2.9 percent and 1.2 percent, respectively, of complete stall-feeding and partial stall-feeding after the installation of the plants. On the other hand, complete free grazing was found to decrease by 1.6 percent.

It can be also be revealed from Table 5.18 that the percentages do not always add up to 100 possibly because the three management options are not mutually exclusive. Some households were found to subject some of their animals to complete stall-feeding and the rest to either partial stall-feeding or free grazing.

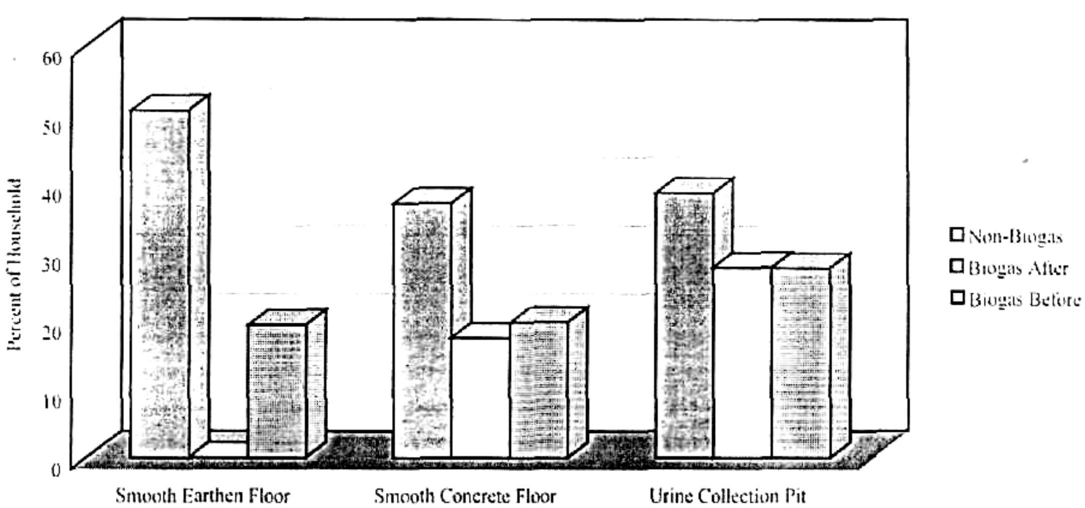
B. Condition of Cattle Sheds

The data presented in Table 5.19 and Figure 5.5 indicate the conditions of cattle sheds in the Biogas and Non-Biogas areas.

Table 5.19 - Condition of Cattle Shed

Shed Condition	Percentage of Respondents		
		Biogas	
	Non-Biogas	Before	After
A. Smooth earthen floor	50.7	37.2	38.7
B. Smooth concrete floor	-	17.5	27,8
C. Total improved floors (A+B)	50.7	54.7	66.5
D. Unimproved floors (100-C)	49.3	45.3	37.5
E. Urine collection pit[1]	19.4	19.8	27.7

Figure 5.5 Cattle Shed Conditions



It is important to have smooth floors in the cattle sheds for efficient collection of dung to be fed into the biogas plant. Table 5.19 shows that in the Non-biogas households, none of the respondents reported having smooth concrete floors in their cattle-sheds. On the other hand, a significant proportion of households with biogas plants already had smooth concrete floors even before the installation of the plants. After the installation of the plants, the percentage of households with smooth

[1] Existence of urine collection pit is treated as a different category and so it cannot be added up with the other two categories. On the other hand, the sum of the two categories "smooth earthen floor" and "concrete floor" together, represent improvement of the shed. The remaining households do not have improved cattle sheds.

concrete floor in their cattle sheds increased by 10.3 percent compared to before biogas situation. In ease of the urine collection pits in the cattle sheds, there was no difference between the households in the Non-biogas area and those in the Biogas area before the installation of the plants. But after the plant installation, the percentage of the households that had constructed urine collection pits increased by about 8 percent.

5.8.3 Fodder Availability and Use

Table 5.20 summarizes the data obtained from the household survey in the Biogas and Non-biogas areas. Fodder for feeding the animals and to a certain extent to be used as the bedding materials are normally available from either the nearby forests or from own production in the farms. The amount collected daily depends on the number of animals owned.

Table 5.20 - Fodder Collection

Source	Non-biogas		Biogas			
			Before		After	
	No. of Farmers	Kg/day	No. of Farmers	Kg/day	No. of Farmers	Kg/day
From forest	110	5.1	90	4.8	93	4.7
Own production	**389**	25.1	469	38.2	495	41.4

In general, it appears that more farmers are engaged in collecting fodder for their animals in the Biogas area than those in the Non-biogas area. This agrees well with the fact that a significantly greater number of households in the Biogas area own livestock than in the Non-biogas area as seen in Table 5.15. It is interesting to note that the average collection of fodder from the forest is more or less the same in all cases, while the households in the Biogas area obtain greater amount from their own production. Average own production appears to be 3.2 percent greater after the installation of biogas plants in (he Biogas households than before.

5.8.4 Water Consumption

Water consumption for cattle in the Biogas area before and after biogas installation is shown in Table 5.21.

Table 5.21-Water Use for Cattle
(In liters per household per day)

	Before	After
	Before	After
Non-biogas HH	40	
Biogas HH	61	65

The result of survey showed that in the Non-biogas area, the livestock consumed about 40 liters of water per day. In comparison, a considerably larger volume of water, on an average, was reported consumed by the livestock in the Biogas area. The increased amount of water consumption in the biogas area after the installation of the biogas plants was registered at 4 liters/day. This is in general agreement with the fact that there had been an increasing tendency of stall-feeding of animals after the installation of the plant as observed earlier in section 5.6.2.

5.8.5 Milk Production

The data on average milk production for domestic and commercial use have been described in table 5.22.

Table 5.22 - Average Milk Production
(In liters per day per household)

Purpose	Non-biogas	Biogas			
		Before		After	
		Summer	Winter	Summer	Winter
Domestic use	2.27	2.57	2.30	2.55	2.33
Commercial	1.04	1.14	1.06	0.99	0.91
Total	**3.31**	**3.71**	**3.36**	**3.54**	**3.24**

Table 5.22 shows that the households in the Biogas area produce somewhat higher amount of milk both for domestic and commercial purposes than those in the Non-biogas area. No appreciable changes in production after the installation of the biogas plants were detected in the Biogas area before and after installation of biogas and also during summer or winter.

5.9 Forest Resources

5.9.1 Effect of Dingus on Fuelwood Consumption

The effects of biogas installation on fuel wood consumption have been dealt with in detail in Chapter III. The result of the survey shows about 50 percent reduction in fuelwood consumption due to biogas plant installation.

Out of the 22 community level discussions held in the Terai region, 17 (77%) reported significant decrease in the collection of wood for fuel from nearby forests. The percentage of reduction ranged from 25 to 75 with a weighted average of about 50 percent. Similarly, in the hills, about 70 percent of the communities consulted reported decrease in fuel wood collection from the forests and the average reduction worked out to nearly 35 percent. The remaining communities said that there had been no change in fuelwood collection from the forests in their areas.

Table 3.10 (Chapter III) indicates that as a result of the installation of biogas plants, the reduction of fuel wood consumption per household per day amounted to 5.54 kg in the summer and 6.47 kg in the winter in the Hills region. The corresponding figures for the Terai are 3.39 kg in the summer and 7.55 kg in the winter seasons. Taking simple averages, fuelwood saved through the use of biogas is calculated at 6 kg per household per day for the Hills and 5.47 kg per household per day for the Terai. At these rates, the annual reduction in the use of fuel wood from an average biogas households amount to 2190 kg in the Hills and 1997 kg in the Terai regions. With the assumption that 32.7 metric Tons of firewood is harvested per hectare of forest per annum (IUCN 1995), an estimation of the existing and potential impact of biogas on the protection of forest is made and presented in Table 5.23.

Table 5.23 - Impact of Biogas on Forest Area

Particulars	Hills	Terai	Nepal	Remarks
A. Fuel wood saved	6	5.47		
15. Animal savings'	2.190	1.997		*A * 365/1000*
C. Tutal saving at present (Tons/Year)	104,748	77,024	181,772	*B * 47,30 for the Hills; B * 38.570 for Terai*
D. Potential saving at full development (Tons/Year)	1,325,973	1,781,174	3,107,147	*B * 605,467for the Hills; B* 891.925 for Terai*
E. Equivalent forest area protection al full development	40,550	54,470	95,020	*D / 32.7(32.7 MT firewood harvest per ha)(IUCN, 1995)*

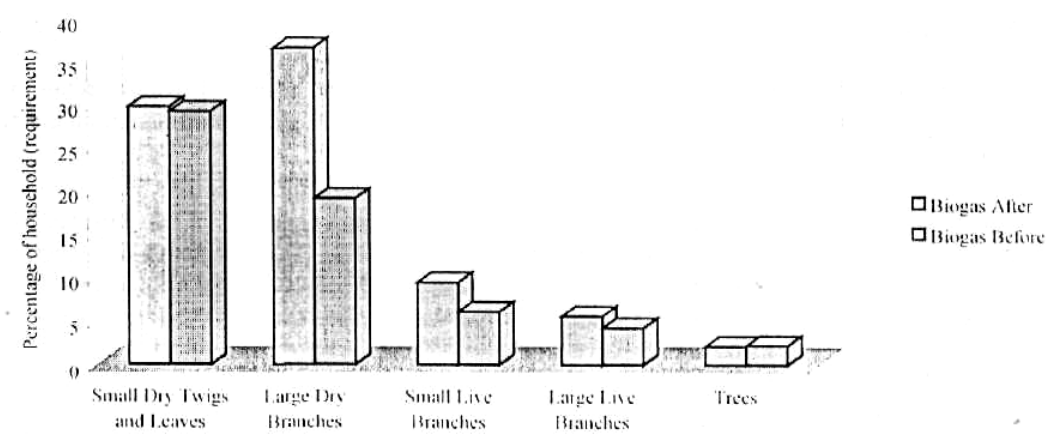
5.9.2 Types of Wood Used for Fuel

Relevant data on the types of wood collected from the forest for household uses are illustrated in Table 5.24 and Figure 5.6.

Table 5.24 - Types of Wood Used for Fuel
(Percent of Total Household Requirement)

Type of Wood	Before	After
Small dry twigs and leaves	29.63	29.08
Large dry branches	36.49	18.95
Small live branches	9.25	5.98
Large live branches	5.48	4.17
Trees	2.1 1	2.19

Figure 5.6 Types of Wood Used for Fuel



It becomes clear from Table 5.24 and Figure 5.6 that most of the respondents, both before and after the installation of biogas plants, collected small dry or dead twigs, some larger dry branches of trees and leaves mostly from the forest floors. Although fewer respondents reported collecting twigs and leaves after the installation of the plants, the percentage requirement of the households met from this source did not change. The collection of large, dry branches and small and large live branches of trees appear to be reduced significantly, both in terms of number users as well as in percentage per household, after the installation of the biogas plants. Curiously enough, the use of whole trees, although small in both cases, appeared to be unchanged. This indicates that the trees are collected for other purposes (such as construction) that are not related to biogas.

5.9.3 Collection of Non-timber Forest Products (NTFP)

It is generally assumed that with the increased use of biogas in the rural households, the degradation of forests in the vicinity would be countered. This would then result in the increased availability and collection of non-limber forest products (NTTT). Al the same time, however, it is necessary to keep in mind that with the increased awareness about the need to protect the forests and effective forest protection measures taken in most of the community forests, indiscriminate collection of NTFPs are being discouraged. This situation led to the realization, at the outset, that it would be difficult to collect reliable data on this aspect and to relate it directly to the installation and use of biogas plants through the questionnaire at the household level. Therefore, it was decided to collect such information through community level discussions. The results obtained from such discussions on the patterns of collection of NTFPs are summarized in Table 5.25.

Table 5.25 - Collection of Non-timber Forest Products

Description	Increased (%)	Decreased (%)	No Response (%)
Food items	50	18	32
Medicinal herbs and spices	50	15	35
Raw materials for cottage industry	47	21	32

Out of the 38 communities where the discussions were held, 50 percent reported increased collection of food items, herbs and spices from the forests and just below 50 percent reported increased collection of raw materials for cottage industries. At the same time, quite a substantial proportion (15 to 21% of the respondents) reported decreased collection of such items. It is interesting to note that almost a third of the communities did not respond to this query, most probably because they are not used to collect NTFPs.

5.9.4 Encroachment of Forest for Agricultural Purposes

The information regarding the conversion of forest land to agriculture was also obtained from the community level discussions. The extent of the encroachment of forest areas for agricultural purposes, as perceived by the communities, is shown in Table 5.26. The table shows that while 21 percent of the communities interviewed in the Hills reported conversion of forest area into agriculture during the past three year period, the corresponding figure for the Terai was 45 percent. Actual area converted ranged from 0.5 to 2.5 hectares in the Hills and 3.5 to as much as 84 hectares in the Terai. This clearly shows that there exists a much more serious problem of forest encroachment in the Terai than in the Hills.

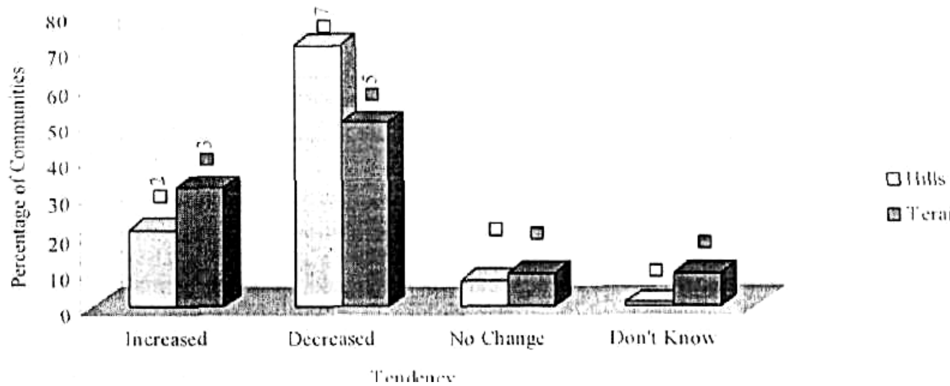
Table 5.26-Forest Encroachment for Agriculture

	Hills	Terai
% of communities reporting encroachment	21	45
Estimated area encroached (Range in ha.)	0.5 to 2.5	3.5 to 84

While Table 5.26 shows the present extent of forest encroachment for agriculture in the Hill and Terai communities Figure 5.7 illustrates the trend of encroachment which is likely to continue into the future as well. The figure shows that a very high proportion of the communities are experiencing a decreasing tendency of forest encroachment. The Hills communities appear to be more advanced in this respect as it is seen that 71 percent of these communities as opposed to only 50 percent of the Terai communities experienced this decreasing trend. This is also supported by the finding that 32 percent of the Terai communities reported increased tendency of encroachment as opposed to only 21 percent of the Hill communities (Figure 5.7).

Increased population pressure and occupation by the landless squatters were cited by the communities as the main reasons for the encroachment of the forests for agricultural purposes. On the other hand, the decreasing trends of forest encroachment were attributed to the following reasons: successful implementation of community forestry programmes, strong forest protection measures, increased awareness about the need to protect the forests, and the proliferation of the use of biogas. Thus, it appears that while biogas definitely plays a positive role in forest protection, it is not possible, at this moment, to attribute such effects only to the use of biogas because other programmes like the community forestry also play a major role in this.

Figure 5.7 Tendency of Forest Encroachment



5.9.5 Forest Fires

Table 5.27 presents the data on the occurrences of forest fires in the communities interviewed, both in the Hills and in the Terai. The Table clearly shows much more frequent forest fires that occur in the Terai region than in the Mills. Most of the Hill communities (93%) experience forest fires once every two to three years, while the majority of the Terai communities (62 %) report forest fire occurrences every year. The 14 percent of the Terai communities who say that it is not applicable u> them really mean that they have no easy access to the forests,

Table 5.27 - Occurrences of Forest Fire

Frequency	% Communities	
	Hills	**Terai**
Every year	-	**62**
Every 2-3 years	**93**	**14**
Once in less than 3 years	**7**	**9.5**
NA*	-	**14**

* These represent the communities that have no easy access to forests within their neighborhoods, particularly in the Terai.

As regards the area affected, the communities in the Terai reported damages by forest fires ranging from 0.7 lo 3.5 hectares, whereas those in the I Mils said that they had lost from 0.5 to 10 hectares. The larger area affected in the Hills probably means that once started, it is very difficult to contain the fires in the Hills than in the Terai. In terms of frequency of occurrence, however, it is quite logical to expect much more frequent fires in the much drier conditions of the Terai than those in the Hills.

5.10 Land Use Changes

Trends of land use changes in the surveyed area were analyzed from the responses obtained from the community level discussions. The results are illustrated in Figure 5.8 which provides a trend comparison between the Hill and Terai regions.

Figure 5.8a Land Use Changes in the Hills

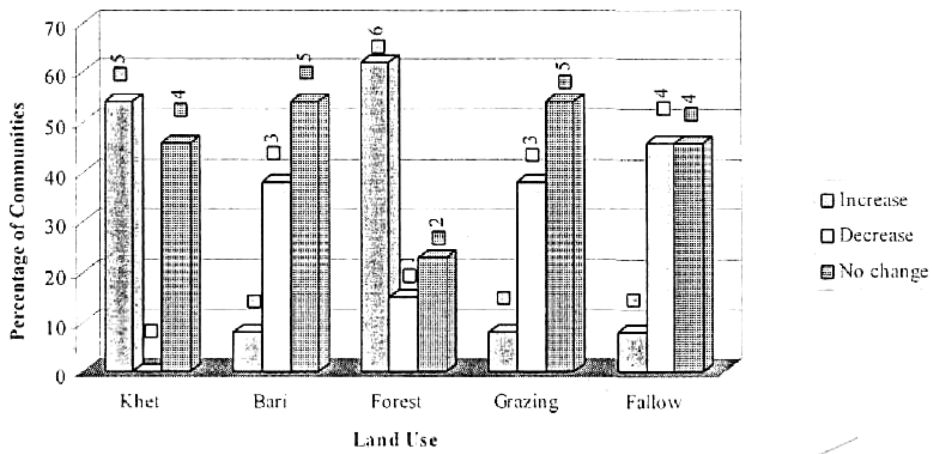
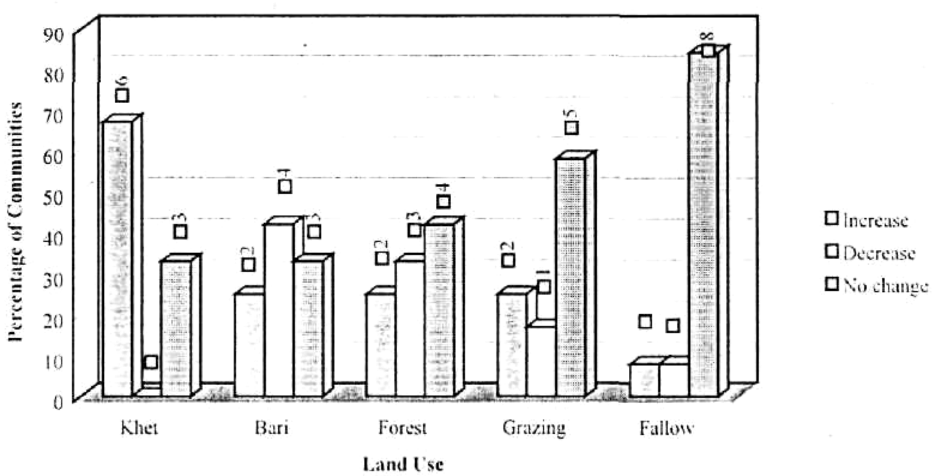


Figure 5.8b Land Use Changes in the Terai



The figure shows the percentages of communities that responded in terms of whether there had been an increase, decrease, or no change in the particular land use type under question. In other words. 54 percent of the communities interviewed in the Hills said that there had been considerable increase in the khet land cultivation type in their community, none said that there had been a decrease, and 46 percent said there had been no noticeable change. From Figure 5.8a and Figure 5.8b, it becomes clear that in both regions there had been a tendency of an increase in the khet land cultivation. One encouraging finding is that in the Hills people reported a healthy increase in forestland use. Although some increase in forest use was reported in the Terai, a greater proportion of the communities experienced decreased forestland in their communities. These findings point to a possibility that the khet land increase in the Hills was achieved through the conversion of the bari land and parts of the grazing and fallow lands had regenerated into forests. In case of the Terai, however, the khet land increase has occurred at the expense of the forest. Most of the fallow land in the Terai has remained unchanged.

CHAPTER VI
IMPACTS ON CLIMATE CHANGE

CHAPTER VI
IMPACTS ON CLIMATE CHANGE

Global warming and the ensuring climate change is one adverse example of environmental transformation brought about by human society's interference. Once, all climate changes occurred naturally. However, the onset of the Industrial Revolution led to the beginning of altering of our environment and climate through changing agricultural and industrial practices. The ever increasing population explosion, fossil fuel burning, and deforestation has resulted in the alteration of the chemical composition of the atmosphere through the build-up of greenhouse gases - primarily carbon dioxide, CFCs, methane and nitrous oxide. The increased atmospheric concentration of these greenhouse gases has significantly raised the threat of global warming. Studies have indicated that the global mean surface temperatures have increased 0.5-1.0°F since the late 19th century. The 20th century's 10 warmest years all occurred in the last 15 years of the century. [1] It has been calculated that a doubling of carbon dioxide concentration would lead to an increase in temperature ranging anywhere from 1.5 °*C* to 4.5 °C (Kojima 1998). Such observations and predictions have succeeded in projecting global warming as one of the most serious environmental problem facing the world today.

Growing concern about the effects of climate change has led to increasing research, policy initiatives, and development of innovative programs and projects around the world. One such mitigating measure is the substitution of biomass and fossil fuels with alternative energy sources with lower global warming commitment. Biogas is one such alternative, especially in the rural communities, which offer the opportunity of providing a renewable source of household energy with extremely low global warming commitment (Smith et. a!. 2000). This chapter aims at assessing the carbon emissions saved after the substitution of various traditional biomass fuels and fossil fuels by biogas.

6.1 Carbon Emission Saved from the Decrease in Use of Fuelwood

Because of their poor combustion conditions, the traditional stoves using fuelwood are thermally inefficient and thus divert a significant portion of the fuel carbon into products of incomplete combustion (PICs), which generally have a greater impact on climate than CO_2. A study done by Smith et. al. (2000) indicates that a kilogram of wood burned in a traditional mud stove generates 418 gram Carbon (g -C) equivalent of Carbon emission[2]. Hence, the decrease of fuelwood by 3.39 kg in summer and 7.55 kg in winter, in case of Terai, corresponds to the reduction of 1419 g -C and 3160 g -C equivalent of Carbon emission per day per household in summer and in winter respectively. Similarly, in case of the Hills there has been a reduction of 2319 g -C and 2708 g -C equivalent of Carbon emission per day per household in summer and in winter respectively. The regional variation of Carbon emission saved and its break-up into different Carbon forms is shown in Table 6.1.

The stuck assessed the carbon emission saved from the decrease in kerosene consumption, which is presented in Table 6.1 and Figure 6.1/6.2.

Table 6.1 - Carbon Emission Saved from the Decrease in Use of Fuelwood

Region	Carbon Emission Saved per day per Household (g-C)									
	CO_2		PIC Carbon		TSP Carbon		Char/Ash		Total Carbon	
	In Summer	In Winter	In Summer	In Winter	In Summer	In Winter	In Summer	In Winter	In Summer	In Winter
Terai	1286	2865	124	276	3	7	5	12	1419	3160
Hills	2102	2455	202	236	5	6	9	10	2319	2708

[1] http://www.epa.gov/globalwarming/
[2] The figure is for Acacia

Figure 6.1 Carbon Emission Saved from Reduction of Fuelwood in Summer

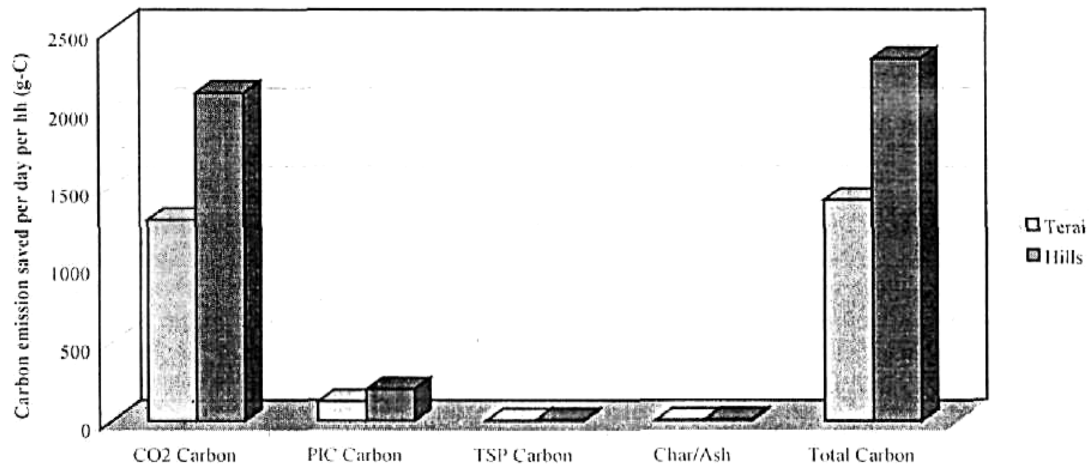
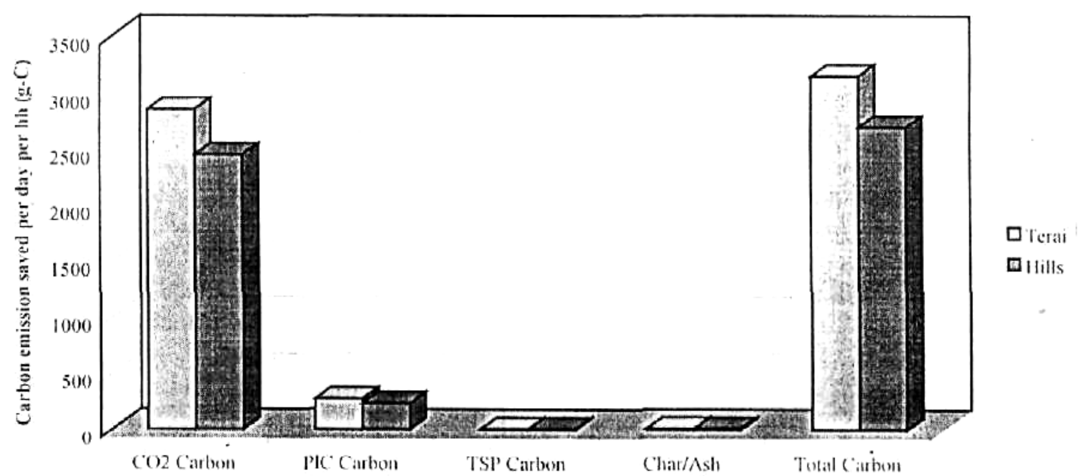


Figure 6.2 Carbon Emission Saved from Reduction of Fuelwood in Winter



A study carried out by Smith ct. al. (2000) indicates that a kilogram of kerosene binned in a pressure stove generates 843 gram Carbon (g -C) equivalent of Carbon. Hence, the decrease in kerosene consumption by 0.30 and 0.33 kg in Terai during summer and winter respectively corresponds to the reduction of 253 and 278 g -C equivalent of Carbon per day per household. Similarly, in the Hills the decrease in kerosene consumption contributes to the reduction of 304 and 312 g -C equivalent of Carbon per day per household in summer and in winter respectively.

6.2 Carbon Emission Saved from the Decrease in Use of Agricultural Residues

The decrease in consumption of agricultural residues as fuel contributes significantly in reducing the Greenhouse gases (GHGs) as the global warming commitment (GWC) of using agricultural residues, as fuel is much higher as compared to biogas stoves. Studies have shown that a kilogram of agricultural residue[1] burned in a traditional mud stove generates 381 gram Carbon (g -C) equivalent o Carbon emission (Smith et. al., 2000). The study result is shown in Table 6.2 and Figure 6.3./6A

Table 6.2 - Carbon Emission Saved from the Decrease in Use of Agricultural Residues

Region	Carbon Emission Saved per day per household (g-C)									
	CO_2 Carbon		PIC Carbon		TSP Carbon		Char/Ash		Total Carbon	
	In Summer	In Winter	In Summer	In Winter	In Summer	In Winter	In Summer	In Winter	In Summer	In Winter
Terai	1283	1283	111	111	3	3	2	2	1399	1399
Hills	665	-190	57	-16	2	-1	1	-1	725	-207

Figure 6.3 Carbon Emission Saved from the Reduction of Use of Agricultural Residue (Summer)

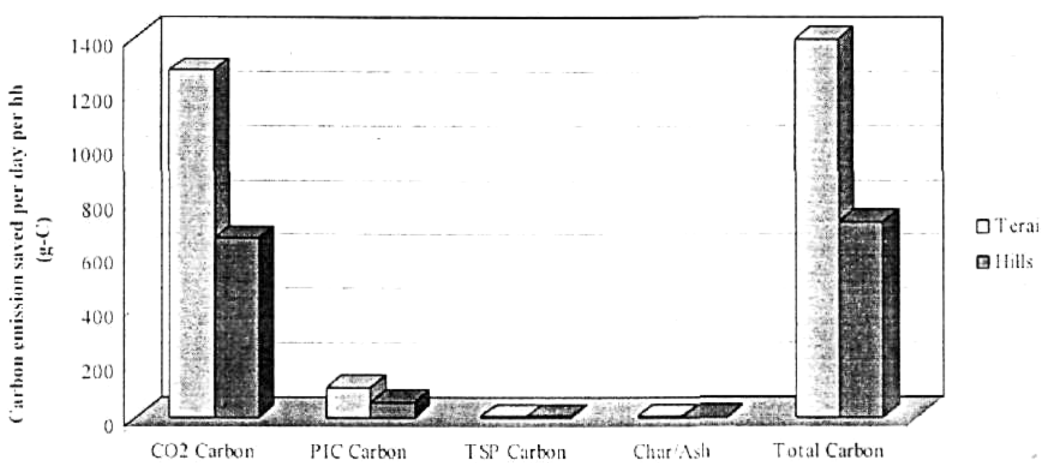
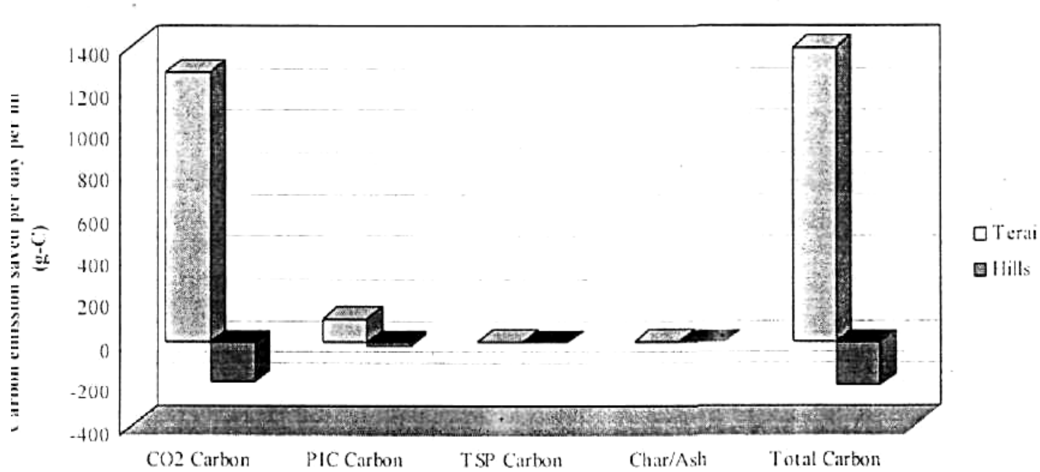


Figure 6.4 Carbon Emission Saved from the Reduction of Use of Agricultural Residue (Winter)



[1] The figures are for rice stalks

Above findings show that the decrease of agricultural residue by 2.7 kg in Terai corresponds to the reduction of 1399 g -C equivalent of Carbon per day per household. Similarly, in the Hills during summer the decrease of agricultural residues by 1.4 kg is equal to the reduction of 725 g -C equivalent of Carbon per day per household. However, during winters the Hills experience an increase in Carbon emission from agricultural residues by 207 g -C equivalent of Carbon per clay per household.

6.3 Carbon Emission Saved from the Decrease in Use of Dung

Dung is considered as the lowest quality fuel in the 'household energy ladder' (Smith et. al. 2000) with the highest global warming commitment (GWC) among the common household fuels. A study carried out by Smith et. al. (2000) has concluded that a kilogram of thing burned in a traditional mud stove generates 334 gram Carbon (g -C) equivalent of Carbon emission.

Table 6.3 present the survey results on Carbon emission saved from the decrease in use of dung have been presented in Table 6.3 and Figure 6.5/6.6.

Table 6.3 - Carbon Emission Saved from the Decrease in Use of Dung

Region	Carbon Emission Saved per day per Household (g-C)									
	CO_2 Carbon		PIC Carbon		TSP Carbon		Char/Ash		Total Carbon	
	In Summer	In Winter	In Summer	In Winter	In Summer	In Winter	In summer	In Winter	In Summer	In Winter
Terai	5714	6022	111	819	33	35	294	310	6818	7186
Hills	5014	5014	682	682	29	29	258	258	5982	5982

Figure 6.5 Carbon Emission Saved from the Reduction of Use of Dung (Summer)

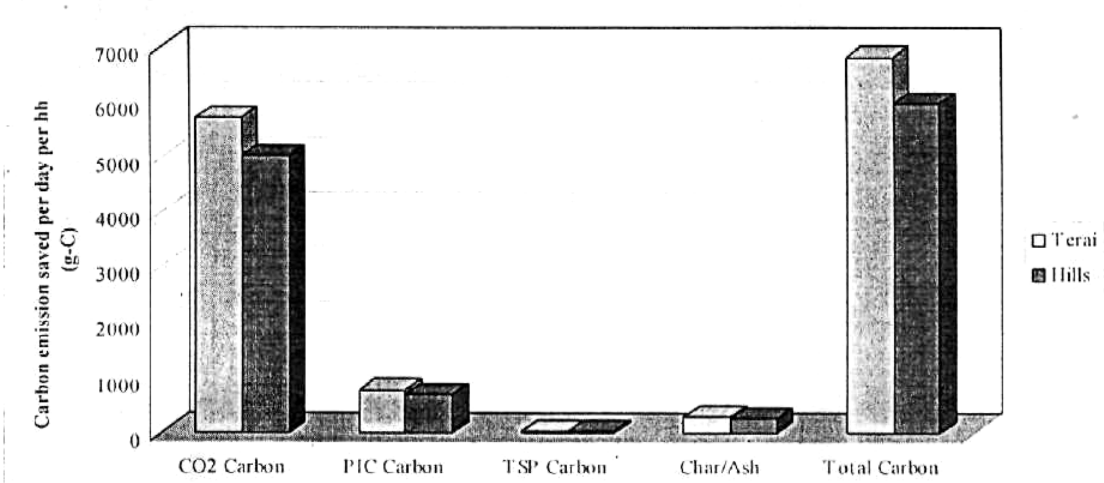
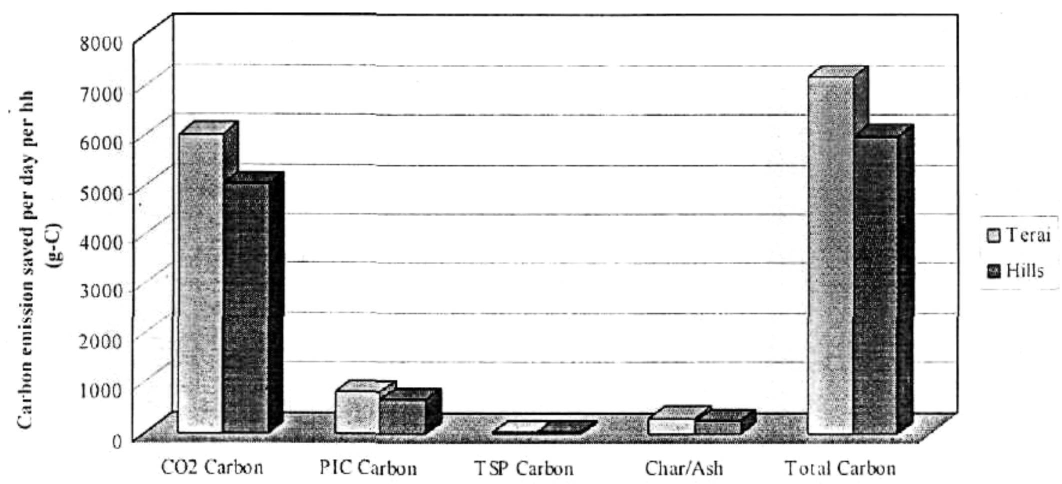


Figure 6.6 Carbon Emission Saved from the Reduction of Use of Dung (Winter)



It can be revealed from above data that the decrease in use of dung by 20.4 kg and 21.5 kg in Terai during summer and winter respectively corresponds to the reduction of 6818 and 7186 g -C equivalent of Carbon per day per household. Similarly, in the Hills the decrease in use of dung by 17.9 kg is equal to the reduction of 5982 g -C equivalent of Carbon per day per household.

6.4 Carbon Emission Saved from the Decrease in Use of Kerosene Consumption

A study carried out by Smith et. al. (2000) indicates that a kilogram of kerosene burned in a pressure stove generates 843 gram Carbon (g -C) equivalent of Carbon. Hence, the decrease in kerosene consumption by 0.30 and 0.33 kg in Terai during summer and winter respectively corresponds to the reduction of 253 and 278 g -C equivalent of Carbon per day per household. Similarly, in the Hills the decrease in kerosene consumption contributes to the reduction of 304 and 312 g -C equivalent of Carbon per day per household in summer and in winter respectively.

The study assessed the carbon emission saved from the decrease in kerosene consumption, which is presented in Table 6.4 and Figure 6.7/6.8.

Table 6.4 - Carbon Emission Saved from the Decrease in Kerosene Consumption

Region	Carbon Emission Saved per day per Household (g-C)									
	CO_2 Carbon		PIC Carbon		TSP Carbon		Char/Ash		Total Carbon	
	In Summer	In Winter	In Summer	In Winter	In Summer	In Winter	In summer	In Winter	In Summer	In Winter
Terai	241	265	12	13	0.2	0.2	0	0	253	278
Hills	289	297	14	15	0.3	0.3	0	0	304	312

Figure 6.7 Carbon Emission Saved from the Reduction of Kerosene (Summer)

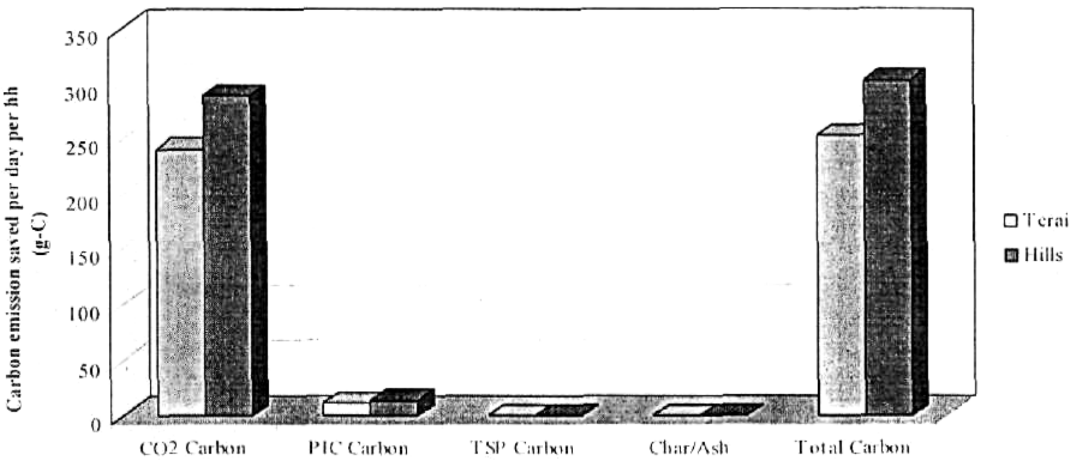
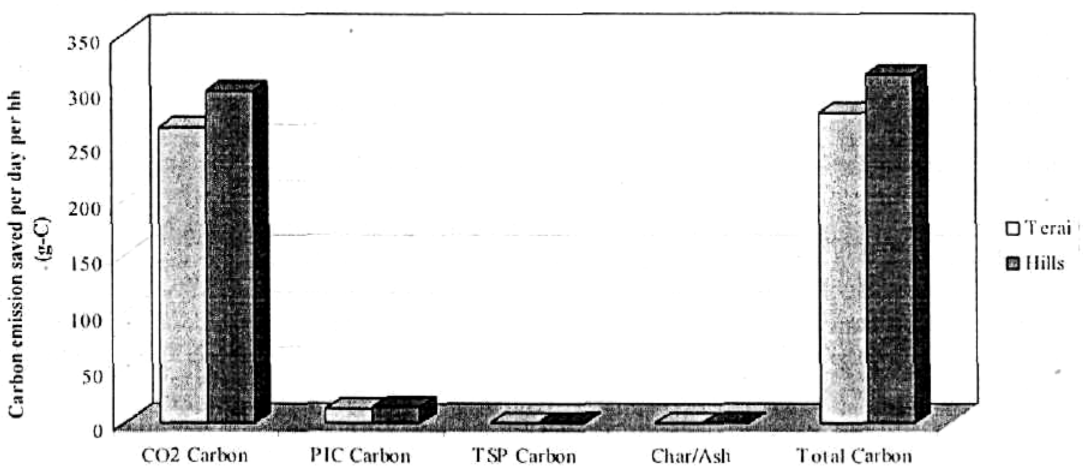


Figure 6.8 Carbon Emission Saved from the Reduction of Kerosene (Winter)



6.5 Carbon Dioxide Emission Reduction at National Level

The reduction in carbon emission from the reduction *of* various conventional fuels after the introduction of biogas at the household level has already been dealt with in the previous paragraphs. On the basis of these household - level replacement values, the potential replacement values at the national level has been assessed for three different scenarios (Table 6.5). The first (Scenario I) is for the present scenario with about 86,000 installed biogas plats. The second (Scenario II) focuses on the target of the third phase of BSP, which is 100,000 biogas plants. Finally, the third (Scenario III) is a long-term scenario focusing on the future situation when the technically feasible 1.3 million biogas plants will be installed.

Table 6.5 - Carbon Dioxide Emission Saved from the Decrease in Use of Conventional Fuels

Fuels	Average daily CO_2 reduction per household (g-C)	CO2 reduction at national level (mil. g-C / day)		
		Scenario I	Scenario II	Scenario III
Fuelwood	2,177	187	218	2,830
Agricultural residue	760	65	76	990
Dung	5,440	468	544	7,070
Kerosene	213	18	21	280
Total		**738**	**859**	**11,170**

Table 6.5 shows that at present (Scenario I) 738 million-gram equivalent of Carbon dioxide emission is being reduced everyday at the national level. Once the BSP III targets are achieved (Scenario II), there would be a daily saving of about 859 million-gram equivalent of Carbon dioxide emission. Similarly, when all the technically feasible biogas plants will be installed (Scenario III), these plants will lead to the daily saving of 11,170 million-gram equivalent of Carbon dioxide emission.

Table 6.5 also clearly indicates that, in case of Nepal, the replacement of animal dung as fuel has contributed to the maximum deduction in Carbon dioxide emission followed by the reduction in use of fuelwood. From the above results it can be concluded that replacement of kerosene by the biogas plants has not contributed much in the reduction carbon dioxide. However, it needs to be noted that kerosene has much more Carbon dioxide emission per unit fuel input than all other conventional fuels (Smith et. al. 2000). As at present the use of kerosene is negligible as compared to the use of other conventional fuels. Carbon dioxide reduction by kerosene may seem to be insignificant. But if the biogas plants had not been introduced, it is very probable that with increasing scarcity of fuelwood and easy access of kerosene in future, many households would have shifted to kerosene as a fuel source; thus causing high carbon dioxide emission. When analyzed from this point of view, biogas plants can be accredited with a potential of even greater carbon dioxide emission saving.

CHAPTER VII
IMPACTS ON SOCIO-ECONOMIC CONDITIONS

CHAPTER VII
IMPACTS ON SOCIO-ECONOMIC CONDITIONS

Various studies have been done in the past to assess the socio-economic conditions of biogas users. (see Bibliography). However, it appears that little effort has been made to compare the socio-economic status between users and non-users of biogas. Hence this chapter fulfills this gap by focusing the differences in socio-economic status of the biogas users and non-users. In doing so, established socio-economic criteria and parameters further supported by the literature and the relevant work done in the past has been taken into account.

7.1 Ethnicity of the Household

The data on ethnicity of the sampled biogas household have been given in Table 7.1.

Table 7.1 - Ethnicity of SHS Households

S.N.	Ethnicity	Percent
1.	Brahmin	53.2
2.	Chhetri	17.8
3.	Magar	7.5
4.	Tamang	4.5
5.	Newar	4.5
6.	Gurung	2.2
7.	Rai	1.8
8.	Tharu	1.0
9.	Others	7.5
	Total	**100.0**

Table 7.1 shows that among the sampled biogas households, there was the dominancy of Brahmin and Chhetri compared to other ethnic groups. Thus combined percentage of Brahmin (53.2%) and Chhetri (17.8%) comprised of 71 percent in the sampled biogas HHs.

This finding is in agreement with various Biogas Users Surveys conducted by BSP and AEPC from 1992/1993 to 2000/2001 in which the average combined percentage of Brahmin and Chhetri in the sampled areas was found to be 76 percent (NEPECON, 2001 pp 10-3).

According to Table 7.1 after Brahmin and Chhetri, Magar comes in the third category comprising of 7.5 percent. In the sampled biogas HHs, each of two ethnic groups namely Tamang and Newar was found to be 4.5 percent whereas Gurung, Rai and Tharu consisted of 2.2, 1.8 and 1.0 percent respectively. The less advantaged ethnic groups that included Kami, Damai and Kumal covered the remaining 7.5 percent.

7.2 Average Family Size and Sex of Household Head

7.2.1 Average Family Size

The result of the survey revealed that average family size of the sampled biogas HH was 7.17 compared to 6.18 in case of non-biogas households. Thus, examining the difference in the family size between users and non-user of biogas, it can be deduced that the average size of biogas family is slightly larger than that of non-users.

7.2.2 Sex of the Household Mead

The data on the percentage of male and female of the sampled area of biogas and non-biogas HH has been shown in Table 7.2 and Figure 7.1.

Table 7.2- Sex of Household Head

Sex	Biogas HH		Non-Biogas HH	
	Frequency	Percent	Frequency	Percent
Male	546	91.0	536	89.3
Female	54	9.0	64	10.7
Total	**600**	**100.0**	**600**	**100.0**

Figure 7.1 Sex of Household Head

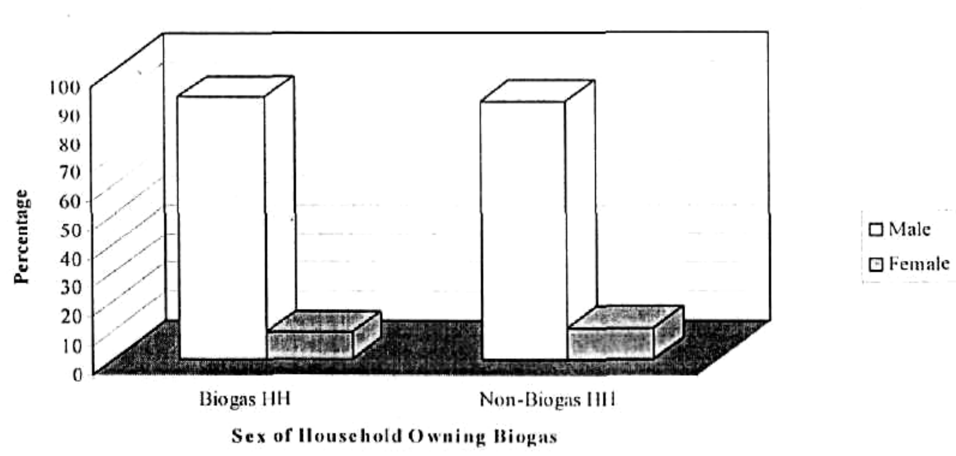


Table 7.2 and Figure 7.1 show that in case of sampled biogas HHs, males HHs possessed 91 percent plants, while only 9 percent females had their ownership. In case of non-biogas sampled HH, the percentage of female-headed households was found slightly higher (i.e. 1.7% more) than the biogas HHs.

7.3 Major Occupation and Education Level of Household Head

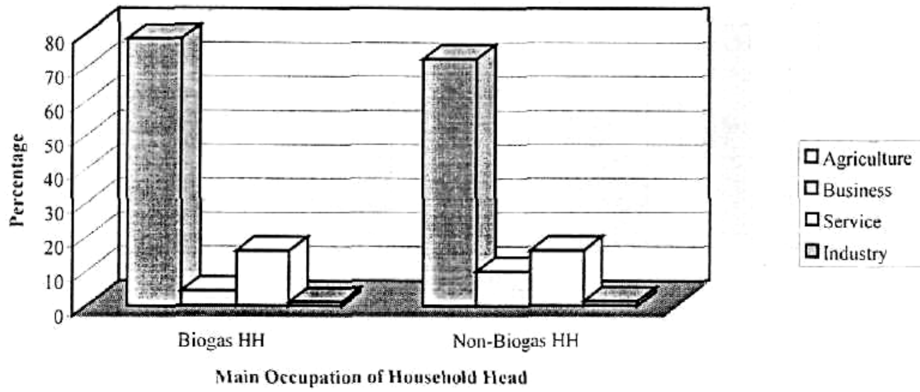
7.3.1 Major Occupation of the Household Head

Major occupation practiced by the household head of the users and non-users of biogas has been described in fable 7.3 and Figure 7.2.

Table 7.3 -Main Occupation of Household Head

S.N.	Description	Biogas HH		Non-Biogas HH	
		Frequency	Percent	Frequency	Percent
1.	Agriculture	465	78.4	427	72.5
2.	Business	26	4.4	59	10.0
3.	Service	95	16.0	95	16.1
4.	Industry	7	1.2	8	1.4
	Total	**593**	**100.0**	**589**	**100.0**

Figure 7.2 Major of Household Head



In general, no remarkable difference was found between main occupation of the household heads using or not using biogas. Agriculture was found to be the main occupation of ail the sampled households followed by service, business and industry. Table 7.3 and Figure 7.2 indicate that 78.4 percent of biogas HHs head has practiced agric ulture, while the percent was about 6.0 percent lower (72.5%) in case of non-users of biogas. On the other hand, the percent of household head undertaking business was 5.6% more in case of non-users HHs than users HHs. Only negligible percent of the sampled households are found involved in industry (1.2 to 1.4%).

7.3.2 Education Level of the Household Head

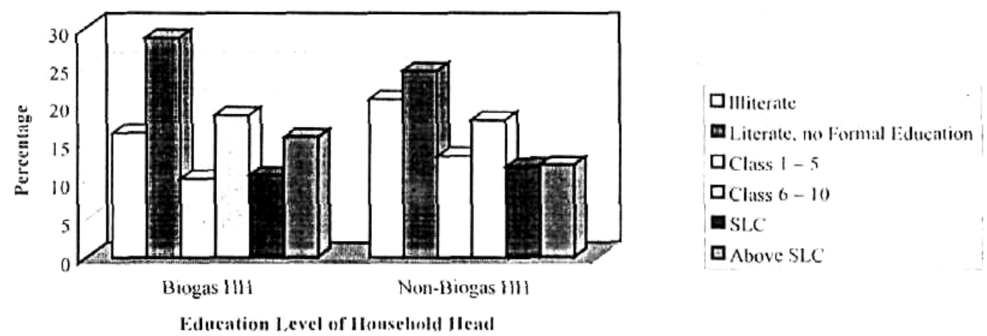
It is usually experienced that the level of education is higher in the adopters of biogas than the non-adopters, who are comparatively less educated or illiterate. In this connection, education level of the household head of both the users and non-users of biogas has been presented in Table 7.4 and Figure 7.3 below:

Table 7.4 - Education Level of Household Head

S.N.	Education Level	Biogas HH		Non-Biogas HH	
		Frequency	**Percent**	**Frequency**	**Percent**
1.	Illiterate	97	16.2	122	20.6
2.	Literate, no Formal Education	173	28.8	145	24.5
3.	Class 1 -5	61	10.2	78	13.2
4.	Class 6- 10	111	!8.5	106	17.9
5.	SLC	64	10.7	70	11.8
6.	Above SLC	94	15.7	71	12.0
	Total	**600**	**100.0**	**592**	**100.0**

The data cited in Table 7.4 and Figure 7.3 reveal that illiteracy percentage of the non-biogas household head was 4.4 percent higher (20.6%) than the biogas HH (16.2%). As regards literacy percentage (both with or without formal education), the same difference (4.4%) was found between biogas and non-biogas households indicating that percentage of the former is 4.4 percent higher than the latter.

Figure 7.3 Education Level of Household Head



7.4 Possession of Cattle and Landholding

7.4.1 Possession of Cattle

The situation of livestock holding pal tern has been elucidated in Chapter V of this report (Sec. 5.6.1). In this section the average number of livestock heads possessed by non-biogas IIII and the biogas I III before and after biogas situation has been .summarized and discussed (Table 7.5).

Table 7.5- Average Number of Livestock Heads Possessed by Non-Biogas HH and the Biogas

Kinds of Animals	Non-Biogas HH (Average Livestock Number)	Biogas	
		Before	After
Cattle	2.00	2.51	2.33
Buffalo	1.36	2.42	2.07
Goals/Sheep	1.88	2.33	2.08

As discussed in Chapter V, it can be deduced from table 7.5 that on an average Biogas HH own more cattle, buffalo and goats/sheep compared to Non-biogas HHs. If the scenario of livestock situation before and after biogas installed is compared, there seems a decreasing trend of livestock after plant installation. Similar finding has also been reported in the past study (Sec Chapter II, Section 2.2). It is recommended to explore the possible cause for the reduction of livestock after biogas installation.

7.4.2 Possession of Landholding

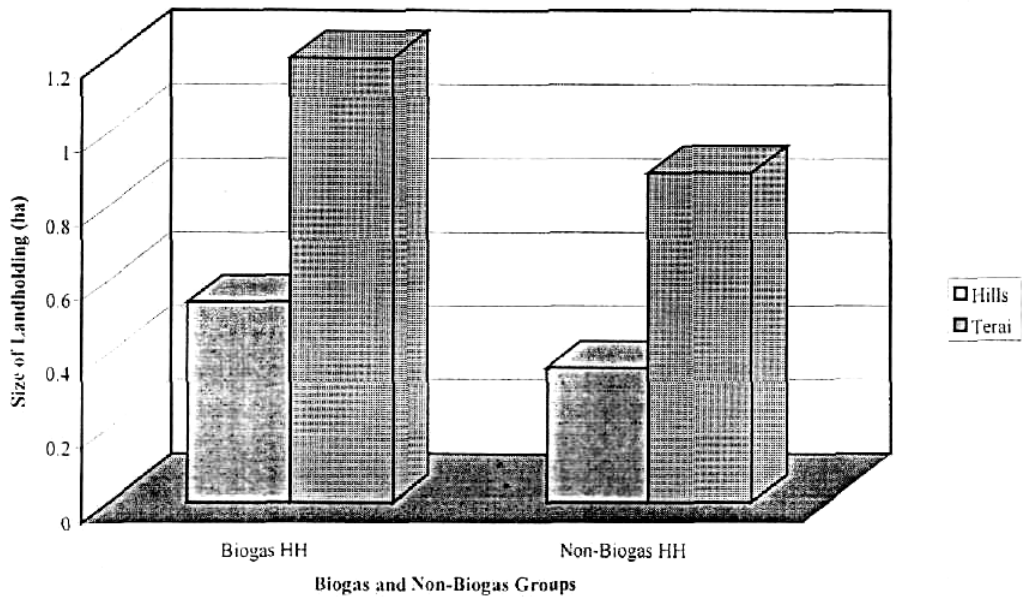
The detailed breakdown of the landholding with respect to *bari* and *Khet* both in Biogas and Non-biogas areas has been presented in Chapter Five of this report (see Section 5.1). Table 7.6 and Figure 7.4 present a comparison of landholding possessed by Biogas and Non-biogas HH in the context of Hills and Terai.

Table 7. 6 - Lund Molding Sizes by Hill and Terai Regions (Total average holdings in Hectares

Region	Biogas HH		Non-Biogas HH	
	Landholding (Ha)	Categories of HH	Landholding (Ha)	Categories of HH
Hills	0.54	Medium Fanner	0.36	Small Fanner
Terai	1.20	Small Farmer	0.89	Marginal Fanner

Group	**Hill farm size (ha)**	**Terai Farm size (ha)**
Marginal	Uplo0.2	Upto 1.0
Small	0.2-0.5	1.0-3.0
Medium	0.5-1.0	3.0-5.0
Large	>1.0	>5.0

Figure 7.4 Land Holding Sizes by Hill and Terai Regions (ha)



Above table and figure show that in both regions, the biogas households owned more land than the non-biogas ones. In accordance with the size of land holding, it can be judged that the average Biogas HHs in the hills is a medium farmer, while it is small farmer in case of non-biogas HHs. In the same manner, the biogas HHs in Terai is rated as small farmer whereas it is only the marginal farmer in case of non-biogas HHs. Hence, it seems clear that the biogas HHs is one step forward compared to Non-biogas HHs so far as possession of landholding is concerned.

7.5 Income of the Household

Income of the family members is also a prime consideration to evaluate the economic status of the households. Because of incomplete field data, the present study could not be focused on this subject. However, similar studies carried out in the recent past in this direction can throw better light and seems worth citing. Hence, the relevant Findings about average income of biogas households from difference sources have been presented below, as an example.

Table 7.7 - Average Annual Income of Biogas Households from Difference Sources

S.N.	Activities	Percentage	Average Annual Income (Rs)
1.	Farm ins;	21.75	16,800
2.	Farm Labour	0.65	510
3.	Skilled Labour	4.00	3,100
4.	Wage Labour	1.10	850
5.	Governmental service	26.10	20,180
6.	Nongovernmental Service	7.67	5,930
7.	Foreign Service	20.57	15,900
8.	Trade	18.16	14,040
	Total	**100.0**	**77,310**

Biogas Users Survey, 2000/2001, NEPECON

Above table revealed that the average annual income of biogas households from differences source is found around Rs 77,000. Similarly, in a recent study carried out by RUDESA in Kaski and Tanahu, the average annual income of biogas user was found to be around Rs 81,000, while another study conducted in Chitwan and Makawanpur reported the figure to be around Rs 86,000. All the three examples quoted above clearly confirm that the annual income of the sampled biogas users from different sources is fairly higher than the average national household income of the country (around Rs 42,000). On the other hand, it necessitates conducting a comparative study between the users and non-users of biogas to establish economic differences.

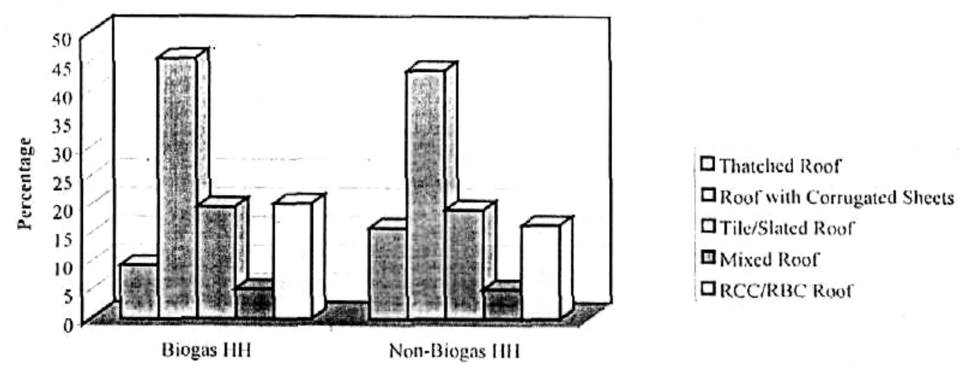
7.6 Types of House

Type of the houses built by the sampled households can indicate their economic status. For this study, the houses possessed by the respondents were divided into five categories; thatched roof, roof with corrugated sheet, tile/slated roof", mixed roof and RCC/RI3C roof (Table 7.8 and Figure 7.5).

Table 7.8 - Types of Houses Possessed by Biogas HH and Non-Biogas HH

S.N.	Categories of Houses	Biogas HH		Non-Biogas HH	
		Frequency	**Percent**	**Frequency**	**Percent**
1.	Thatched Roof	56	9.4	95	15.9
2.	Roof with Corrugated Sheets	273	45.6	260	43.5
3.	'file/Slated Roof	1 17	19.6	1 14	19.1
4.	Mixed Roof	31	5.2	31	5.2
5.	RCC/RBC Roof	121	20.2	98	16.4
	Total	**598**	**100.0**	**598**	**100.0**

Figure 7.5 Types of House



Types of Houses Possessed by Biogas HH and Non-Biogas HH

Table 7.8 and Figure 7.5 show that regarding corrugated and tile/slated roof possessed by biogas and non-biogas group, it was almost equal in both the cases. With regard to RCC/RBC roof, the percentage of biogas HI Is was found 4 percent more than their non-biogas counterparts. However, this difference is not statistically significant (Z=1.720). On the other hand, the percentage of thatched roof possessed by non-biogas HHs exceeded to 6.5 percent compared to biogas HHs. Statistical analysis revealed that Z=3.395 at 0.05, which is significant at 0.05. Hence there is significant difference between two study groups in this case.

It appears that biogas HHs seem slightly well off compared to non-biogas HHs so far as improved type of houses are concerned.

7.7 Access to Electricity in the House

Table 7.9 indicates the percent of the sampled households having access to electricity in their houses.
Table 7.9 - Access to Electricity in the House

Electricity Access	Biogas HH		Non-Biogas HH	
	No. of HH	Percent	No. of HH	Percent
Yes	426	71.0	401	67.4
No	174	29.0	194	32.6
Total	**600**	**100.0**	**595**	**100.0**

Table 7.9 shows that in case of biogas HHs, 71 percent has access to electricity in their houses compared to 67.4 percent in case on non-users of biogas. This means that biogas HHs having access to electricity was found only 3.6 percent higher than the non-biogas HHs. Statistical analysis revealed that Z=1.350, which is not significant at 0.05. Hence there is no significant difference between two study groups.

7.8 Means of Media and Transportation Available at Home

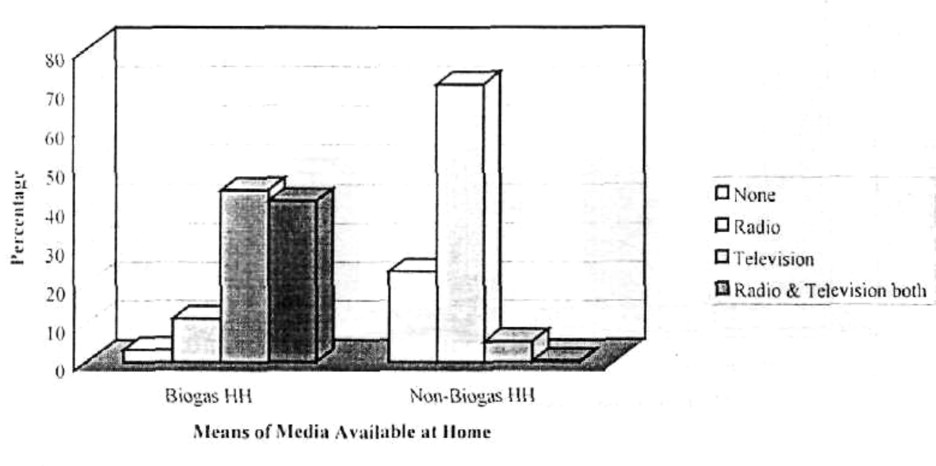
7.8.1 Means of Media Available at Home

The data of survey regarding the possession of different types of media such as radio, television or both in the sampled biogas and non-biogas HH are given in Table 7.10 and Figure 7.6.

Table 7.10 - Means of Media Available at Home

Availability of Media	Biogas HH		Non-Biogas	
	No. of HH	Percent	No. of HH	Percent
None	19	3.2	140	23.3
Radio	67	11.2	427	71.2
Television	265	44.2	32	5.3
Radio & Television both	249	41.5	1	0.2
Total	**600**	**100.0**	**600**	**100.0**

Figure 7.6 Means of Media Available at Home



The survey results on means of media presented in Table 7.10 and Figure 7.6 point out that only 3.2 percent of biogas HHs did not possess any means of media, while the figure in case o!" non-biogas HHs was 23.3 percent. This difference is statistically significant (Z=0.303).

From above table, it can also be deduced that 53 percent of biogas users (in fact 67 HHs -+316 HHs = 383 HHs) have a radio or television with a difference of 18 percent less compared to non-biogas hh.

With regard to the possession of TV, a remarkable difference was observed between biogas and non-biogas users. The difference was about 39 percent more in case of biogas HH than non-biogas HHs. Statistical analysis revealed that Z= 15.586, which is significant at 0.05. Hence there is significant difference between two study groups in this case.

According to Table 7.10, non-biogas HI I were found to possess remarkably higher percentage of radio than biogas HHs. Statistical Analysis revealed that Z= 21.117, which is significant at 0.05. Hence there is significant difference between two study groups in this case. On the other hand, biogas HHs possessed surprisingly higher percentage of TV compared lo non-biogas group. The difference is significant (Z=l 5.586). Likewise, the percentage of biogas Mils owning both TV and Radio was found to be 41.5 percent, while the figure was negligible (0.2%) in case of non-biogas I 111. There is significant difference between two study groups in this case (Z=15.586).

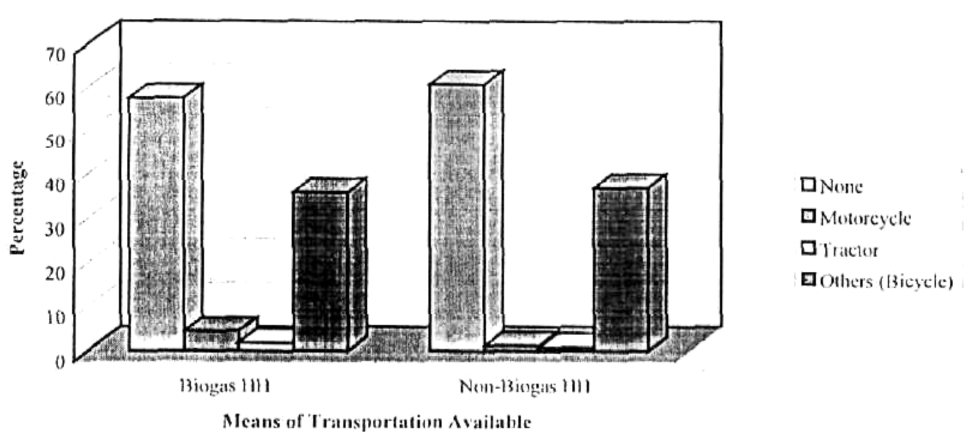
7.8.2 Means of Transport Available at Home

The results of survey presented in Table 7.1 1 and Figure 7.7 indicate a trend that for biogas HHs the situation is slightly better than non-biogas 1II Is so far the possession of the means of transport is concerned.

Table 7.11 - Means of Transportation Available at Home

Means of Transport	Biogas HH		Non-Biogas HH	
	No. of HH	Percent	No. of HH	Percent
None	346	57.7	365	60.8
Motorcycle	27	4.5	8	1.3
Tractor	II	1.8	5	0.8
Others (Bicycle)	216	36.0	222	37.0
Total	**600**	**100.0**	**600**	**100.0**

Figure 7.7 Means of Transportation Available at Home



Above table shows that 57.7 percent of biogas HHs and 60.8 percent of non-biogas HHs did not possess any means of transportation at their house. Biogas HHs had 3.2 percent more motorcycle (4.5%) than non-biogas HHs (1.3%). Statistical analysis revealed that 2=3.259, which is significant at 0.05. Hence there is significant difference between two study groups in this case.

It also appeared that bicycle is the main means of transport for both biogas and non-biogas HHs, which they possessed almost in equal percentage (i.e., 36% in case of biogas HHs and 37% in case of non-biogas HHs). Only few percentage of the sampled HHs possessed tractor (1.3% in case of biogas HHs and 0.8% in case of non-biogas HHs).

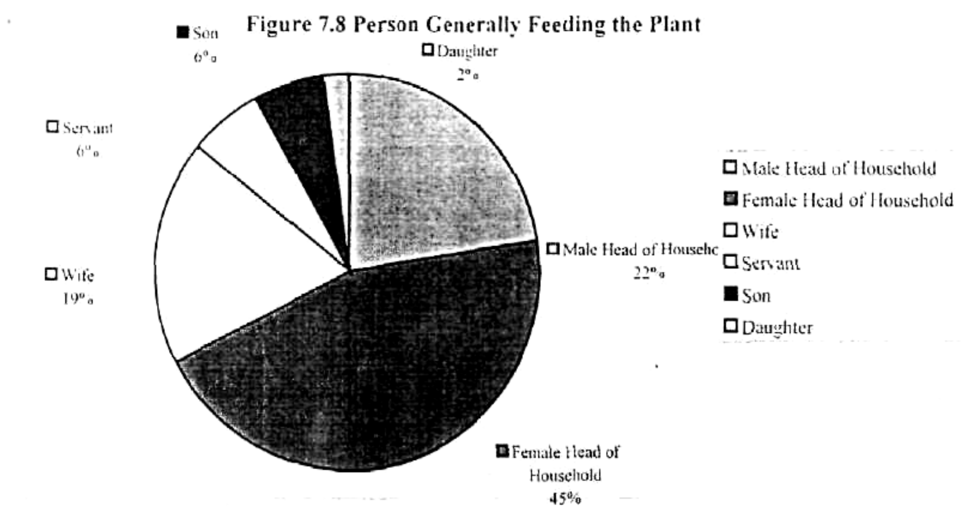
7.9 Person Generally Feeding the Plant

Feeding the plant is one of the most important operations, which needs to be performed daily by the responsible person, whether it may be family member or a servant residing in the biogas installed house. In this connection, the relevant data are presented in Table 7.12.

Table 7.12 - Person Generally Feeding the Plant

Person Generally Feeding the Plant	No. of HH	Percentage
Male Head of Household	131	22.4
Female Head of Household	261	44.7
Adult women other than Female head of	109	18.7
Daughter	13	2.2
Son	34	5.8
Servant	36	62
Total	**584**	**100.0**

NB: In following figure Change Wife by Adult Women other than Female HH Head



It is clear from Table 7.12 and Figure 7.8 that among the persons generally feeding the plant, male head comprises of 22.4 percent and female head double than male (44.7%). Specifically, the contribution of adult women other than female HHs head of the household (e.g. daughter-in-law) to feed the digester is 18.7 percent. If we combine the work of female (female head, other adult women and daughter), we can conclude that in biogas HHs, females' contribution amounts to about two-thirds compared to male members so far as responsibility of feeding the digester is concerned. The servant has to play some role in this matter (6.2%) whereas the contribution of the daughter and the son is negligible.

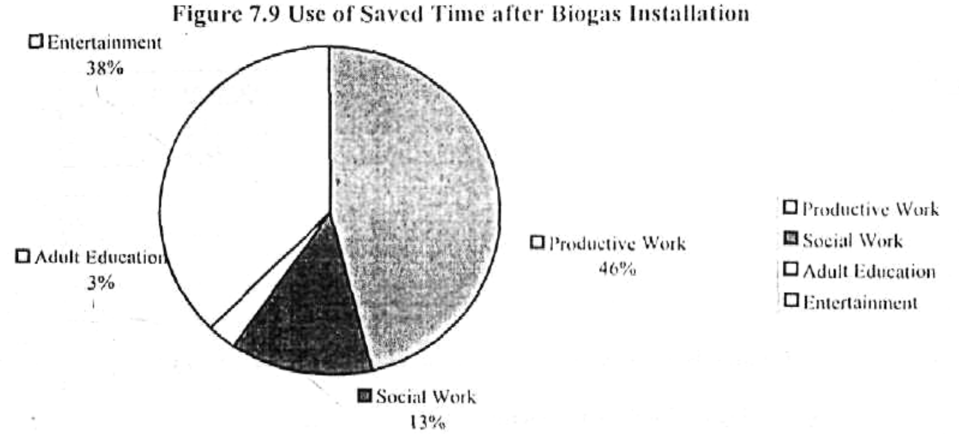
7.10 Use of Saved Time after Biogas Installation

As has already been pointed in Chapter II of this report that on an average, biogas households can save about 2.30 to 3.0 hours a day compared to cooking with firewood. In this connection, questions were asked to the biogas family as to how they spend the time so gained. The result of the survey is given in Table 7.13 and Figure 7.9.

Table 7.13 - Use of Saved Time sifter Biogas Installation

Use of Save Time	No. of HH	Percentage
Productive Work	347	46.2
Social Work	100	13.3
Adult Education	22	2.9
Entertainment	283	37.6
Total	**752**	**100.0**

Figure 7.9 Use of Saved Time after Biogas Installation



About 46 percent of the respondents were of the opinion that they use the saved time for productive purpose. Similarly, about 37 percent expressed that they resort to entertainment. Another 13 percent respondents used the saved time by engaging themselves in social services. Only a small percentage (3%) utilized the saved time in adult education.

The respondents also mentioned that they utilized the saved lime by taking rest, cleaning their house, regularizing household affairs and taking care of the children.

7.11 Biogas In Relation to Gentler

Little information was collected in the present study to assess the role of gender's participation in biogas related work. On the other hand, realizing the importance of the role played by gender in biogas, SNV/BSP has been carrying out routine survey to determine gender's role in biogas. In this connection, the outcome of the study carried out by NEPECON (2001) and RUDESA (2002) with support from ABPC has been quoted and presented briefly in following sub-sections.

7.11.1 Ownership of Assets of the User Households

Ownership of var ious resources possessed by the biogas households in the gender's context has been shown in Table 7-14.

Table 7.14- Ownership of Assets of the User Households

S.N.	Ownership of Resources	Male (%)	Female (%)	Both (%)	Total (%)
1.	Biogas Plant	85	15	-	100
2.	Land	82	8	10	100
3.	Cattle/Livestock	71	6	23	100
4.	House	96	-	4	100
5.	Vehicle/Tractor/Cycle	88	9	3	100
6.		90	7		100

Source: NEPECON (2001) Biogas Users Survey 2000/2001

It is clear from Table 7-14 that in the surveyed households, only percent 15 females had the ownership for biogas plants, while 85 percent of the plants were in the name of males. As regards to the ownership of land property, the male owned 82 percent, the females 8 percent and 10 percent by both. Similarly, about 71 percent of the livestock was in the name of males, 6 percent was owned by the female and the rest 23 percent by both. The joint ownership of livestock was more in this respect compared to other resources.

The table also revealed that 88 percent of the houses were registered in the name of males, 9 percent in female's name and the rest 3 percent had joint ownership.

7.11.2 Women's Role in Decision Making

It is important to know who plays decision making role between wife and husband in the management of household affairs or other matter whether it is related to biogas or not. Experience shows that sometimes wife can play better role than husband in decision-making and still it is considered better if the matter is thoroughly discussed between themselves before taking concrete decision. The relevant data on various kinds of decision taken my male, female or both relating to biogas are given in Table 7-15.

Table 7.15 - Decision Making

S.N.	Kinds of Decision	Male (%)	Female (%)	Both (%)	Total (%)
1.	First installation of biogas plant	61	10	29	100
2.	More inclined for plant installation	43	22	35	100
3.	Leading person for managing finance	82	7	II	100
4.	Leading person for selecting company	80	8	12	100
5.	Leading person for latrine attachment	33	6	61	100
6.	Leading person for site selection	71	7	22	100
7.	Leading person for cattle shed construction	56	8	36	100
8.	Leading person for taking care of the plant	81	12	7	100

Source: NEPECON (2001) Biogas Users Survey 2000/2001

Above table reveals that mostly there is the dominance of male's role in decision making over the female. However, joint decision of both the sexes has been reflected regarding the initiation and inclination towards plant installation, site selection, and latrine connection to biogas plant and cattle-shed construction. The results also indicate that male plays leading role in the management of finance (82%), selection and dealing with company

7.11.3 Women's Participation in Management

In a study carried out by RUDESA, various questions were asked to identify women's role in different phase in management aspects including planning, resource mobilization and implementation and supervision phase. The following Table 7.16 shows rating of women's participation in Management.

Table 7.16- Rating of Women's Participation in Management

S.N.	Kinds of Decision	Rating		
		Main Role	Secondary Role	Insignificant Role
1.	Planning Phase	14.8	63.0	22.2
2.	Resource Mobilization	11.1	51.8	37.1
3.	Implementation Phase	14.8	63.0	22.2
4.	Supervision	*25.9*	55.5	18.5

Source: RUDESA(2002) A Study of Biogas Users with Focus on Gender Issues (Jhapa District)

Above table reveals the fact that male played lead and main role of all phases including planning, resource mobilization, implementation and supervision. In 26 percent of biogas users HH women played main role in supervision, while the figures for women's role during implementation and planning were 15 percent. In general women's role was more supportive rather than lead role. In order to identify needs of women and deliver them the benefits of the technology, the programme should endevour maximum participation of women in all stages of management.

CHAPTER VIII
CONCLUSION AND RECOMMENDATIONS

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CONCLUSIONS AND RECOMMENDATIONS

Based upon the outcome of the Integrated Environment Impact Assessment (IEIA) study and review of the relevant work on the past study, following conclusions and recommendations have been derived. It is recommended that the concerned organizations particularly SNV/BSP and AEPC should take necessary steps to implement the recommendations of this study.

8.1 Conclusion

8.1.1 Energy Use

Biogas stoves seem to have succeeded in substituting the traditional biomass and fossil fuel sources in the project areas to a great extent. The substitution is more pronounced in the cooking fuels as compared to lighting fuels, which highlights the popularity of biogas in cooking. This transition in the energy source is an upward movement in the energy ladder, which is definitely an environmentally positive indicator.

When biogas is substituting biomass fuels, at the national and regional level it is reducing the pressure on the forest resources while at the household level the main benefit mainly for women is the saving of time in fuel-wood collection. The operation of biogas also requires certain time but generally less time consuming and more importantly qualitatively it is an easier task. However, in case *of* the households, which used to purchase firewood, the introduction of biogas could mean extra lime requirement in its operation. On the other hand, in areas where fuel-wood has to be purchased, the introduction of biogas leads to a significant saving in the household economy. Similarly, w hen biogas is being used as a substitute of fossil fuels, it is contributing towards reducing the foreign exchange out-flows. At the household level, there has been a significant monetary saving as biogas is much cheaper fuel than fossil fuels. This saving w ill be even more prominent in the Hills, as the cost of the fossil fuels in these areas tends to be higher as compared to the Terai owing to the high transportation costs.

The biogas plants, however, have not completely substituted the biomass and fossil fuels. Other energy sources, especially fuel-wood, are still found to be supplementing the biogas plants. The main reason seems to be the insufficiency in the production of the gas to meet the requirements. As the feeding percentage of the biogas plants in the study areas are below the recommended values, there is a possibility of increasing the gas production to some extent by increasing the feeding capacity. In order to get the maximum benefits from biogas technology, the access to sufficient dung has to be ensured. However, the dung requirement is far below par in majority of the cases. One way of increasing the feeding capacity could be the use of human excrement as a supplementary feedstock to dung.

Some salient features, which can be inferred from the present study regarding the impact of biogas plants on energy use. have been highlighted below.

1. **Number of Operational Biogas Plants**: Out of the total 600-biogas plant installed households, the biogas plants are operational in 5S4 HHs (97.3%) at present. In the rest 16 HHs (2.7 %). they were found to be non-operational. The reasons for non-operation are known for only 8 BGHs. Among these 8 BGHs, 5 cited appliance failure. 2 cited civil structure damage and I cited no feeding as the probable cause for non-operation of the BGPs.

2. **Average Biogas Stoves / Lamps per Plant:** The average biogas stoves per plant in case of Terai is 1.76 and is 1.23 in case of Mills. Majority of the BGHs (75.2%) in Terai have 2

biogas stoves per plant, whereas most of the BGHs (73,9%) in Hills have just a single biogas stove per plant. The average biogas lamp per plant is 0.14 for both Terai as well as the Hills.

3. **Frequency of Dung Feeding:** Majority of the BG1 Is Iced their plants once a day (46.5%) or twice a day (45.9%). In case of Terai most of the BGHs (51%) feed twice a day. whereas in case of the Hills the majority of the BGHs (46%) feed once a day.

4. **Quantity of Available Dung:** The overall average quantity of dung available per day per BGH is 33.85 kg and the similar figures for Terai and the Hills are 41.71 kg and 27.21 kg respectively

5. **Average Size of Biogas Plant:** The overall average size of a biogas plant is 7.12 m. However, the average biogas plant size in Terai is 7.85 m" and in case of the Hills, it is 6.49 m^3. In case of the Hills, majority of the plants are of the size of 6 m (53.2%) followed by those of 8 m^3 (23.6%). But in Terai, majority of the plants are of 8 m^3 (41.4%) followed by those of 6 m^3 (31.3%).

6. **Feeding Capacity of Biogas Plants:** The recommended dung feeding per day is 58.87 kg for Terai and 38.94 kg for Hills. However, the survey results indicate that the actual feeding per day is 41.71 kg in case of Terai and 27.21 kg in case of Hills, which means there is dung deficiency of 17.16 kg and 11.73 kg in case of Terai and Hills respectively. The available data, hence, indicate that the feeding percentage in case of Terai and Hills is 70.85 percent and 69.88 percent, respectively.

7. **Gas Production:** Assuming the conditions to be favourable, in case of the Terai, it can be expected that about 1680 liters of biogas is daily produced per plant during summer and about 1180 liters during winter. Similarly, in case of the Hills it can be expected that the daily production of biogas is about 1080 liters during summer and 750 liters dining winter.

8. **Gas Consumption:** The total gas consumed per plant per day for Terai varies between 1235 - 1385 liters in summer and between 1225 - 1335 liters in winter. The corresponding values for the Hills, however, do not vary seasonally and remain constant at around 905 - 1015 liters. A large portion of the gas (above 95 % of total gas produced) is used in cooking purpose whereas insignificant amount of gas is consumed in lightening purpose.

9. **Excess or Deficiency of Gas Produced:** The production and consumption figures suggest that during summers, both in the Terai and the Hills, the production of biogas far exceeds the consumption rate. In case of Terai the excess production varies from 295 - 445 liters per day whereas in the Hills the production exceeds from 65 - 175 liters per day. However, during winters the biogas production does not seem to be able to fulfill the consumption rate. There seems to be a deficiency of 45 - 155 liters of gas in a day in the Terai and of 155 - 265 liters per day in the Hills.

10. **Change in Use of Fuelwood:** In Terai, there has been a decrease of 3.39 kg Kiel wood per household (BGH) per day in summer and 7.55 kg fuel wood per household per day in winter. The corresponding figures for the Hills arc 5.54 kg and 6.47 kg in summer and in winter respectively. At national level 490 tonnes of fuel-wood is being replaced daily at present, which is a saving of about Rs. 790,000 daily. Once the BSP III targets are achieved there would be a daily saving of 570 tonnes of fuel-wood, which at present rates would worth Rs. 920,000. Similarly, when all the technically feasible biogas plants will be installed, these plants will lead to the saving of 7410 tonnes of fuel-wood per day, This saving of fuel-wood is worth Rs. 1 1.93 million at current prices. .

11. **Change in Use of Agricultural Residues as Fuel:** In Terai, there has been a decrease of agricultural residue by 2.7 kg daily per household in both seasons which is a decrease of 30 percent from the previous use pattern. Even though there is a more pronounced decrease in the Hills during summer (1.4 kg daily per household), the use of agricultural residue has shown an increase by 0.14 kg per day per household during winter.

12. **Change in Use of Dung as Fuel:** In Terai, there has been a decrease in use of dung as fuel by 20.4 liters per household per day in summer and by 21.5 liters in winter. This is a decrease of 77.3% and 71.7% in summer and in winter respectively. In the Hills there has been a decrease by 17.9 liters daily per household in both seasons, which is a decrease of 99.4 % from the previous use pattern.

13. **Change in Use of Kerosene:** After the introduction of biogas plants the consumption of kerosene has been reduced by 0.30 liters and 0.33 liters per day per household in Terai in summer and winter respectively. Similarly, the BGHs in the Hills have experienced a decrease by 0.36 liters per day per household in summer and 0.37 liters in winter. At national level 29.240 liters of kerosene is being replaced daily at present, which is a saving of about Rs. 550,000 daily. Once the BSP III targets are achieved, there would be a daily saving of 34,000 liters of kerosene, which at present rates would worth about Rs. 640,000. Similarly, when all the technically feasible biogas plants will be installed, these plants will lead to the saving of 442,000 liters of per day. This saving of kerosene is worth Rs. 8.28 million at current prices.

14. **Change in Use of LPG:** The consumption of LPG in BGHs of Terai has reduced by 1.0 cylinder per household per year in summer and by 0.9 cylinders in winter. The scenario in case of the Hills is opposite as it shows an annual increase in LPG consumption by 2 cylinders per household. However, as the households using LPG is negligible (1% overall) compared to other fuel sources, the change in consumption pattern of LPG does not have significant implications in financial saving or in Greenhouse gas emission at present.

15. Change in Cooking Efficiency: Prior to the installation of the biogas plants, majority of the households were dependent upon the traditional cooking stoves (96.7%) followed by the kerosene stoves (21.3%). At present, the biogas stoves have substituted the traditional stoves and the kerosene stoves to a great extent. Now only 54.2 percent households are using traditional mud stoves and only 12.8 percent are using kerosene stoves.

8.1.2 Health Situation

1. **Building of Latrine:** In the sampled area, the percentage of the biogas HHs building their own toilet/latrine was found significantly higher than those of non-biogas HHs. Similarly, significant percentage of biogas HHs have attached their latrine with biogas plants. Majority of the non-biogas HHs were found self-motivated to build toilet compared to biogas HHs. In case of biogas HHs, Biogas companies have played an influencing role in building the toilet. Both the categories of HHs were less motivated by family members or neighbours to build the latrine, while the NGO had little role to play in this matter.

2. **Possession of Kitchen Garden:** The biogas HHs were found to possess slightly more percentage kitchen garden compared to non-biogas HHs, which indicates that they can use the bio-slurry in order to produce more vegetables so as to improve their health. However, the difference between the two study groups is found insignificant.

3. **Eye Problem:** The beneficial effect of biogas is seen by the fact that the non-biogas HHs had slightly more eye problems compared to biogas HHs, who are able to cook their food in clean and health}- atmosphere. In this connection, the percentage of *'increased eye infection'* for the last three years in non-biogas HHs was found higher (11%) than the biogas HHs. Similarly,

biogas HHs reported somewhat higher percent of" *"decreased eye infection"* in comparison to the non-biogas HHs. However, (he difference between two study groups is statistically insignificant.

4. **Respiratory Problem and Cough:** Presence of respiratory disease was found to be about 4 percent more in non-adopter of biogas than the adopter. This difference between the two study groups is statistically significant. Slightly more percentage of non-biogas Hi Is reported increased cough than non-biogas Ill-Is, which is statistically insignificant. On the other hand, the percentage *of 'decreased cough'* in the households with biogas plants was found more than 20 percent in comparison to household without biogas. This difference is statistically significant. This clearly indicates the positive impact rendered by biogas technology for the improvement of the family members' health and hygiene, particularly women who have to undergo drudgery of cooking.

5. **Diarrhoeal Episodes:** In terms of the diarrhoeal diseases under examination, no differences was perceived between biogas HHs and non-biogas Mils, while the ' *increased diarrhoea'* for the last three years in non-biogas HHs was found higher than that of biogas HHs. The '*decreased diarrhoea"* also exceeded to some extend in biogas HHs compared to non-biogas HHs. However, this difference between the two study groups is statistically insignificant.

6. Dysentery: hi terms of the dysentery disease under examination, the installation of BGP might be of some significance as 11 percent non-biogas HHs reported dysentery compared to 5 percent in biogas HHs. This difference is statistically significant. Regarding the status of dysentery for the last three years, the study did not reveal any significant difference between the two study groups. However, it should be noted that dysenteric episodes might not necessarily be related with biogas, it may also depend upon the general cleanliness.

7. **Tapeworm Infection:** In case of tapeworm infestation for the last three years, the difference in the percentage of *"increased tapeworm infection'* in non-biogas HHs was found about 11 percent more than the biogas Mils. However, this difference between the two study groups is 'statistically insignificant. Similarly, the percentage of biogas HHs stating *"decreased tapeworm infection'* was found 8 percent higher than non-biogas HHs, which is not significant.

8. **Burned Cases:** The result of the survey has clearly demonstrated that there is a high danger **of** burning cases in the households without biogas plant and that introduction of biogas has been very conducive to control the burned cases in the households. The difference in the decrease in this case in the Biogas HHs was reported to exceed by 22 percent compared to non-biogas HHs. Further analysis of data showed that there is n high danger of burning cases in the households without biogas plant.

9. **Safety on the Use of Biogas Stove**: Majority of biogas HHs found a very high degree of safety on the use of biogas stove after they have had the biogas plants.

10. **Mosquito Breeding:** About 70 percent of biogas HHs reported that mosquito breeding was increased as a result of biogas installation. The principal reasons for mosquito proliferation may be attributed to the dampness on the upper part of the outlet of biogas plant. Furthermore, if firewood is burnt inside the kitchen, the smoke produced from it drives out mosquito, while in clear illumination of biogas lamp or electric bulb, there is every risk of mosquito attack.

8.1.3 Agriculture and Sustainable Land Use

1. **Land and Livestock Holding:** The households in the biogas area tended to have a relatively better access to resources indicated by their holdings of khet land and large animals. However, there appeared to be no real change in the land holding after the installation of biogas plants. The number of cattle, on the other hand seems to decrease slightly after the installation of biogas plants than before.

2. **Crop Production:** No real differences in the crops and cropping patterns were detected as a result of the installation of biogas plants. Use of digested slurry is found to increase the yields of maize and cabbage crops by 10 to 20 percent when applied at the rates of 10 to 20 tons per hectare. Use of slurry compost, when properly prepared, appears to be the most effective form of application.

3. **Use of Slurry:** With the installation of biogas plants the uses of liquid slurry and compost prepared with the slurry appeared to increase dramatically while the uses of regular FYM and compost without slurry decreased significantly. The uses of slurry in different forms appear also to have replaced the uses of chemical fertilizers by about 10 percent.

4. **Lack of Awareness and Limitation of the Use of Slurry:** A significant proportion (14%) of biogas plant owners are still not aware of the fertilizing value of the slurry they produce and 13 percent don't know proper methods of application. Most of the households (more than 68%) prefer to use the slurry in composted form and only about 10 percent use it in a liquid form. More than a quarters of the households in the program area said that the liquid slurry is too difficult to transport to the fields, so they rather let it dry before using it, even if it means that it loses most of its nutrients.

5. **Uses of Crop Residues:** Most of the crop residues are used for feeding animals and a significant proportion is used for cooking purposes. After the use of biogas for cooking, the extra residues became available for composting purposes.

6. **Livestock Management Practice**: Significant increases in complete stall-feeding practices and associated decreases in free grazing occurred after the installation of biogas plants. The condition of the cattle sheds improved considerably due to biogas as is indicated by 9 to 11 percent increase in the tendency to construct concrete floors and urine collection pits. In the non-program area, smooth concrete floors were almost non-existent.

7. **Fodder Collection:** Fodder for animals in all cases are collected mostly from on-farm production than from the forests, but more so in the program area. While the collection from the forests remained the same, the collection from own farm production increased significantly after the installation of the biogas plants.

8. **Forest Resources:** Fuelwood consumption decreased to almost one-third of the previous consumption rate since the installation of biogas plants. Information obtained from the household survey and community level discussions indicate that at least 50 percent reduction in the collection of fuelwood from the forests occurred as a result of the use of biogas, thus reducing the pressure on the forests.

9. **Changes in the Types of Wood:** Positive changes in the types of wood used for fuel after the installation of biogas plants were observed. The proportion of the household demand for large dry branches decreased most dramatically and significant reductions in the uses of small and large green branches occurred. The use of small, dry twigs and fallen leaves remained more or less the same. The use of whole trees also remained the same indicating that the trees are probably used for other purposes like construction.

10. **Availability and Collection of Non-timber Forest Products:** Availability and collection of non-timber forest products increased in most of the communities after the installation of biogas plants. Use of biogas is cited as one of the reasons for this but other factors like more effective forest management practices through community forestry programs and strong protection measures are also responsible for this.

11. Encroachment of Forest: Encroachment of forest for agricultural purposes is decreasing. This tendency is more prominent in the Hills than in the Terai.

12. Land Use Changes: Conditions of forests have become better in the Hills but those in the Terai are still degrading. Khet land appears to have increased in both regions. The increase in the khet land in the Hills is associated with decreases in bari lands and some grazing land but in the Terai, such increases have occurred at the expense of the forest land.

8.1.4 Climate Change

The study shows that the substitution of traditional biomass fuels and fossil fuels by the greenhouse friendly alternative, the biogas, has caused significant decrease in the carbon emissions. The decrease is more pronounced from the substitution of biomass fuels, primarily dung followed by fuel-wood and agricultural residues, than from the substitution of kerosene. It is generally assumed that biomass fuels, as long as they rely on renewable harvesting, are greenhouse gas neutral. The recent studies (Smith et. ill. 2000) have highlighted that even when renewably harvested, the biomass fuels arc often not greenhouse gas neutral as previously assumed. Because of their poor combustion conditions, these biomass fuels divert a significant portion of the fuel carbon into products of incomplete combustion (PICs), which in general may have greater impacts on climate than carbon dioxide. The current findings of this study indicate greater carbon emission saving from biomass energy sources.

Being an energy source with higher thermal and combustion efficiency compared to traditional biomass and fossil fuels, biogas technology has offered the opportunity of providing a renewable energy source with extremely low global warming commitment (GWC), especially in the rural settings. It has global benefits in the form of cost effective greenhouse gas (GHG) reductions while providing even greater local benefits in the form of better quality fuels and healthier environments. Biogas, hence, can definitely be taken as an attractive opportunity for true win-win intervention in mitigating the global warming problem to some extent.

Some important inferences regarding the impact of biogas plants on climate change that can be deduced from the current study are outlined below.

1. **Carbon Emission Saved from the Reduction of Fuelwood:** In case of Terai, there has been a reduction of 1419 g -C and 3160 g -C equivalent of Carbon emission per day per household in summer and in winter respectively. Similarly, in case of the Hills there has been a reduction of 2319 g -C and 2708 g -C equivalent of Carbon emission per day per household in summer and in winter respectively.

2. **Carbon Emission Saved from the Reduction of Use of Agricultural Residues as Fuel:** In Terai, there has been a reduction of 1398 g -C equivalent of Carbon per day per household in both seasons. Similarly, in the Hills during summer there has been a reduction of 725 g -C equivalent of Carbon per day per household. However, during winters the Hills experience an increase in Carbon emission from agricultural residues by 207 g -C equivalent of Carbon per day per household.

3. **Carbon Emission Saved from the Reduction of Use of Dung as Fuel:** In Terai there has been a reduction of 6818 and 7186 g -C equivalent of Carbon per day per household during summer and winter respectively. Similarly, in the Hills there has been a reduction of 5982 g-C equivalent of Carbon per day per household in both seasons.

4. **Carbon Emission Saved from the Reduction of Kerosene:** In Terai, there has been a reduction of 253 and 278 g -C equivalent of Carbon per day per household during summer and winter respectively Similarly, the Hills have experienced a reduction of 304 and 312 g-C equivalent of Carbon per day per household in summer and in winter respectively.

5. **Carbon Dioxide Emission Reduction at National Level:** At present 738 million-gram equivalent of Carbon dioxide emission is being reduced everyday at the national level due to the replacement of conventional fuels by the biogas plants. Once the BSP III targets are achieved, the biogas plants have a potential of saving about 859 million-gram equivalent of Carbon dioxide emission per day. Similarly, when all the technically feasible biogas plants will be installed, these plants will lead to the daily saving of 11,170 million-gram equivalent of Carbon dioxide emission.

8.1.5 Socio-economic Conditions

1. **Family Size, Ownership, and Gender's Role:** Biogas HHs had larger family size than non-biogas HHs. In comparison to non-biogas HHs, the biogas HHs heads were found more literate. There was the dominance of male over female in the ownership of biogas plants, as the male HHs head owned about 91 percent plants. In biogas HHs, females' contribution amounts to about two-thirds compared to male members so far as responsibility of feeding the digester is concerned.

2. **Occupation:** Agriculture was found to be the main occupation of all the sampled biogas or non-biogas households followed by service, business and industry. The percent of biogas HHs head practicing agriculture was somewhat higher than the non-users of biogas. But in case of business it was just reverse.

3. **Accessibility to Electricity and Kinds** of **Roof:** Accessibility to electricity was found somewhat higher in biogas HHs non-biogas HHs. The difference between the two study groups is statistically insignificant. Likewise, biogas HHs were found to be somewhat superior to non-biogas HHs as the more percentage of the former group possessed RCC/RBC roof compared to the latter group, but the difference was not significant. On the other hand, non-biogas HHs had more thatched roof than biogas HHs, which is statistically significant. It appears that biogas HHs seem slightly well off compared to non-biogas HHs so far as improved type of houses are concerned.

4. **Means of Media:** 3.2 percent of biogas HHs did not possess any means of media, while the figure in case of non-biogas HHs was 23.3 percent. This difference is statistically significant. With regard to the possession of TV. a significant difference was observed between biogas and non-biogas users. On the other hand, non-biogas HHs were found to possess significantly higher percentage of radio than biogas HHs. The percentage of biogas HHs owning both TV and radio was found to be 41.5 percent, while the figure was negligible (0.2%) in case of non-biogas HHs.

5. **Means of Transport:** Regarding means of transport, 57.7 percent of biogas HHs and 60.8 percent of non-biogas HHs did not possess any means of transportation. Bicycle was found to be main means of transport for both biogas and non-biogas HHs, which they possessed almost in equal percentage. Biogas HHs had 3.2 percent more motorcycle (4.5%) than non-biogas HHs (1.3%). This difference is statistically significant. Only a few percent of the sampled HHs possessed tractor as means of media, biogas HHs had slightly higher percentage of motorcycle and tractors than non-biogas HHs. But in case of bicycle, both biogas and non-biogas HHs possessed them almost in equal percentage.

6. **Utilization of Saved Time:** It was found in this study that after biogas installation, they utilize about 50 percent of the time saved in productive purposes and the rest in entertainment, social services and adult education.

8.2 Recommendations

Following recommendations have been derived from the study. It is recommended to implement them during the Fourth phase of BSP that starts in 2003.

1. It is recommended to determine the nutrient contents of different forms of bio-slurry (i.e., digested slurry, slurry compost, etc.) with appropriate sample collection and standard analytical methods-

2. The responses of crops to the application of different forms of slurry should be determined by systematic field trials with adequate number of replications.

3. The exact cause for the increase of mosquito population due to introduction of biogas should be investigated with necessary solution for the control of mosquito.

4. Appropriate research should be carried on health and hygienic aspects of latrine-attached biogas plants by conducting pathogenic test on fresh and digested slurry as well as slurry compost.

5. Improvement in diseases as a result of biogas introduction may not necessarily be related to biogas but it may depend upon several factors associated with health improvement. Therefore, while designing research in this area, it is recommended to take such factors into consideration.

6. A comparative study between the users and non-users of biogas should be done to determine the economic differences in their annual income.

7. It is recommended to carry out regular study to assess the role of gender in biogas related activities such as women's role in decision-making, their participation in management etc.

8. It is recommended to carry out a direct measurement of the fuels used in certain sampled HHs using standard measuring units. In order to obtain seasonal and regional variations, these observations should be carried out in both summer and winter and in both Tcrai and the Mills.

9. To assess the accurate figures for CO_2, CH_4 and NO_2 emission reduction and also for detecting methane leakage from the biogas plants, it is recommended to carry out a direct measurement for these emissions using appropriate effective measuring equipment.

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APPENDICES

APPENDIX I
ADVICE FOR TOR FOR AN IEIA FOR THE BIOGAS SUPPORT PROGRAMME IN NEPAL

Advice for Terms of Reference for an Integrated Environmental Impact Assessment for the Biogas Support Programme in Nepal

16 February 2001

041-093

MAIN POINTS OF THE ADVICE

The Commission would like to highlight the following questions in order to focus the study.

1. To what extent does biogas (i) substitute the use of fuelwood and (ii) influence a change in the total energy consumption?

2. What is the total emission of greenhouse gasses due to the installation of biogas and to what extent does it contribute towards the national emission of greenhouse grasses?

3. To what extent does the decreased use of fuelwood due to the installation of biogas plants contributes
4. to slow down the process of deforestation?

5. To what extent has the activity profile of men and women been changed due to the installation of biogas plants. What does this mean for the socio-economic position of households with and without a biogas installation in a settlement?

6. To what extent does the slurry from the biogas plants influence the agricultural production and sustainability of land use?

1. INTRODUCTION

1.1 Setting of the Biogas Support Programme

The Government of Nepal and the Government of the Netherlands arc working together in implementing the Biogas Support Programme (BSP) in Nepal. The BSP represents a working partnership between the Government of Nepal, the Netherlands Government (I)GIS), the German Financial Cooperation through the German Development Bank (KfW), the Agricultural Development Bank of Nepal, the Netherlands Development Organisation (SNV), the private biogas sector of Nepal and the farmers of Nepal. The Ministry of Science and Technology (MOSTE) authorises the implementation of BSP and SNV is responsible for the implementation of the programme. The Alternative Energy Promotion Centre (AEPC) is Nepal's Government Agency that promotes and coordinates all small-scale renewable energy initiatives in the country and BSP is one of the renewable energy programmes of AEPC.

The objective of BSP is to promote the wide scale use of biogas as a substitute for fuelwood, agricultural residues, animal dung and fossil fuels (kerosene/LPG) that is presently used for cooking and lighting needs in rural households.

The BSP started in July 1992 with the first phase. Presently, implementation of the third phase 1997-2002 is carried out and in the summer of 2000 it has been celebrated that 50,000 biogas plants had been constructed The fourth phase will start in 2003.

A number of evaluations of BSP have been executed so far by internal as well as external assessors. The conclusions of these evaluations are rather positive. The biogas plants provide several benefits to the household, the settlement and the nation, such as: improvement of the health situation of women and decline in physical workload of women. A potential negative impact might be the leakage of methane, which is one of the greenhouse gasses.

1.2 Request for Advice

MOSTE and SNV are of the opinion that it is required to quantify as far as possible and substantiate the impacts of BSP and therefore they are planning to execute an integrated environmental impact assessment (IEIA). The independent Netherlands Commission for Environmental Impact Assessment ("the Commission") has been requested by the Alternative Energy Promotion Centre to draft the Terms of Reference (ToR) for the study and to review the finalised study, see Appendix I for the request.

The results of the integrated environmental impact assessment arc planned to be used as an important input for the evaluation study of BSP phase III, which will most likely be executed on behalf of the Directorate General for International Cooperation of the Netherlands Ministry of Foreign Affairs.

The objective of this advice is: to provide guidelines for the execution of the integrated environmental impact assessment (guidelines on tiie type of information to be gathered and analysed). These guidelines will be used as a review framework by the Commission for EIA, when the report will be reviewed, as foreseen for September 2001. This advice is prepared by a joint Netherlands / Nepalese working group of the Netherlands Commission for E1A. For the composition of the working group is referred to Appendix 2. The Netherlands experts visited Nepal from 21- 26 January 2001 to draft this advice jointly with the experts from Nepal. For the programme of the visit see Appendix 3.

The Commission is willing to advise for two reasons. First, there is a request for an independent review of the impacts of BSP. Secondly, the Commission has an agreement with the Ministry of Population and Environment (MOPE) in Nepal to assist this Ministry upon request with reviewing of EIAs. Although biogas plants are not subject to Environmental Impact Assessment (EIA) according to the national EIA legislation, the Commission is of the opinion that the integrated environmental impact assessment offers a good opportunity for exchange of EIA experiences and therefore MOPE as well as EIA experts from Nepal have been consulted during the visit. The draft advice has been discussed with a group of key persons in the field of sustainable energy in Nepal during a consultative meeting. In Appendix 3 the list of persons who attended this meeting is presented.

In preparing this advice use is made of a number of valuable evaluative studies which are recommended to be used. A list of key documents is presented in Appendix 7.

The Commission would like to thank the staff and supporting staff of BSP for their hospitality and their support in facilitating the work of the Commission during their stay in Nepal.

1.3 Scope of the Study

The proposed study is an integrated environmental impact assessment (IEIA). The objective of this study is: (i) to objectify and to quantify (as far as possible) the impacts of BSP phase III (BSP III) for cooking and to a lesser extent lighting and (ii) to come up with recommendations for further improvement of the fourth phase of BSP. This means that the direct as well as the indirect impacts of BSP III will be evaluated and described for:

- The environmental situation, in particular: sustainable land use, forest resources and the contribution of the greenhouse gasses (carbon dioxide, methane and N_2O) to climate change;
- The health and socio-economic situation of the households, including gender relations; and
- Employment in the biogas sector: construction, promotion and extension activities by private companies.

The study is considered as an integrated environmental impact assessment due to: (i) the scope of the study; the environmental as well as the socio-economic impacts of the programme will be assessed and; (ii) the approach applied for the implementation of the study; a mixed team of experts from different disciplines will closely work together to execute the study. The added value of such an integrated approach, instead of a sectoral or aspect-by-aspect approach, is as follows:

- It offers the opportunity to study and present a complete overview of the positive as well as the negative impacts;
- Interrelations between thematic fields become clear;
- The underlying causes of the impacts will become clear. In case of negative impacts this information offers the opportunity to come up with mitigating measures;
- It offers the opportunity of balancing and prioritising of the impacts: and
- It offers the opportunity of a financial-economic evaluation of the impacts, although it has been stated in section 5.7 that not all impacts can be monetarised.

In Appendix 4 guiding principles for an integrated approach of the IEIA are provided.

The following chapters will provide the guidelines for the IEIA.

2. PROBLEM ANALYSIS AND OBJECTIVES

The purpose of describing the problem analysis and objectives is to assess if the proposed programme does solve the observed[1] problems and to assess if the programme objectives will be achieved.

2.1 Problem Analysis

In the IEIA the problems which are assumed to be solved by implementation of the programme should be stated in clear terms and the underlying causes of these problems should be analysed. To make the problem analysis as specific as possible, it should be elaborated for the following geographical zones: the Terai, the Hills and the Mountain region. It is known that biogas plants are not functioning effectively anymore in areas with a low average temperature. This seems to be the most important reason for the low level of biogas plants in the Mountain region compared to the other two regions. With respect to the Mountain region the opportunities to install biogas plants should be studied. The problem analysis for the distinguished regions should be described from two perspectives: the household and the settlement.

12 Objectives of BSP

The long-term objectives and the objectives for the third phase of BSP should be described in order to assess if they solve the problems, which have been identified during the problem analysis of the study. On basis of the findings of the evaluation of the impacts of BSP III the objectives for the fourth phase could be determined.

3. INSTITUTIONAL SETTING

The purpose of describing legislation, regulations and policies is: (i) to check if BSP III is compatible with the legal and political context and (ii) to get insight in the opportunities and constraints concerning the development of alternatives.

3.1 National Policy

- **Energy Policy**

The national (rural) energy policy for the short and long term should be described on basis of the present 9th Five-year plan (1998-2002). In particular the future position of sustainable energy and biogas in the national policy should be described.

- **Policy on Sustainable Land Use**

The national forestry and agricultural policy should be described on basis of the present 9th Five-year plan (1998-2002).

- **Policy on Health**

The national health policy as far as related with indoor air pollution and hygienic conditions at household level should be considered.

3.2 EIA legislation and regulations

In view of the national EIA regulations an EIA is not mandatory for the BSP. The EIA, which will be executed, must be considered as a voluntary EIA. Although the formal EIA procedure will not be followed, it is recommended to consult all stakeholders who are involved in a mandatory EIA in Nepal. This could be done by organising a consultative meeting when the draft: report is available.

4. BSP III AND THE REFERENCE SITUATION

The purpose of describing DSP IN is to enable determination of the impacts and the mitigating measures.

To enable a proper assessment and comparison of the impacts of BSP III in this study, the situation with biogas (BSP III) and the situation without biogas (the reference situation) should be described.

This study should focus primarily on cooking as biogas is predominantly used for cooking. Biogas is also used, to a lesser extent for lighting by a gas lamp. In this study the impacts of lighting by biogas will only be compared with the impacts of lighting by kerosene/LPG.

4.1 BSP III-Installing Biogas Plants

It should be taken into consideration that biogas will not completely substitute the use of other energy sources for cooking and lighting. It is recommended to elaborate the impact for (at least) the following two scenarios.

- A short term scenario focussing on the targets of the third phase of BSP; and
- A long term scenario focussing on a future situation in which the maximum number of plants will be installed in Nepal. The figures about the potential number of biogas plants that could be installed differ between 750,000 and 1,500,000 at national level, a distinction should be made for the Terai and the Hills. In the study the maximum number of plants should be justified on basis of a clear calculation and determination of assumptions.

Insight should be provided into the differences between these two scenarios. Particularly interesting to know is, if an increase in number of plants will have unexpected changes of the impacts.

4.2 The Reference Situation and Autonomous Development

The reference situation in Nepal should be described in the IEIA. This is the rural energy situation without biogas. This means that the impacts of the present use of energy sources for cooking will be described.

Activity cooking: In Nepal the situation without biogas means cooking on basis of fuelwood (in open fires or improved stoves), dung cakes, agricultural residues and fossil fuels (kerosene/LPG) or a combination of these sources. In the study the composition of the different fuels applied for cooking should be determined. This fuel mix should be used as a starting point for the assessment of the impacts.

Activity lighting: The situation in Nepal concerning lighting means no light at all, lighting on basis of kerosene/LPG, a connection to the electrical grid or relative new forms of energy generation such as micro / mini hydropower[1] and Solar Photo Voltaic (SPV). As stated before the impacts of biogas used for lighting will only be compared with the substitution of fossil fuels (kerosene/LPG) due to the fact that the other sources are of minor importance at national level. For lighting this means that the reference situation which has to be elaborated is lighting on basis of kerosene/LPG.

The autonomous development (in Nepal called the status quo scenario) is the development of the present situation of energy use for cooking without installing biogas plants in the future. This should be described in the IEIA. With respect to the autonomous development it is assumed that the composition of different energy sources and the total amount of energy used for cooking will remain the same. In case there are indications that that this assumption is not realistic this should be justified in the study.

4.3 Strategic Impact Assessment Study **for Rural Energy Supply** ' ,,i,,/nrv!V _''

In Appendix 6 an outline is presented for a strategic impact assessment study for rural energy supply in Nepal. This strategic study should ideally be elaborated on basis of the findings of the proposed integrated environmental impact assessment study. The outline for the strategic study is only presented in this advice to get an idea of the setting of the proposed study and to make use of the opportunity to discuss the relevance and the contents of such a strategic study with the involved Nepalese parties. . .-.,;.•;,,-,.;-%,,.,,..........

5. **IMPACT** ASSESSMENT T

The purpose is: (ij to identify and assess the scope and significance of potential impacts; and (iij to describe a reference situation, which enables comparison with the impacts of'BSP III.

5*1 Methodology for the impact assessment , r--J; is? ;,r-: "IJ- ; .:. .<¦ ¦ ;.-,-; x *£¦. ?,:::• < ..

5.1.1 General

In the study the impacts of BSP (phase **III)** and the reference situation should be described. In this chapter guidelines are provided for the short-term scenario directly related to objectives of the fourth phase. The impacts of a long-term scenario should be described more briefly.

The first step in the elaboration of this study is a review of available documentation as a lot of issues requested for in this advice have been studied already. Therefore a list of key documents is presented in Appendix 7. The second step is to identify the issues which require further additional and / or in depth study. This chapter provides guidelines for all information to be gathered to execute the study. This chapter does not provide detailed guidelines and methodologies on how to gather, analyse and present the information asked for. The to be recruited IEIA team is requested to propose a detailed methodology before implementing the study. The following five main issues should be distinguished:

- Substitution of biomass fuel and fossil fuels;
- Health situation;
- Sustainable land use;
- Climate change; and
- Socio-economic situation.

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[1] In general, micro hydropower is <100 kW and mini hydropower is 100-1000 kW.

In Appendix 8 an overview is presented of the major impacts of the installation of biogas plants. The Commission would like to acknowledge that this matrix reflects her ideas. In the IEIA the links between and the significance of the impacts should be substantiated. To facilitate the discussion between the members of the study team it is recommended to work with an impact matrix

5.1.2 Variables and Indicators

In Appendix 5 for each issue a number of final variables (underlined) are presented which have to be assessed. To make an assessment of these variables possible indicators are provided.

5.1.3 Scale of the Study; National; Settlement and Household Level

In the study three different levels should be considered: the national level, the settlement level and the household level. Dependent on the type of impacts and the availability of data a choice is made for one of the levels. For each issue it will be mentioned in this chapter at which level the information should be gathered, analysed and presented.

Household level: In general, it is known that the impacts of biogas plants differ from place to place in Nepal. However, it seems that impacts in the same geographical zone arc more or less comparable. Therefore, two of the three main geographical zones in Nepal should be used as one of the starting points in the study: the Terai and the Hills. The Mountain region, also called the remote hills should be excluded in this study as justified before.

To get insight in the impacts on household level, the study should be executed in the Terai as well as in the Hills in settlements with a high penetration level of biogas plants[1]. In total at least ten settlements should be selected (4 in the Terai and 6 in the Hills because the Terai is more homogeneous compared to the Hills). The households in the selected settlements should be divided into two groups: a group of households with a biogas plant and a group of households without a biogas plant. This latter group provides information for the reference situation.

Settlement level: To get insight in the impacts on forest resources and the land use system at settlement level, use should be made of the settlements selected with a high penetration rate in the Terai and the Hills as mentioned above. In order to determine the reference situation, additionally to the ten settlements, a number of villages in the Terai and in the Hills with a zero or low penetration rate of biogas plants should be selected. Settlements with low penetration rate, used for impact assessment at the settlement level, should be situated in areas with the same physiographic conditions. In table 1 an overview is presented of the level of data gathering for the identified main issues to be studied.

National level: For a description of the impacts of certain issues it is only relevant to do this at national level. In these cases a desk study can provide the information required. For some issues the overall results of the study on household level should be extrapolated to the national level.

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[1] In Nepal the following administrative units are distinguished: districts, village development committees and wards. The ward is the smallest administrative unit and in nil cases nine wards form a village development committee. A ward consists of one to a number of settlements. A settlement is no administrative unit but is used here because common resources, such as a forest are used and managed by one or some settlements.

Table 1: Level of Data gathering for the Main Issues to be Studied

Main issue	National	Settlement	Household
1. Substitution of bio mass fossil fuels	X		X
2. Health situation			
- Diseases	X		X
3. Sustainable land use			
- Agriculture/livestock	X		X
- Forestry	X	X	
Land use system		X	
4. Climate change	X		
5. Socio-economic sit.			
- Saving time & money			X
- Health condition			X
- Social status & spending			X
- Economic improvement			X
- Employment	x		

5.1.4 Gender relations and socio-economic groups

At household level it is known that the impacts of biogas plants differ between and within households and therefore a distinction in the following number of socio-economic groups is required for the groups of households with and without a biogas plant:

- Socio-economic status of households of a settlement (inter household differences), three groups should be distinguished on basis of the number of cattle owned: group 1 < 2 live stock unit (LSU), group II 2-4 LSU an group III>4 LSU; and
- Within households distinction should be made between men and women (intra household differences) to provide information on the impact on gender relations.

Assessment of the selected issues which will be executed at household level should take into account this differentiation in socio-economic groups.

5.2 Substitution of biomass fuel and fossil fuels by biogas

Biogas is predominantly used for cooking and in about 20% of the plants, (part of the) biogas is used for lighting. This relatively low share is caused by technical problems with the gaslamps. Also the limited availability of biogas may play a role, as plant owners may give priority to cooking above lighting.

In most cases biogas will replace biomass fuels (primarily fuelwood) and / or fossil fuels (kerosene/LPG). A recent study estimated that in an average biogas plant about 3 tonnes fuelwood and 38 litres of kerosene/LPG are annually replaced (1998 level). For the current situation these figures may be different, as the average plant size has reduced during the last two years.

In this study the impacts on the overall savings of fuelwood and fossil fuels should be quantified on a national levei. As various surveys have already been executed, and as much information is available at BSP, the impact can be assessed by means of a desk study in which the available information will be reviewed and updated. In case this information is not yet available this issue should be included in the survey to be executed at household level and the inter household differences (distinction of socio-economic groups on basis of LSU) should be taken into account.

- **Changed Demand of Fuelwood**

When there is no biogas available, in most cases fuelwood is used by the rural population for cooking. The fuelwood is burned in open fires or improved stoves. By substitution of the fuelwood by biogas, the same energy service has to be delivered (also the same amount of food has to be cooked). Taking into account the different efficiencies for the various types of stoves, the amount of fuelwood that is annually replaced can be calculated. However, installation of a biogas plant might lead to a higher energy consumption and the households might still be cooking partly on fuelwood. This effect will further be assessed in the study. The saving of fuel wood is assumed to have a positive effect on the prevention of forest degradation and deforestation, it has to be examined however, if this substituted amount of fuelwood that is calculated here has indeed a positive impact on forest resources (see paragraph 5.4).

- **Changed demand of kerosene/LPG**

Besides fuelwood also kerosene/LPG is saved when biogas plants are installed. Although the share is relatively small compared to substituted fuelwood, on a national level the amount and cost of substituted kerosene/LPG could still be considerable due to the large number *of* biogas plants that are planned to be installed. As kerosene/LPG has to be imported in Nepal, substitution by biogas will have a positive effect on the foreign currency savings. Also here, the possible occurrence of an increased energy consumption will be included.

5.3 The health situation

Direct impacts; the study will assess the direct impacts of 1 he Biogas Programme on the incidence of four groups of diseases and the occurrence of accidents. This information should be gathered at household level in selected settlements. Settlements should be selected as elaborated in paragraph 5.1. In these settlements households with and without biogas plants will be selected randomly. A systematic household survey should elaborate upon differentiating effects according lo sex and age groups as provided below. The results could be extrapolated to national level.

1a	Male	< 1 yr
lb	Female	< I yr
2a	Male	1-4 yr
2b	Female	1 -4 yr
3a	Male	5-14 yr
3b	Female	5-14 yr
4a	Male	15-49 yr
4b	Female	15-49yr
5a	Male	50 +
5b	Female	50 +

Indirect impacts; The general health situation of the household member might be affected due lo changes in agricultural production and rise of income. These impacts are elaborated in paragraph 5.6 on the socio-economic situation.

- **Incidence of Acute Respiratory Infections (ARI)**

Many studies have already been undertaken to assess the impact of traditional or improved wood stoves on ARI. As far as known such studies arc not yet executed for biogas. Qualitative results seem to indicate that use of biogas for cooking probably reduces the risk of ARI compared to fuelwood burning. ARI is considered to be mainly caused by heavy smoke development from open fire and traditional stoves inside houses. This study should make an effort to substantiate this positive impact.

- **Incidence of Eye Infections**

Less documented studies are available which studied the link between eye infections and indoor air quality. Smoke in combination with soot is one of the risk factors for eye infections. The incidence of eye infections should be assessed.

- **Incidence of Gastro-Intestinal (G I) Discuses**

Initial studies already carried out indicate that biogas plants have a positive effect on hygiene and sanitation and thus on health conditions in the direct surroundings of homes, in part also due to the fact that in a number of cases a toilet is attached to the biogas plant. As animal dung is gathered to *ked* the biogas plants, thus reducing water pollution and hygienic conditions around houses, the risk for GI diseases seems to be lowered considerably. This study intends to substantiate these findings in the same systematic survey proposed above for ARI. Also here a differentiation will be made according to gender and the mentioned age groups. It is stated but not yet documented that slurry is free of pathogens. If this is the case this could also be one of the causes for a decrease of GI diseases. Therefore, the slurry should be tested in order to determine if it is free of pathogens.

- **Incidence of Increased Mosquitoes and Related Risks**

As indicated by households possessing a biogas plant, there seems to be an increased occurrence of mosquitoes, especially at the slurry outlet of the biogas plant. The 1EIA will provide first indications on how serious and widespread this effect is. If these first observations are confirmed further study (not included in this IEIA) will be needed to assess increased risks of malaria. Another potential risk (transmitted by mosquitoes) which should be included in the survey is the inci dence of Japanese encephalitis. It seems that there is a link between the occurrence of this disease and keeping the cattle at the stable the whole year (zero grazing).

- **Occurrence of Accidents**

It is known that burning accidents occur but as far as known this has not yet been documented. This should be assessed. There is a risk of gas explosions in houses that cook on biogas. So far, no gas explosions have been reported and for that reason it is not relevant to be included in the study.

5.4 Sustain able Land Use

The study will assess the impacts of BSP HI in the following domains of sustainable land use: agricultural and livestock production, forest resources and the land use system as a whole. Information will be obtained primarily from secondary data and through informal semi-structured interviews (Participatory Rural Appraisal - PRA) at the household level for the issues of sustainable agricultural production and sustainable livestock production. In the household survey a distinction should be made between the impacts on men and women. The overall results of the study on these issues could be extrapolated in a more generic way to the national level. Impacts on the forest regeneration / degeneration and the land use system will be gathered at the settlement level. Impact on deforestation should be analysed at national level.

- **Sustainable Agricultural Production**

Impacts of biogas programmes upon land use have thus far not yet received much attention, the emphasis often being given to energy use and possible related socio-economic impact. However, it is assumed that the by-product of biogas plants, the slurry, may have high nutrient and organic matter value and could be used to increase soil fertility levels. If this is so, biogas programmes could have an important positive impact in sustaining agricultural production. In China the main objective of biogas plants is to convert biomass (in the form of dung, agricultural residues and kitchen waste) in organic fertilizer rather than the production of biogas. The assessment will focus on the impact of slurry use on land qualities and on cropping patterns.

With respect to land qualities special attention should to; (i) the impact of slurry use on soil fertility and (ii) the possible impacts (on land use and socio-economic conditions of people) of the use of water for the biogas plants and the addition of agricultural residues to dehydrate the slurry. At the same time agricultural residues can be added to the slurry to improve the quality and increase the quantity of the compost. With regard to cropping patterns the IEIA will study possible effects on changes in cropping intensity and types of crops.

- **Sustainable Livestock Production**

Use of biogas plants is highly related to livestock and especially cattle and buffaloes. Impact of biogas programmes on livestock production has thus far however not yet received the attention it should get. Impact assessment will deal at least with issues related to number and type of livestock, fodder and water use. and livestock man agement (free grazing or stall -feeding).

- **Forest Regeneration and Degeneration**

BSP III is supposed to have a major downward impact on fuelwood consumption. Fuelwood is primarily collected from forest areas around settlements. This can be done as well from community forests, private forests or state/protected forest. Irrespective of the ownership and management of these different types of forest, reduced fuelwood collection is supposed to enhance forest regeneration and to reduce forest degradation. Improved forest regeneration/reduced forest degradation will have a positive impact on biodiversity, the availability of wood and non-timber forest products (NTFP) and (reduced) CO_2 emissions. It is therefore considered important to assess the real impact of increased penetration of biogas plants on forest resources, also to confirm or invalidate the hypothesis thus far made of a positive impact.

As it will be unrealistic to assess the impact of individual biogas use on forest resources, emphasis will be given to assessment at the settlement level. It needs to be recognized that increased penetration of biogas plants is certainly not the only factor affecting quality of forest resources. Therefore it is recommended to select settlements with very high and low bioga s penetration under similar physiographic and population conditions ' (population density), as to compare possible differences in forest regeneration and degeneration due to a high presence of biogas plants.

- **Deforestation**

It is widely assumed that reduction of fuel wood consumption for cooking is limiting deforestation. However, the relative importance of this impact may be questioned. There arc many other factors that are leading to deforestation, such as expansion of agriculture, forest fires, road development, urbanisation. It is therefore considered important to assess the real impact of increased penetration of biogas plants on deforestation as to validate or invalidate the above hypothesis. It is therefore recommended to compare in a relative way the importance of other causes of deforestation with fuel wood collection. This assessment could be carried out at national level by making use of available documentation and statistics.

- **Land Use System**

The existing land use system might change as a result of developments in the components of this system induced by an increasing penetration of biogas plants in a settlement. The potential changes in these components are addressed in the above paragraphs. From the land use systems in the Hills it is known that they consist of a delicate balance between the components of such a system. Changes in one of the components can therefore have considerable indirect impact on the system as a whole. Changes of this system should be studied at household level and at settlement level for those settlements that are studied already to assess the changes in forest degeneration / regeneration.

5.5 Climate Change

By replacing fuel wood or kerosene/LPG, the use of biogas can contribute to the reduction of carbon dioxide emissions and therefore help to reduce the Global Warming Potential. The use of manure in the digester can decrease methane emissions (the effect of methane is 21 times the effect of carbon dioxide). In contrast to these benefits, it has been reported that in some cases methane leakage has occurred from the biogas plant. In this study the reduction of greenhouse gas emissions is calculated on national level (in tonnes CO_2-equivalcnts).

- **Greenhouse Gas Emissions**

The reduction of CO_2-emissions depends on the type of fuel that is substituted by biogas, In case fossil fuels are replaced (i.e. kerosene/LPG) there is a clear CO_2-reduction. When fuelwood is replaced by biogas there is only a reduction of CO_2-emissions when the fuel wood is produced in a sustainable way. Burning fuel wood is anyway causing CO_2 emissions. However, when fuel wood is produced in a sustainable way (through sustainable forest management), these CO_2-emissions are assumed to be compensated by CO2 sequestration in new forest growth, replacing the cut fuelwood. In the situation of fuelwood produced in forest which is managed in a non-sustainable way this is not the case. When biogas is compared with fuelwood also the N_2O emissions that occur when fuelwood is burnt will be included.

Concerning the methane (CH_4)-emissions the use of the manure in the reference situation without biogas plays an important role. If the manure is spread on the field predominantly aerobic digestion occurs, and only very limited CH_4-emissions will occur. In Nepal also a part of the manure is stored in a pile, leading to increased CH_4-emisssions. In Nepal also a part of the manure is applied in rice fields. In case manure is applied under water (anaerobic) high CH_4-emissions will occur. Secondary information might be available from the International Panel on Climate Change (IPCC). According to the IPCC (1997), under European conditions IPCC daily spreading of manure on the fields results in the release of O.I - 0.5 % and storage of solid manure results in the release of 1.0- 1.5% of the manure's methane potential.

When the manure is anaerobic digested, also CH_4-emissions may occur by (i) further anaerobic digestion of the slurry, (ii) by leakage of the gas pipe or (iii) by biogas escaping from the slurry outlet.

(i) After the slurry leaves the digester through the slurry outlet, further decomposition might occur resulting in CH_4-cmissions. Under European conditions N'CC estimates that this can result in the release of up to 4% of the manure's total methane potential. In the IE1A these emissions will therefore have to be estimated for the specific situation in Nepal.

(ii) CH_4-emissions can also occur because of leakage in the gas pipe between the digester and the cooking stove. As new plants are subject to severe quality standards and penalties for the construction companies have been set in the case of leakage, this leakage is strongly reduced.

(iii) Another possibility is leakage through the slurry outlet, which will occur when during a certain period more biogas is produced than is used. At the moment that the gasholder is full, the biogas will leave the digester through the slurry outlet. This leakage has been visually observed in some plants during warm periods (high biogas production). The exact effect of this leakage is not known at this moment, and depends on factors like plant design and operation and climate. Therefore it will be necessary to measure these types of CH_4-emissions. A test with a new built plant starts in February 2001. In this study a representative sample of plants has to be determined where the methane emissions will be monitored.

5.6 Socio-economic Situation

Apart from the direct impact on employment caused by the construction of biogas plants (to be elaborated at national level) all issues raised in this paragraph are indirect impacts of BSP III affecting the socio-economic situation of households and should therefore be studied at household level. All indirect impacts are induced either due to increased income from agriculture/livestock or to savings of time and / or money. Therefore, the savings in time and money should be quantified as much as possible. So far, limited study has been done concerning the impacts of those savings.

- **Saving of Time and Money**

In a number of studies it is stated that installation of biogas plants on average saves about three hours of time for women. This is due to the fact that the time used for fuelwood collection is decreased considerably. To substantiate these conclusions a daily activity profile should be elaborated; summarising the time used during a typical day by man and women of different age groups. The purpose is to identify the impacts which affects men, women and children differently: (i) directly (e.g. physical workload and breast-feeding practices by lactating women) and (ii) indirectly change in time spent on different activities and change in income situation / spending pattern.

The direct changes in the income situation due to savings in costs for fertilizer and fuel wood/kerosene are mentioned in different studies. As far as known in none of the studies the indirect changes in the economic situation of the households due to changes in the daily activity pattern has been determined. Therefore, the spending pattern of the household should become clear. On basis of changes in the spending pattern indirect impacts on the following issues for households can be determined: health conditions, social status, social spending and economic situation. All this information should be gathered at household level. For the information asked for in this paragraph use should be made of the annual users survey executed by BSP and the gender survey which is presently developed by BSP.

- **Health Conditions**

Apart from direct positive effects of biogas plants on the occurrence of diseases (as mentioned in § 5.3) possible impact on health conditions may take place due to other effects of the biogas plants, such as changes in land use. in time use and in income. This 1EIA will look also imo these questions and will give specific emphasis to possible positive or negative impacts from changes in livestock management (change to stall feeding), from raise or decrease in income in different socio-economic and gender categories because of negative /positive effects of the biogas slurry on agricultural and livestock production. Also it will be worthwhile to consider the effects from changes in time use and physical workload, due to the installation of biogas plants.

- **Social Status**

It is assumed that the introduction of biogas plants in rural households has considerable impact on social status of both men and women concerned. For instance, it is observed that women involved in the biogas support programme feel more free to discuss issues with outsiders through the exposure obtained in the implementation of the programme (training, visits, etc). Also possible time gains may have led women to find more time for their education. Possible time gains may have also been beneficial to both men and women to be more actively involved in community organization and 'polities', giving them also higher social recognition. Moreover changing land use practices may have altered changes in roles and tasks between men and women.

- **Social Spending**

The changes in agricultural and livestock production diie to the introduction of the biogas plants may possibly have increased or decreased incomes and available time. These impacts being assessed in this IE1A, it also is recommended to assess how people are using differently extra or less time and money. One may think of increased or decreased participation in social and cultural activities and education (probably due to increase of the quality of lighting by gas lamps) but also of changes in alcohol consumption and time and money spent on gambling.

- **Economic Improvement or Marginalization**

Possible changes in income through increased or decreased agricultural and/or livestock production and by alternative use in time may have occurred due to the introduction of biogas plants. It is important to emphasize here that the installation of a biogas plant may have positive income effects for owners of biogas plant (to be assessed), but may have at the same time negative effects on other often poorer households not benefiting from such a biogas plant. Results of these assessments will be also analysed for possible changes in income distribution and in access and control to resources,

- **Impact on Employment**

It is recognized that the biogas support programme is creating additional employment for the manufacturing of the plants and the needed appliances as well as for their installation, servicing and maintenance. The IKIA will assess the nominal and relative importance of such increase in employment, in terms of contributions to the national economy. Analysis will be done by study of available documents and statistics at the national level.

5.7 Financial-economic evaluation of impacts

The study should assess the financial/economic impacts at three different levels:

- Financial evaluation on household level;
- Economic evaluation on household level; and
- Economic evaluation on a national level.

The necessary data for the implementation of the financial/economic evaluation will be provided by the impact assessment of the main issues as asked for in the previous paragraphs. The Commission would like to recommend that the following two points should be taken into consideration in the evaluation on household level: (i) the possibly negative financial/economic impact on households and (ii) the possibly negative financial/economic impact on households not benefiting from the biogas plants, this might be substantial and influence the results of the economic analysis in a negative sense.

- **Financial Evaluation on Household Level**

In many studies that have been carried out so far, the financial impact of the use of biogas on household level has been assessed. Most of these evaluations show that the use of biogas can lead to a reduction in costs for cooking and lighting, but that this reduction is strongly dependent on the price of the substituted fuelwood, kerosene / LPG. A limitation of most of these studies is however, that only the impacts originating from the avoided purchase of fuel wood and fossil fuels (and sometimes the avoided purchase of fertilizer) arc taken into account, while other possible impacts that will be assessed in this study are not included.

Therefore, in this study a financial evaluation on household level should be executed taking into account the following items:

- Reduced purchase of wood fuel, kerosene / LPG;
- Reduced purchase of fertilizer and pesticides;
- Hired labour for biogas plant induced activities;
- Cost of additional bought inputs related to biogas plant induced activities (e.g. seeds, fodder and pesticides);
- Possible increase in crop yields (current and new crops), due to the use of (composted) slurry;
- Possible increase in milk production, due to stall feeding of cattle;
- Possible change in income, due to biogas plant induced income generating activities;

- Possible other impacts that are encountered during the IEIA (such as sale of dung cakes, manure and/or compost produced from slurry); and
- Capital costs and maintenance costs (including the biogas plant construction costs, subsidies, down payment, annual loan repayment).

The costs/benefits will depend on the size and location of the biogas plant, and should be compared with cost/benefits of the reference situation (the situation without biogas plant).

The purpose of the financial evaluation is: to compare the situation with and without biogas. The result should provide insight at household level, into the annual savings/costs for households with a biogas plant. A breakdown in the various costs/benefits should be included. A sensitivity analysis should be conducted.

- **Economic Evaluation on Household Level**

In the economic evaluation, the economic costs and benefits on household level when installing a biogas plant will be evaluated. Basis for this economic evaluation is the above-mentioned financial evaluation on household level. In order to be able to convert the financial costs/benefits in economic costs/benefits, economic factors have to be determined. Economic cost of saved or additional family labour (shadow prices) should be included here as compared to the reference situation. Also should be taken into account the cost (as compared to the reference situation) of inputs like water, dung, fodder and crop residues used, not any more used, or used in another way (e.g. crop residues used as fodder in stead of fuel; dung as fertilizer instead of fuel).

- **Economic Evaluation at a National Level**

In order to assess the overall benefits of biogas to society, an economic evaluation will be made on a national level. Basis will be the economic evaluation on household level, which will be extended to a national level. In addition the expenditures of BSP should be included (e.g. genera! programme cost and technical assistance), as well as the impacts that have an influence on national level. The following issues have to be incorporated:

- Changes in health conditions;
- Forest regeneration/degeneration;
- Changed emission of greenhouse gasses; and
- Changes in employment situation.

The impacts on these issues have been discussed already in the previous paragraphs. To convert them into economic values, shadow values have to be determined. The impacts to be included in the economic evaluation are briefly discussed for the selected issues.

Changes in Health Conditions

The introduction of biogas plants is expected to have impacts on the occurrence of certain diseases (see paragraph 5.3). The use of biogas for cooking is expected to lead to a reduction in ARI, as the indoor air quality is improved compared to the situation where woodfuel is used. In a study that was carried out in Nepal it is estimated that the economic value of smoke exposure reduction per household is US$ 100 (Reid et. al, 1986). The attachment of toilets to the biogas plants improves the hygiene and sanitary conditions and may therefore reduce the costs of GI diseases. When the change in occurrence of GI diseases due to the installation of biogas plants can be determined, the economic value of GI diseases should be estimated (e.g. on the basis of secondary information or on the basis of the average costs of treating diarrhoea).

Forest Regeneration/Degeneration

The introduction of biogas plants is expected to lead to a decrease in fuel wood consumption and might therefore have an impact on the regeneration/degeneration of forests. When this impact can be quantified in this study, the economic value of the forest regeneration/degeneration has to be determined, where possible based on the information from literature or secondary information.

Changed Emission of Greenhouse Gasses

The total change in emission of greenhouse gasses will be quantified (see paragraph 5.5). An economic value per ton CO_2-equivalent should be determined in this study, based on the current (inter) national used levels.

Changes in Employment Situation

The large-scale introduction of biogas plants may lead to increased employment. This impact will be included in the economic calculation. It should be noted however, mat the change in employment due to the construction of biogas plants is already taken into account for by conversion of financial values of the biogas plant construction into economic values by using the economic factor. The same goes for the possible income generation due to saved labour.

The main indicator of the economic analysis on national level is the EIRR (economic internal rate or return), which is calculated on the basis of the cash flow analyses of yearly costs and benefits. A breakdown into the different costs and benefits should be made and a sensitivity analysis for the main parameters should be included.

6. DESCRIPTION OF MITIGATING MEASURES

The purpose of this step is to get insight into the opportunities to prevent or reduce negative impacts in phase IV of BSP.

The study could elaborate mitigating measures to prevent or reduce negative impacts in the next phase of BSP. Presently, amongst others the following potentially negative impacts (might) occur which could be mitigated:

- Emission / leakage of methane: measures to prevent methane emissions such as; focus on farm specific scale of the plant (balancing demand and supply), fine tuning of the management, firing of the gas;
- Increase of malaria and or Japanese encephalitis due to the fact that musquitos breed in the outlet of the plant. A mitigating measure could be the redesigning of the outlet of the plant; and
- Existence of a socio-economic gap between households with and without a biogas plant and even marginalization of the poor households due to e.g. a decrease in the availability of dung which could be collected flee in the fields for use by poor households.

7. COMPARISON OF THE IMPACTS OF BSP III AND THE REFERENCE SITUATION

The purpose of comparing the impacts of BSP and the reference situation is to get insight in the differences of the impacts.

The impacts of BSP III must be compared with the reference situation and should be presented by making use of tables, figures and an impact matrix.

8. GAPS IN KNOWLEDGE AND INFORMATION

The gaps in knowledge and information should become identified.

Annex- I

Letter from the Alternative Energy Promotion Centre dated 29 August 2000 with request for advice.

PROJECT INFORMATION

Proposed activity: Integrated Environmental Impact Assessment for the Biogas support programme in Nepal.

Categories: biogas DAC/CRS code 46000

Project numbers: Commission for E1A 041

Procedural information:
Request for advice (draft): 26 August 2000

Significant details: A joint Nepalese-Netherlands working group of the Commission is requested to prepare an advice for ToR for the execution of an integrated environmental impact assessment. In this study the direct and indirect environmental as well as the socio-economic impacts of the third phase of the Biogas Support Programme will be evaluated and compared with the situation without biogas. The ToR will be drafted in January 2001 in Nepal.

Members of the working group:

Mr D. van der Berg
Mr P. van Ginneken (only first meeting)
Mr K.B. Karki (local expert)
Mr P. Laban
Mr A. Pijpers (chairman)
Mr A. Pradhan (local expert)
Mr K. Rijal (local expert)

Secretary of the working group: Mr A.J. Kolhoff

PROGRAMME SITE VISIT

23 January	09.00-10.00	Welcome by Mr Sundar Bajgan and Mr Felix ter Heegde
	10.00-11.00	Acquaintance of the working group members from Nepal and the Netherlands
	11.00-14.00	Visit of a biogas plant
	14.00-15.00	Discussion on the first draft advice
24 January	09.00-10.00	Presentation of BSP by Mr Felix ter Heegde
	10.00-18.00	Meeting of the working group
25 January	09.00-10.00	Meeting of the working group and drafting of the advice
25 January	10.00-14.00	Presentation of the draft advice and discussion in a consultative meeting (the list of participants is presented below)
	14.00-14.30	Debriefing with Mr Jan Brouwers
	14.30-15.30	Meeting with Mr Felix ten Heegde
	15.30-19.00	Final meeting with the working group
27 January	09.00-14.00	Redrafting of the first draft advice

CONSULTATIVE MEETING-LIST OF PARTICIPANTS

1	Mr Jan Brouwer	Sector Manager, Biodiversity, SNV/Nepal
2	Mr Prashun Bajracharya	Programme Manager, NBPG
3	Mr Kishor Gyawali	Chairman. PGC
4	Mr Shankar Bahadur Singh	General Manager, GGC
5	Mr Shekhar Aryal	Chairman, RGG
6	Mr Madan B.Basnyat	Executive Director, AEPC
7	Mr Mohan B. Karki	Joint Secretary, MoST
8	Mr Pramod Poudyal	Chief loan Division, ADB/N
9	Mr Deepak Kharal	Environmentalist, WECS
10	10 Mr Prakash Chandra Ghimire	Executive Director, Dev-Part
11	11 Mr Bikash Pandey	Director, REPSO
12	Mr Jagannath Shrestha	Director, CES
13	Mr Surendra Lai Shrestha	Under Secretary, NPC
14	Mr Hari Regmi	Under Secretary, MOF
15	Mr Bikash Sharma	CREST
16	Mr Janak Raj Joshi	Joint Secretary, MOPE
17	Mr Govinda Derkota	Universal Consultancy
18	Mr Ram Khadka	Associate Professor, SchEMS

GUIDING PRINCIPLES FOR AN INTEGRATED APPROACH OF THE STUDY

On basis of experience[1], the Commission is of the opinion (hat the quality of an integrated assessment is predominantly determined by an appropriate coordination of the study. Guiding principles for the execution of an integrated assessment are:

- a multi disciplinary team should carry out the study;
- experience with implementation of Environmental Impact Assessment is required;
- one coordinator should coordinate the study;
- exchange of information between the different specialists is necessary;
- the terms of reference should be discussed by the study team and in particular it should become clear who is responsible for data gathering and -analysis of the cross cutting issues;
- the results of the assessment should be discussed by the study team;

Exchange of information between the different specialists of the study team is one of the conditions for a qualitative good integrated study. Therefore it is recommended to organise a number of workshops (at least four) at crucial moments in the process:

- workshop I; discussion about the ToR, set up of the study and division of the themes;
- workshop 2; presentation of and discussion about the secondary data and determination of the primary data to be collected;
- workshop 3; presentation and discussion about the first results of primary data; collection and analysis within the study team by making use of an impact matrix;.
- workshop 4; consultative meeting of the final draft with stakeholders and processing of the information by the study team.

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[1] The experience of the Commission concerning integrated assessment is recorded in the following documents:
- Scholten, J & R. Post: Strenghtening the integrated approach for impact assessment in development cooperation. In: Sustainable development and integrated appraisal in a developing world (ed. by N. Lee and C. Kirkpatrick). pp 23-31; 2000.
- Post, R, A, M. , A. J. Kolhoff and B. J. A. M. Velthuyse: Towards integration of assessments, with reference to integrated water management in third world countries, In: Impact Assessment and Project Appraisal. 19 (1). p.50; 1997.
- Velthuyse B.: Integraal denken inlegraal doen. Een ondcrzoek naar de mogelijkhcclcn voor een integrate effectrappoprtage ij de Commissie voor dc m.e.r; 1997.

SUGGESTIONS FOR INDICATORS TO MEASURE THE IMPACT OF THE B1OGAS SUPPORT PROGRAMME (PHASE III)

Indicators are elaborated for each of the main domains of impact (final variables are provided) identified in chapter 5 of the advice on the terms of reference for this Integrated Environmental Impact Assessment study.

1. Impacts on energy use

Substitution of biomass fuel and kerosene

- number of operational biogas plants
- gas production (number of hours for cooking - seasonal variation)
- quantity of available dung (feeding in the plant)
- average size of biogas plants .
- feeding capacity of biogas plants
- increased/reduced use of fuelwood
- increased/reduced use of agricultural residues as fuel/fodder
- increased/reduced use of dung as fuel/fertilizer
- change in amount of kerosene /LPG used
- change in cooking efficiency (of induced device)
- change in energy services (useful/secondary energy)

2. Impact on the health situation

Diseases

- incidence of Acute Respiratory Infections (ARI)
- incidence of eye infection (smoke related)
- exposure to indoor air pollution
- incidence of Gastro-Intestinal (GI) diseases
- incidence of malaria and other mosquito induced diseases
- level of pathogens in slurry
- accidents (fire accidents, burning)

3. Impacts on sustainable land use

Forest regeneration and degeneration

- increased/reduced fuelwood collection
- increased/decreased use of types of wood (parts of the tree; dead/living wood)
- increased/reduced use of NFTPs (for medicines, utensils, food and spices)

Deforestation

- encroachment by agriculture (ha/year)
- irreversible damage of forest by forest fires (ha/yr)
- encroachment due to urbanisation and road building (ha/yr)
- conversion of fueiwood and timber (tonnes/yr)

Soil fertility

- increased/decreased use (quantity)of different fertilizers (manure, compost and chemical fertilizers)
- increased/decreased crop yields
- increased/reduced incidence of crop pests and diseases (crop health)
- increased/decreased use of crop residues (as soil cover; to make compost or as fuelwood)
- increased/decreased use of surface water

Cropping patterns

- changes in cropping intensity (crop rotation, crops/yr, mixed or monocrops)
- changes in types of crops (cash, staple, fodder, vegetable, fruit crops)
- change in land use patterns

Livestock production

- increased/decreased numbers and breed of diary and other animals
- increased/decreased fodder availability (distance, type)
- changes in fodder cultivation
- changes from free grazing to stall feeding
- increased/decreased use of water for animal husbandry (feeding and fodder cultivation)

4. Impacts on climate change

Emissions of greenhouse gasses

- change in carbon dioxide emissions
- change in methane emissions
- change in N_2O -emissions

5. Impacts on socio-economic conditions

N.B. 1. Especially the items mentioned here need to be differentiated according to gender and income categories.

N.B.2. Outcomes of investigations on issues mentioned below need to be analysed also for increasing/decreasing gaps between biogas owners and non-biogas owners, as well as related different income categories

Saving of time and money

- fuelwood collection
- fodder collection
- water collection
- feeding of biogas plants
- cattle feeding
- use and processing of slurry/compost (including transport and application)
- cultivation practices
- milking
- trading of milk and other agricultural products
- cooking and cleaning of kitchen and utensils

Social status

- changes in daily habits
- social recognition of men and women
- changes in roles between men and women
- changes in educational status (men and women)
- increased education and exposure of women
- degree of involvement in community organization and 'politics';

Social spending (in terms of time and money)

- pilgrims and festivals
- improved schooling
- social organization (services and donations)
- quality of light
- gambling, idle lime

Health conditions

- breast feeding practices
- time devoted to look alter the children
- change in consumption of nutritious food
- change in medicine use
- change in alcohol consumption

Economic changes (improvement or marginalization)

- changing gap in incomes between hh with and without a plant

- change in control and access to natural resources (dung, agr. residues, water, fodder) of landless and poorest farm-households
- changes in income (negative/positive) through alternative use of time and increased soil fertility)
- changes in money spending patterns (e.g. medicines, education and food)
- change in milk production
- Increased/decreased gambling
- ' increase in household assets (e.g. furniture and t.v.)
- increased use of modern technologies
- increased direct financial benefits of biogas plants (sale of dungcakes, manure and/or compost produced from slurry ; sales of excess crop yields due to slurry induced higher soil fertility
- decreased access to free dungcakes and manure for landless and poorest households
- credit worthiness

Employment

- number of companies
- number of people involved in construction
- number of people involved in promotion and extension activities
- indirect employment due to the construction of plants (secondary activities : e.g cement industry)

STRATEGIC IMPACT ASSESSMENT STUDY FOR RURAL ENERGY SUPPLY

This strategic study is not meant to be implemented together with the integrated environmental impact assessment of energy use for cooking. In the preparatory phase of the drafting of this advice for guidelines representatives of MOSTE and the National Planning Commission have expressed their interest in the execution of a strategic impact assessment study for the rural energy supply. The results of the proposed study could become an important input for such a strategic study at national level in the near future.

The existing energy situation in rural Nepal indicates that fuel wood, agricultural residues, dung cakes and biogas in being used for cooking purposes. The multi-power application is primarily provided by grid electricity by micro hydropower. Solar Photo Voltaic (SPV) and biogas. All possible sources of energy supply lo meet the different types of energy services, need to be included i:V *a* strategic impact assessment with regard to rural energy supply, taking into consideration the impacts on local, regional and global environment. In case this strategic study will be implemented later on, one could think of the following dimensions/starting points.

- Composition of energy profiles of the different energy user groups (the present and the future energy demand) specified for all distinguished geographical zones in Nepal.
- Supply of energy in the present situation as starting point and development of scenarios for future energy supply. It is expected that electricity will become an important energy source for all kind of activities (such as milling, pumping for irrigation, radio/TV and lighting) Electricity will become supplementary to energy sources used for cooking such as fuelwood and biogas. Therefore an alternative could/should be elaborated aiming at an increase of the rural electricity demand. Electricity can be generated by different sources, concerning the building blocks for scenarios one could think of:

- Electrification by a central grid (energy supply generated primarily by hydropower).
- Electrification by a local gird (biomass, gasifiers, mini and micro hydropower, wind turbines and diesel generators) or stand alone SPV.

LIST OF KEY DOCUMENTS

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- SNV/N; Final Report on the Biogas Support Programme Phase f and II. Development through the market, June 1997.
- Velthuyse B.: Integraal denken integrant doen. Ben onderzoek naar de mogelijkheden voor een integrate effectrappoprtage bij de Commissie voorde m.e.r: 1997.
- WECS, Energy Synopsis Report.

APPENDIX II
COMPOSITION OF TOR COMMITTEE AND STUDY TEAM

Appendix II

COMPOSITION OF TOR COMMITTEE AND STUDY TEAM

Member of TOR Committee

1. Mr. D. van der Berg
2. Mr. P. van Ginneken
3. Dr. K. B. Karki (Local Expert)
4. Mr. P. Laban
5. Mr. A. Pijpers (Chairman)
6. Mr. A. Pradhan (Local Expert)
7. Dr. K. Rijal (Local Expert)
8. Mr. A. Kolhoff

Member of Study Team

1. Prof. Jagan Nath Shrestha
2. Dr. Amrit Bahadur Karki
3. Mr. Blnod Sharma

APPENDIX III
FIELD DATA COLLECTION TEAM

Appendix III

FIELD DATA COLLECTION TEAM

S.N.	Name	Assign Post	Address/Phone No,
1.	Mohan Parajulee	Coordinator	Student Partnership Worldwide, Kathmandu
2.	Nirmal Mulmi	Supervisor	Sinamangal, Kathmandu, 489119
3.	Anil Paudel	Supervisor	Lazimpat, Kathmandu, 438586
4.	Suraj Shrestha	Supervisor	Chabhil, Kathmandu, 496869, 540157
5.	Basanta Rai	Enumerator	Gyaneshwore, 438540
6.	Riddo Bahadur Thapa	Enumerator	Dhankuta-7, 332509 (Kirtipur)
7.	Surya Thapaliya	Enumerator	Baluwatar, Kathmandu, 425269
8.	Saroj Uprety	Enumerator	Sanepa, Lalitpur, 542927, 542736
9.	Niranjan Pradhan	Enumerator	NewBaneshore,499219
10.	Rabina G. Rasaily	Enumerator	Jawalakhel, Lalitpur, 543069
li.	Binod Basnet	Enumerator	Kirtipur-15, Kathmandu, 410498
12.	Manoj Koirala	Enumerator	Battisputali, Kathmandu, 490562
13.	Bikash Hari Koiraia	Enumerator	Gongabu, Kathmandu. 355469, 240616
14.	Purushottam Bista	Enumerator	Bishankhu Narayan-1, Lalitpur, 560091
15.	Narayan Silwal	Enumerator	BishankhuNarayan -1, Lalitpur, 560091
16.	Anu Shrestha	Enumerator	Samakhushi, Kathmandu, 355469, 240616

APPENDIX IV
A SET OF QUESTIONNAIRES
(QUESTIONNAIRE A, B AND C)

Appendix – IV

A SET OF QUESTIONNAIRES
(Questionnaire A, B and C)
Questionnaire A: Biogas HH

1	**GENERAL INFORMATION**		
100	**Interview**		
101	List of materials to be taken by enumerator:	☐ Questionnaire	☐ Ruler
		☐ Pen	☐ Tape measure
		☐ Paper	☐ Weighing balance
		☐ Clip board	
		☐ ID	☐ Umbrella
		☐ Authorization letter	☐ 1st aid kit
		☐ Request letter	☐ Torch
102	Name enumerator		
103	Date interview	2057 / /	
104a	Interview starting time	Start: . hrs minutes	
110	**Farm location**		
111	Name District	*To be copied from sample list*	
112	Name VDC	*To be copied from sample list*	
113	Ward number	*To be copied from sample list*	
114	Name of the plant owner	*To be copied from sample list*	
115	Walking distance to road head	days; hours; minutes	
116	Walking distance to water source.	minutes	
117	Elevation of location (amsl)	meters	
120	**Plant identification**		
121	Plant code	______ / ______ / ____ / ______ **to be copied from sample list**	
122	Plant completion date	Year: 205___ Month: *to be copied from sample list*	
123	Plant size	m^3 *to be copied from sample list*	
130	**General observations**		
131	Type of house	☐ 1 Thatched roof ☐ 2 Corrugated sheets ☐ 3 Tile / slated roof ☐ 4 Mixed ☐ 5 RCC/RBC roof	
132	Latrine on the yard	☐ 1 yes ☐ 2 no	
133	*If q 132 = yes:* Latrine connected to biogas plant	☐ 1 yes ☐ 2 no	
134	Electricity	☐ 1 yes ☐ 2 no	
135	*If q 134 = yes:* Source of electricity	☐ 1 National Grid ☐ 2 Local hydro grid ☐ 3 Solar ☐ 4 Local Diesel generator	
136	Media **Verify with hh member**	☐ 1 None ☐ 2 Radio ☐ 3 Television	
137	Transport **Verify with hh member**	☐ 1 none ☐ 2 bicycle ☐ 3 motorcycle ☐ 4 tractor ☐ 5 Others: __________	

138	Animals *# of heads observed*	Numbers observed ☐ 1 none ☐ 2 cow / ox ____ ☐ 3 buffalo ____ ☐ 4 pigs ____ ☐ 5 goats / sheep ____ ☐ 6 poultry
140	**Household identification**	
141	Name of head of household	Mr. / Mrs.
142	Sex of head of household **Tick only one**	☐ 1 Male ☐ 2 Female
143	Educational level head of household	☐ 1 Illiterate ☐ 2 Literate, no formal education ☐ 3 Class 1 to 5 ☐ 4 Class 6 to 10 ☐ 5 SLC ☐ 6 Above SLC
144	Caste of household **Tick only one**	☐ 1 Bramin ☐ 2 Chhetri ☐ 3 Newar ☐ 4 Tharu ☐ 5 Rai ☐ 6 Magar ☐ 7 Kumal ☐ 8 Gurung ☐ 9 Tamang ☐ 10 Damai ☐ 11 Kami ☐ 12 Harijan ☐ 13 Others:________ ☐
145	Major occupation of head of hh **Tick only one**	☐ 1 Agriculture ☐ 2 Business ☐ 3 Service ☐ 4 Industry
150	**HH member identification**	*Age in completed years*
151	# of hh members under 5	Male ______ persons Female ______ persons *Total # of persons under 5: persons*
152	# of hh members 5 to 14	Male ______ persons Female ______ persons *Total # of persons 5 to 14: persons*
153	Educational level 5 to 14 **Attending or highest level** **Note # of persons in category**	*(see table below)*
154	# of hh members over 14	Male ______ persons Female ______ persons *Total # of persons over, 14 persons*
155	Educational level over 14 **Attending or highest level** **Note # of persons in category**	*(see table below)*
156	Occupation over 14 **Note # of persons in category**	*(see table below)*

153:

# of persons	Male	Female
1 Illiterate		
2 Class 1 to 5		
3 Class 6 to 10		
Total # of persons 5 to 14:		*persons*

155:

# of persons	Male	Female
1 Illiterate		
2 Literate		
3 Class 1 to 5		
4 Class 6 to 10		
5 SLC		
6 Above SLC		

156:

# of persons	Male	Female
1 Agriculture		
2 Business		
3 Service		
4 Industry		

157	Total number of persons in the hh **Verification**	According to interviewee ______ *According to 151 + 152 + 154* ______ *According to 151 + 153 + 155*		
2.	**Agriculture and land use**			
200	**Landholding**			
201	Area of land under cultivation. *Including cultivated land under tenancy*		Khet	Bari
		Ropani		
		Anna		
		Bigha		
		Katha		
202	Total land owned. **Including non cultivated land**		Khet	Bari
		Ropani		
		Anna		
		Katha		
		Bigha		
210	**Information on livestock**			
211	Livestock holding of household: Current holding. **Note # of heads per category**	*# of animals*	Adults	Calves
		1 none		
		2 cow/ox		
		3 buffalo		
		4 pigs		
		5 goat/sheep		
212	Livestock holding of household: Holding before installation of biogas plant. **Note # of heads per category**	*# of animals*	Adults	Calves
		1 none		
		2 cow/ox		
		3 buffalo		
		4 pigs		
		5 goat/sheep		
213	Cattle feeding: current practice. **Cow, ox & buffalo only**	☐ 1 Complete stall feeding ______ heads ☐ 2 Partial stall feeding ______ heads ☐ 3 Complete free grazing ______ heads		
214	Cattle feeding: practice before biogas installation. **Cow, ox & buffalo only**	☐ 1 Complete stall feeding ______ heads ☐ 2 Partial stall feeding ______ heads ☐ 3 Complete free grazing ______ heads		
215	Amount of water fetched for cattle drinking before and after installation		**Before**	**After**
		Amount/day		
216	Fodder collection practice before and after installation of biogas. *Enumerator to measure: **1 bhari** = ____ kg* **Tick as required**	*bharis/day*	**Before**	**After**
		☐ 1 Not applicable, free grazing		
		☐ 2 From jungle		
		☐ 3 Own production		
217	***Amount of water used for own fodder production before and after biogas installation***	*Litres per day*	**Before**	**After**
		Amount/day		
218	Cattle stable condition **Tick as required**		**Before**	**After**
		1 Smooth, earthen floor	☐ 1 Yes ☐ 2 No	☐ 1 Yes ☐ 2 No
		2 Smooth, concrete floor	☐ 1 Yes ☐ 2 No	☐ 1 Yes ☐ 2 No
		3 Urine collection pit	☐ 1 Yes ☐ 2 No	☐ 1 Yes ☐ 2 No
219	Dairy production before and after biogas installation. *Please note dairy production in litres per day*	**Litres per day**	**Before**	**After**
		☐ 1 None		
		☐ 2 Domestic production		
		☐ 3 Commercial production		

220	**Agricutural production**			
221	Major crops grown before and after the installation of biogas. **Tick as required**	**Summer**		
		Before	**After**	
		☐ Paddy	☐ Paddy	
		☐ Maize	☐ Maize	
		☐ Millet	☐ Millet	
		☐ Summer vegetables	☐ Summer vegetables	
		☐ Cash crop (specify)	☐ Cash crop (specify)	
		☐ Others (specify)	☐ Others (specify)	
		Winter		
		Before	**After**	
		☐ Wheat	☐ Wheat	
		☐ Mustard	☐ Mustard	
		☐ Barley	☐ Barley	
		☐ Winter vegetables	☐ Winter vegetables	
		☐ Cash crops (specify)	☐ Cash crops (specify)	
		☐ Others (specify)	☐ Others (specify)	
		Spring		
		Before	**After**	
		☐ Early rice	☐ Early rice	
		☐ Off-season vegetables	☐ Off-season vegetables	
		☐ Pulses	☐ Pulses	
		☐ Cash crops (specify)	☐ Cash crops (specify)	
		☐ Others (specify)	☐ Others (specify)	
222	How much and what type of fertilizers do/did you use before/after installation of the biogas plant for your crops. *1: unit = bhari* ***1 bhari = ______ kg*** *2: unit = buckets* ***1 bucket = ______ ltr*** *3: unit = kg*		**Before**	**After**
		FYM [1]		
		Liquid biogas slurry [2]		
		Compost [1]		
		Compost with slurry [1]		
		Chemical fertilizers [3]		
223	*If q 222 = no:* What is the reason not to use the slurry	☐ 1 Not aware of fertilizing value ☐ 2 Do not know application method ☐ 3 Not convinced of fertilizing value ☐ 4 Too wet, problem to transport to the fields ☐ 5 Toilet attached, problem to transport to fields ☐ 6 Too little available to bother ☐ 7 Others: ___________		
224	*If q 222 = yes:* In what form is the bio-slurry applied	☐ 1 Liquid ☐ 2 Dried, not composted ☐ 3 Composted ☐ 4 Through irrigation channel		
225	What do you do with crop residue. *(Rice and wheat straw; corn stalk; husks; brans, etc)*	*Note share or % of total production*		
		Use	**Before**	**After**
		☐ 1 fuelwood		
		☐ 2 animals feed		
		☐ 3 compost		
		☐ 4 Soil cover (mulching)		
		☐ 5 Other:_________		

226	In which crops do you use slurry, and in which form. **See q 224 for form of application** ***1 bhari dried slurry = _____ kg*** ***1 bhari composted slurry = _____ kg***	**Crop**	**Form applied** 1	2	3	4	**Quantity** Buckets /bhari
		☐ 1 Paddy					
		☐ 2 Wheat					
		☐ 3 Maize					
		☐ 4 Millet					
		☐ 5 Vegetables					
		☐ 6 Fruits					
		☐ 7 Cash crops					
		8 Other: __________					

227	How often do you have to weed your crops. *Take the 2 crops that are using the most slurry from q 226, and note number of times to weed before and after application of bio-slurry*	**Crop**	**Before**	**After**
		1 __________		
		2 __________		

228	How much land did you allocate for the cultivation of the following crops before and after the installation of biogas plants. *Note area in Ropani Anna or Bigha/Kattha. Please note unit with area!*		**Before**	**After**
		1 Paddy		
		2 Wheat		
		3 Maize		
		4 Millet		
		5 Vegetables		
		6 Fruits		
		7 Cash crops		
		8 Others		

229	What production did you obtain from the following crops (from the area mentioned above) before and after installation of the biogas plant. *Note production in Muri – Pathi – Maund – Seer – Kg. Please note unit with quantity!*		**Before**	**After**
		1 Paddy		
		2 Wheat		
		3 Maize		
		4 Millet		
		5 Vegetables		
		6 Fruits		
		7 Cash crops		
		8 Others		

230	**Bio-slurry and crop health**	
231	Has the use of bio-slurry affected the incidence of pests and diseases in your crops.	☐ 1 Pests and diseases have increased ☐ 2 Pests and diseases have decreased ☐ 3 No change in pests and diseases. ☐ 4 Do not know.

232	*If q 321 = 1:* Details of <u>increase</u> incidence of pests and diseases.	**Crop suffering**	**Type of disease / pest**	**% loss in production**
		☐ 1		
		☐ 2		
		☐ 3		
		☐ 4		

233	*If q 321 = 2:* Details of <u>decrease</u> incidence of pests and diseases.	**Crop benefiting**	**Reduction of disease / pest**	**% gain in production**
		☐ 1		
		☐ 2		
		☐ 3		
		☐ 4		

234	What is the effect of bio-slurry manure on the use of chemical fertilizers	☐ 1 Stopped using chemical fertilizer completely. ☐ 2 Using less chemical fertilizer then before. ☐ 3 Still using the same quantity of chem. fertilizer. ☐ Do not know

235	What are the advantages of slurry over FYM.	☐ 1 Absorbed by the crop very easily ☐ 2 More effective, bigger yield ☐ 3 Others: ____ ☐ 4 No advantages ☐ 5 Do not know
235	What are the advantages of slurry over chemical fertilizer.	☐ 1 Absorbed by the crop very easily ☐ 2 More effective, bigger yield ☐ 3 Others: ____________ ☐ 4 No advantages ☐ 5 Do not know
240	**On-farm fodder production**	
241	Did you grow fodder trees before biogas installation	☐ 1 Yes ☐ 2 No
242	Do you grow fodder trees after biogas installation	☐ 1 Yes ☐ 2 No
243	Are you spending more time on fodder collection after the installation of biogas.	1 Yes, very much so. _____hrs; ____Bharis 2 Yes, to some extend. _____hrs; ____ Bharis 3 No, no change
3	**Biogas plant information**	
300	**Plant functioning**	
301	Principal reason for installation *Rank options from 1 to 8 in order of importance (1 is most important, 8 least important)*	☐ Reduce firewood collection ☐ Convenient cooking ☐ Smokeless kitchen ☐ Saving of time ☐ Slurry substitutes fertilizer ☐ Financial savings ☐ Improved sanitation through toilet ☐ Energy source for lighting
302	Who adviced you in choosing the correct biogas plant size	☐ 1 The constructing company. ☐ 2 Asked for advise at different companies ☐ 3 Another plant owner. ☐ 4 Family, friends. ☐ 5 I found it out myself
303	How did you decide on the correct plant size	☐ 1 Based on family size ☐ 2 Based on the number of cattle ☐ 3 Based on the amount of available dung. ☐ 4 Based on the plant sizes in the neighbourhood ☐ 5 Other : ____________
304	Are you satisfied with the plant-size	☐ 1 Yes ☐ 2 No, plant is too big. ☐ 3 No, plant is too small
305	Is the plant currently producing gas.	☐ 1 yes ☐ 2 no, for ____ days
306	*If q 303 = no:* What is the reason for not producing gas.	☐ 1 no feeding ☐ 2 appliance failure ☐ 3 civil structure damaged ☐ 4 do not know
307	Has the plant in the past ever stopped working	☐ 1 yes, for ____ days ☐ 2 no
308	*If q 304 = yes:* What has been the reason for the plant stopping producing gas.	☐ 1 no feeding ☐ 2 appliance failure ☐ 3 civil structure damaged ☐ 4 do not know
309	How many slurry pits does the plant have	☐ 1 none ☐ 2 one ☐ 3 two
310	**Biogas production**	
311	Number of stoves	☐ 1 no stove ☐ 2 one stove ☐ 3 two stoves ☐ 4 more then two stoves

312	Number of biogas lamps	☐ 1 no lamps ☐ 2 one lamp ☐ 3 two lamps ☐ 4 more then two lamps		
313	Hours of gas used for cooking per day		**# of stoves used**	**Hrs of cooking**
		Summer		
		Winter		
314	Hours of gas used for lighting per day		**# of lamps used**	**Hrs of lighting**
		Summer		
		Winter		
315	Gas production sufficiency	☐ 1 Never sufficient ☐ 2 Sufficient only in summer ☐ 3 Always sufficient		
316	*If q 315 = 1 or 2:* What measures do you take to increase gas production. **Tick as required**	☐ 1 No special measures ☐ 2 Increase feeding ☐ 3 Pre-warm feeding in the sun ☐ 4 Cover plant dome with straw or mud ☐ 5 Add special feeding to plant		
317	*If q 316 = 1 or 2:* Do you use extra kerosene / fuelwood to match your energy need.	☐ 1 Extra fuelwood _____ bhari/kg per day ☐ 2 Extra kerosene _____ litres per day ☐ 3 No extra fuel is added		
318	*If q 316 = 2:* If you increase feeding, how do you obtain the dung	☐ 1 Own dung is available _____ kg per day ☐ 2 Collect form outside the yard _____ kg per day ☐ 3 Buy extra dung kg per day		
319	*If q 316 = 5:* What do you add to the plant feeding to increase gas production.	Note:		
320	**Gas use**			
321	Priority for biogas use. *Rank in order of priority from 1 to 3. If no biogas lamp installed then priority 1 to 2 only.*	☐ 1 Cooking family meals ☐ 2 Cooking cattle food ☐ 3 Lighting		
322	Gas sufficiency: *Note approx time gas is used in minutes: if no lamp is installed, cross (X).*		**Summer**	**Winter**
		Morning tea		
		Morning Dhal Bhat		
		Afternoon tea		
		Afternoon Dhal Bhat		
		Other cooking		
		Lighting		
323	Do you currently use a pressure cooker	☐ 1 Yes ☐ 2 No		
324	Did you use a pressure cooker before the biogas plant was installed	☐ 1 Yes ☐ 2 No		
330	**Plant feeding**			
331	***Type of plant feeding*** **Tick as required**	☐ 1 Cattle dung ☐ 2 Night soil ☐ 3 Pig dung ☐ 4 Alcoholic beverage residue ☐ 5 Other: _________		
332	Who is generally feeding the plant **Tick one option**	☐ 1 male head of household ☐ 2 female head of household ☐ 3 wife ☐ 4 son ☐ 5 daughter ☐ 6 servant		
333	How much dung is fed into the plant **Tick one option** **Check units, measure if necessary** **Verify amounts with actual person that feeds the plant**	☐ 1 Twice a day _____ kg ☐ 2 Once a day _____ kg ☐ 3 Every second day _____ kg ☐ 4 Every third day _____ kg ☐ 5 Twice a week _____ kg ☐ 6 Weekly _____ kg		

334	How much water is fed to the plant *Verify amounts with actual person that feeds the plant*	____ ltr per feeding.
335	How much time is spent on plant feeding. (averages per day)	Dung collection ____ min per day Water collection ____ min per day Mixing ____ min per day
336	If feeding level in inlet is visible, how many cm above bottom inlet.	_____ cm. **Measure inlet pit**
338	Is all available dung fed into the plant	☐ 1 yes ☐ 2 no
339	*If q 328 = no:* What is the reason for not feeding the available dung to the plant: **Tick as required**	☐ 1 Gas is sufficient as it is ☐ 2 Afraid to loose valuable manure for fertilizing ☐ 3 Too much work ☐ 4 Other: _________
340	**Water**	
341	What is the main source of water for the hh.	☐ 1 Tap ☐ 2 Tube well / borehole ☐ 3 Dug well ☐ 4 Spring ☐ 5 River / Canal / Rivulet ☐ 6 Rain water ☐ 7 Others: __________
342	How long does it take to fetch water from the source mentioned above.	________ minutes per single trip.
343	How many trips for water were made yesterday	(see table below)
344	After the installation of the biogas plant, the water consumption of the hh has:	☐ 1 Increased by ______ ltr per day ☐ 2 Stayed the same ☐ 3 Decreased by ______ ltr per day
345	After the installation of the biogas plant, the time necessary to fetch water for the hh has:	☐ 1 Increased by ______ minutes per day ☐ 2 Stayed the same ☐ 3 Decreased by ______ minutes per day
350	**Cooking**	
351	Overall, are you satisfied with cooking on biogas	☐ 1 yes ☐ 2 no
352	Reasons for satisfaction	☐ 1 Cooking is smokeless ☐ 2 Cooking is faster ☐ 3 Meals are tastier ☐ 4 Cleaning of pots and pans less work ☐ 5 Stove does not need constant attention ☐ 6 Others: _____________
353	Reasons for dissatisfaction	☐ 1 Cooking needs more time ☐ 2 Cooking is less tasty ☐ 3 Gas is often not sufficient ☐ 4 Gas use is complicated ☐ 5 Appliances often break down ☐ 6 Others: _____________
354	On average how much time is currently spent on <u>cooking</u> daily	______hrs; ______minutes.
355	How much time was on average spent on <u>cooking</u> before installation of biogas.	______hrs; ______minutes.
356	On average how much time is currently spent on <u>cleaning utensils</u> daily	______hrs; ______minutes.
357	How much time was on average spent on <u>cleaning utensils</u> before installation of biogas.	______hrs; ______minutes.

Question 343 table:

	# of trips	Amount of water (litres) per trip
Children 5-14		
Female adults		
Male adults		

358	What types of food do you cook before and after installation of the biogas plant		**Before**	**After**
		1 Dal		
		2 Bhat		
		3 Tarkari (Jhol)		
		4 Tarkari (Dry)		
		5 Roti		
		6 Kundo		
		7 Milk and milkproducts		
		8 Large feast		
359	Do you boil your drinking water		**Before**	**After**
			☐ 1 Yes ☐ 2 No	☐ 1 Yes ☐ 2 No
360	**Lighting** **Only if lamps are installed**			
361	Overall, are you satisfied with your biogas lamp	☐ 1 Yes go to q 362 ☐ 2 Partially go to q 362 and 363 ☐ 3 No go to q 363		
362	Reasons for satisfaction	☐ 1 Bright light ☐ 2 Easy to use ☐ 3 Enables activities after dark ☐ 6 Others: _____________		
363	Reasons for dissatisfaction	☐ 1 Not enough light ☐ 2 Only light on one place ☐ 3 Frequent break-down ☐ 4 Too much gas is used ☐ 5 Too hot to use ☐ 6 Others: _______________		

370	**Plant maintenance**					
371	Following break downs have occurred on appliances: *Tick appliance as required; note number of failures and tick who did the repair.*			**Repaired by:**		
			# of failures	**Comp**	**Own**	**Not**
		☐ 1 Mixer				
		☐ 2 Main valve				
		☐ 3 Gas pipe				
		☐ 4 Water drain				
		☐ 5 Rubber Hose				
		☐ 6 Gas taps				
		☐ 7 Stoves				
		☐ 8 Biogas lamp				
372	Following break downs have occurred on Civil Structure: *Tick appliance as required; note number of failures and tick who did the repair.*			**Repaired by:**		
			# of failures	**Comp**	**Own**	**Not**
		☐ 1 Inlet pit				
		☐ 2 Toilet				
		☐ 3 Dome				
		☐ 4 Digester				
		☐ 5 Drain pit				
		☐ 6 Drain pit cover				
		☐ 7 Outlet				
		☐ 8 Outlet covers				
373	Amount spent on repairs over last year	NPR.				
374	Regular maintenance done by owner. *Tick as required and note number of times over last year.*	☐ 1 Draining water				
		☐ 2 Cleaning drain and pit				
		☐ 3 Replacing drain washer				
		☐ 4 Checking gas leakage				
		☐ 5 Cleaning gas tap				
		☐ 6 Greasing gas tap				
		☐ 7 Replacing gas tap O-ring				
		☐ 8 Cleaning stove				
		☐ 9 Cleaning lamp				
		☐ 10 Replacing lamp glass				
		☐ 11 Replacing lamp mantle				
		☐ 12 Cleaning slurry overflow				
375	*If 364.4 = yes:* How do you check for gas leakage	☐ 1 Using soap foam ☐ 2 Lighting the gas ☐ 3 Others: ____________				
380	**Plant financing**					
381	The plant was financed by: *Tick only one* **In case of bank loan, note bank name**	☐ 1 Own cash savings only ☐ 2 Own cash savings and loan of family ☐ 3 Own cash savings and loan local money lender ☐ 4 Own cash savings and bank loan:______ ☐ 5 Own cash savings and cooperative loan ☐ 6 Fully financed by loan of family/friends ☐ 7 Fully financed by loan local money lender ☐ 8 Fully financed by bank: _______ ☐ 9 Fully financed by cooperative.				
382	*If q 371 = 1;2;3;4 or 5:* Why did you not obtain a full loan for your plant	☐ 1 Sufficient own funds / funds from family ☐ 2 Insufficient free collateral ☐ 3 Long / complicated application procedure ☐ 4 Others:_________				
383	*If q 371 __is not__ = 1:* Ability of loan repayment	☐ 1 Repaid all instalments so far in time ☐ 2 Repaid the whole loan ☐ 3 Still repaying but instalments overdue ☐ 4 Stopped repayment, instalments overdue				

4	**Health and Sanitation**	
400	**Latrine**	
401	Type of toilet **Tick one only** **If answer is 1, continue with q 411**	☐ 1 no toilet facility ☐ 2 flush toilet ☐ 3 pan connected to sewerage ☐ 4 pan connected to biogas plant ☐ 5 pan not connected to sewerage ☐ 6 pit toilet with door / window ☐ 7 other: ________
402	When was the toilet built	Year 20 Month
403	How many hh members use the toilet.	*# of persons* / **Male** / **Female** Children 5-14 Adults
404	Who motivated you to build a toilet	☐ 1 self ☐ 2 family; neighbours; friends ☐ 3 biogas company staff ☐ 4 NGO programme staff
410	**Kitchen**	
411	What kind of stove is currently used in the kitchen. **Tick as required**	☐ 1 Biogas stove ☐ 2 LPG stove ☐ 3 Kerosene stove ☐ 4 Improved cooking stove ☐ 5 Traditional stove
412	What kind of stove did you use before the installation of the plant in the kitchen. **Tick as required**	☐ 2 LPG stove ☐ 3 Kerosene stove ☐ 4 Improved cooking stove ☐ 5 Traditional stove
413	Has smoke in the kitchen reduced after the installation of the biogas plant.	☐ 1 no ☐ 2 to some extend ☐ 3 drastically
414	Is there a kitchen garden for growing vegetables.	☐ 1 yes ☐ 2 no
415	*If q 415 = yes:* Approximate size of the kitchen garden	Ropani /Anna: ________ Bigha / Khatta:
416	*If q 415 = yes:* Variety of vegetables grown: **Tick as appropriate,** **Note approx production per season in kg**	(see table below)
417	The produce of the kitchen garden is used for:	☐ 1 Strictly own consumption ☐ 2 Sale at the market ☐ 3 Both sale and own consumption
418	For the kitchen garden the following is used as fertilizer: **Tick as required**	☐ 1 Farm Yard Manure ☐ 2 Bio-slurry or bio slurry compost ☐ 3 Chemical fertilizer
419	*If q 418 = 2:* Has the use of bio-slurry / compost affected the production of the kitchen garden.	☐ 1 Increased ☐ 2 The same ☐ 3 Decreased

416 – Variety of vegetables grown:

	Summer	**Winter**
☐ 1 Rayo ko saag		
☐ 2 Cabbage		
☐ 3 Cauliflower		
☐ 4 Onion		
☐ 5 Potato		
☐ 6 Tomato		
☐ 7 Cucumber		
☐ 8 Pumpkin		
☐ 9 Eggplant		
☐ 10 Lady's finger		
☐ 11 Beans		
☐ 12 Fruits (list) __________ __________		
☐ 13 Other		

420	**Eye infections**			
421	Members of hh suffering from <u>eye infections</u> over the last six months: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Person that cooks		
		Other adults > 14		
422	Incidence of <u>eye infection</u> over the last 3 years has:	1 Increased 2 Remained the same 3 Decreased		
423	Members of hh currently under medical treatment for <u>eye infections:</u> **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Person that cooks		
		Other adults > 14		
430	**Respiratory diseases**			
431	Children under five suffering from <u>cough and cold</u> over the last **two weeks.**		**Male**	**Female**
432	Members of hh suffering from <u>cough and cold</u> over the last six months: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Person that cooks		
		Other adults > 14		
433	Incidence of <u>coughing and colds</u> over the last 3 years has:	1 Increased 2 Remained the same 3 Decreased		
434	Members of hh currently under medical treatment for <u>coughing and colds</u> **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Person that cooks		
		Other adults > 14		
440	**Diarrhoea**			
441	Children under five suffering from <u>diarrhoea</u> over the last **two weeks.**		**Male**	**Female**
442	Members of hh suffering from <u>diarrhoea</u> over the last six months: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
443	Incidence of <u>diarrhoea</u> over the last 3 years has:	1 Increased 2 Remained the same 3 Decreased		
444	Members of hh currently under medical treatment for <u>diarrhoea</u>: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
450	**Other intestinal diseases**			
451	Members of hh suffering from <u>dysentery</u> over the last six months: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
452	Incidence of <u>dysentery</u> over the last 3 years has:	1 Increased 2 Remained the same 3 Decreased		
453	Members of hh currently under medical treatment for <u>dysentery:</u> **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		

454	Members of hh suffering from <u>parasite infection</u> over the last six months: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
455	Incidence of <u>parasite infection</u> over the last 3 years has:	1 Increased 2 Remained the same 3 Decreased		
456	Members of hh currently under medical treatment for <u>parasite infection:</u> *Note number of incidences*		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
460	**Other diseases**			
461	Members of hh suffering from <u>encephalitis or malaria</u> over the last six months: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
462	Incidence of <u>encephalitis or malaria</u> over the last 3 years has:	1 Increased 2 Remained the same 3 Decreased		
463	Members of hh currently under medical treatment for <u>encephalitis or malaria:</u> *Note number of incidences*		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
464	Members of hh suffering from <u>tuberculosis (T.B.)</u> over the last six months: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
465	Incidence of <u>tuberculosis (T.B.)</u> over the last 3 years has:	1 Increased 2 Remained the same 3 Decreased		
466	Members of hh currently under medical treatment for <u>tuberculosis (T.B.):</u> *Note number of incidences*		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
467	Members of hh suffering from <u>in-house burning accidents</u> over the last six months: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
468	Incidence of <u>in-house burning incidents</u> over the last 3 years has:	1 Increased 2 Remained the same 3 Decreased		
469	Members of hh currently under medical treatment for <u>in-house burning accidents</u>: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
470	**Safety**			
471	Has their been any accident related to the use of the biogas plant since its installation.	Note if any:		
472	How safe is cooking on biogas compared with cooking on firewood	☐ 1 More safe ☐ 2 Less safe ☐ 3 No differance		

5	**Energy use.**			
500	**Sources of energy for cooking**			
501	Current energy source for cooking, excluding biogas. *Tick as required, note amount in appropriate unit.*		**Amount**	
		Energy source	**Summer**	**Winter**
		☐ 1 Firewood [bhari per day]		
		☐ 2 Kerosene [litre per day]		
		☐ 3 Agric waste [bhari per day]		
		☐ 4 Dung cake [bucket per day]		
		☐ 5 LPG [cylinder/year]		
502	Energy source for cooking, before installation of biogas. *Tick as required, note amount in appropriate unit.*		**Amount**	
		Energy source	**Summer**	**Winter**
		☐ 1 Firewood [bhari per day]		
		☐ 2 Kerosene [litre per day]		
		☐ 3 Agric waste [bhari per day]		
		☐ 4 Dung cake [bucket per day]		
		☐ 5 LPG [cylinder/year]		
503	Time spend on collecting cooking fuel, after installation of biogas plant. **Note in hours per day in column of collecting sex**	**Hrs/day**	**Male**	**Female**
		Firewood		
		Dung		
		Agric. residue		
504	Time spend on collecting cooking fuel, before installation of biogas plant **Note in hours per day in column of collecting sex**	**Hrs/day**	**Male**	**Female**
		Firewood		
		Dung		
		Agric. residue		
505	Type of firewood collected before and after installation of the biogas plant. *Note approximate share in % of total collection.*	*% of collection*	**Before**	**After**
		☐ 1 Dead leaves and small branches		
		☐ 2 Dead bigger branches		
		☐ 3 Live smaller branches		
		☐ 4 Live bigger branches		
		☐ 5 Trees		
506	Local fuel prices *Please note approximate value of local units in kg:* *1 Bhari = ______kg* *1 Bucket = ______kg*	**Fuel**	**Price**	**Unit**
		1 Firewood		/ bhari
		2 Kerosene		/ litre
		3 LPG		/ cylinder
		4 Dung		/ bucket
		5 Electricity		/ unit
		6 Candles		/ piece
510	**Sources of energy for lighting**			
511	Current energy source for lighting, excluding biogas. *Tick as required, note amount in appropriate unit.*	**Source**		**Quantity**
		☐ 1 Kerosene [litre per day]		
		☐ 2 Electricity [units per month]		
		☐ 3 Candles [NPR per month]		
512	Energy source for lighting, before installation biogas. *Tick as required, note amount in appropriate unit.*	**Source**		**Quantity**
		☐ 1 Kerosene [litre per day]		
		☐ 2 Electricity [units per month]		
		☐ 3 Candles [NPR per month]		
6	**Time allocations**			
600	**Time saving before/after installation of biogas plant**			
601	Time to collect dung and clean stable	**Before** [minutes]		**After** [minutes]
602	Time to feed cattle	**Before** [minutes]		**After** [minutes]
603	Time to collect firewood	**Before** [minutes]		**After** [minutes]
604	Time to collect fodder for animals	**Before** [minutes]		**After** [minutes]
605	Time to process and apply FYM / slurry	**Before** [minutes]		**After** [minutes]

104b	Interview end time	. hrs.	
1	**GENERAL INFORMATION**		
100	**Interview**		
101	List of materials to be taken by enumerator:	☐ Questionnaire	☐ Ruler
		☐ Pen	☐ Tape measure
		☐ Paper	☐ Weighing balance
		☐ Clip board	
		☐ ID	☐ Umbrella
		☐ Authorization letter	☐ 1st aid kit
		☐ Request letter	☐ Torch
102	Name enumerator		
103	Date interview	2057 / /	
104a	Interview starting time	Start: . hrs minutes	
110	**Farm location**		
111	Name District	*To be copied from sample list*	
112	Name VDC	*To be copied from sample list*	
113	Ward number	*To be copied from sample list*	
115	Walking distance to road head	days: hours: minutes	
116	Walking distance to water source.	minutes	
117	Elevation of location (amsl)	meters	
130	**General observations**		
131	Type of house	☐ 1 Thatched roof ☐ 2 Corrugated sheets ☐ 3 Tile / slated roof ☐ 4 Mixed ☐ 5 RCC/RBC roof	
132	Latrine on the yard	☐ 1 yes ☐ 2 no	
134	Electricity	☐ 1 yes ☐ 2 no	
135	*If q 132 = yes:* Source of electricity	☐ 1 National Grid ☐ 2 Local hydro grid ☐ 3 Solar ☐ 4 Local Diesel generator	
136	Media **Verify with hh member**	☐ 1 None ☐ 2 Radio ☐ 3 Television	
137	Transport **Verify with hh member**	☐ 1 none ☐ 2 bicycle ☐ 3 motorcycle ☐ 4 tractor ☐ Others: ____________	
138	Animals *# of heads observed*	Numbers observed ☐ 1 none ☐ 2 cow / ox ______ ☐ 3 buffalo ______ ☐ 4 pigs ______ ☐ 5 goats / sheep ______ ☐ 6 poultry	
140	**Household identification**		
141	Name of head of household	Mr. / Mrs.	
142	Sex of head of household **Tick only one**	☐ 1 Male ☐ 2 Female	
143	Educational level head of household	☐ 1 Illiterate ☐ 2 Literate, no formal education ☐ 3 Class 1 to 5 ☐ 4 Class 6 to 10 ☐ 5 SLC ☐ 6 Above SLC	

144	Caste of household **Tick only one**	☐ 1 Bramin ☐ 2 Chhetri ☐ 3 Newar ☐ 4 Tharu ☐ 5 Rai ☐ 6 Magar ☐ 7 Kumal ☐ 8 Gurung ☐ 9 Tamang ☐ 10 Damai ☐ 11 Kami ☐ 12 Harijan ☐ 13 Others:_________ ☐		
145	Major occupation of head of hh **Tick only one**	☐ 1 Agriculture ☐ 2 Business ☐ 3 Service ☐ 4 Industry		
150	**HH member identification**	*Age in completed years*		
151	# of hh members under 5	Male ______ persons Female ______ persons *Total # of persons under 5: persons*		
152	# of hh members 5 to 14	Male ______ persons Female ______ persons *Total # of persons 5 to 14: persons*		
153	Educational level 5 to 14 **Attending or highest level** **Note # of persons in category**	**# of persons**	**Male**	**Female**
		1 Illiterate		
		2 Class 1 to 5		
		3 Class 6 to 10		
		Total # of persons 5 to 14: persons		
154	# of hh members over 14	Male ______ persons Female ______ persons *Total # of persons over 14 persons*		
155	Educational level over 14 **Attending or highest level** **Note # of persons in category**	**# of persons**	**Male**	**Female**
		1 Illiterate		
		2 Literate		
		3 Class 1 to 5		
		4 Class 6 to 10		
		5 SLC		
		6 Above SLC		
156	Occupation over 14 **Note # of persons in category**	**# of persons**	**Male**	**Female**
		1 Agriculture		
		2 Business		
		3 Service		
		4 Industry		
157	Total number of persons in the hh **Verification**	According to interviewee _______ *According to 151 + 152 + 154* *According to 151 + 153 + 155*		
2	**Agriculture and land use**			
200	**Landholding**			
201	Area of land under cultivation. **Including cultivated land under tenancy**		**Khet**	**Bari**
		Ropani		
		Anna		
		Bigha		
		Katha		

202	Total land owned. **Including non cultivated land**		**Khet**	**Bari**
		Ropani		
		Anna		
		Bigha		
		Katha		
210	**Information on livestock**			
211	Livestock holding of household: **Note # of heads per category**	**# of animals**	**Adults**	**Calves**
		1 none		
		2 cow/ox		
		3 buffalo		
		4 pigs		
		5 goat/sheep		
213	Cattle feeding practice. **Cow, ox & buffalo only**	☐ 1 Complete stall feeding ______ heads ☐ 2 Partial stall feeding ______ heads ☐ 3 Complete free grazing heads		
215	Amount of water fetched for cattle drinking.	Amount/day: ______ ltr.		
216	Fodder collection practice. *Enumerator to measure:* ***1 bhari = ____ kg*** **Tick as required**		**bharis/day**	
		☐ 1 Not applicable, free grazing		
		☐ 2 From jungle		
		☐ 3 Own production		
217	***Amount of water used for own fodder production***	*Litres per day*		
218	Cattle stable condition **Tick as required**	1 Smooth, earthen floor	☐ 1 Yes ☐ 2 No	
		2 Urine collection pit	☐ 1 Yes ☐ 2 No	
219	Dairy production. *Please note dairy production in litres per day*		**Litres per day**	
		☐ 1 None		
		☐ 2 Domestic production		
		☐ 3 Commercial production		
220	**Agricutural production**			
221	Major crops grown. **Tick as required**	**Summer**		
		☐ Paddy		
		☐ Maize		
		☐ Millet		
		☐ Summer vegetables		
		☐ Cash crop (specify)		
		☐ Others (specify)		
		Winter		
		☐ Wheat		
		☐ Mustard		
		☐ Barley		
		☐ Winter vegetables		
		☐ Cash crops (specify)		
		☐ Others (specify)		
		Spring		
		☐ Early rice		
		☐ Off-season vegetables		
		☐ Pulses		
		☐ Cash crops (specify)		
		☐ Others (specify)		
222	How much and what type of fertilizers do you use for your crops. *1: unit = bhari* ***1 bhari = ______ kg*** *2: unit = buckets* ***1 bucket = ______ ltr*** *3: unit = kg*		**Amount**	
		FYM [1]		
		Compost [1]		
		Chemical fertilizers [3]		

225	What do you do with crop residue. (Rice and wheat straw; corn stalk; husks; brans, etc)	*Note share or % of total production*		
		Use	**Before**	**After**
		☐ 1 fuelwood		
		☐ 2 animals feed		
		☐ 3 compost		
		☐ 4 Soil cover (mulching)		
		☐ 5 Other:_______		

228	How much land do you allocate for the cultivation of the following crops. *Note area in Ropani/Anna or Bigha/Kattha. Please note unit with area!*		**Area allocated**
		1 Paddy	
		2 Wheat	
		3 Maize	
		4 Millet	
		5 Vegetables	
		6 Fruits	
		7 Cash crops	
		8 Others	
229	What production did you obtain from the following crops (from the area mentioned above). *Note production in Muri – Pathi – Maund – Seer – Kg. Please note unit with quantity!*		**Production**
		1 Paddy	
		2 Wheat	
		3 Maize	
		4 Millet	
		5 Vegetables	
		6 Fruits	
		7 Cash crops	
		8 Others	

230	**Crop health**			
232	Details of incidence of pests and diseases.	**Crop suffering**	**Type of disease / pest**	**% loss in production**
		☐ 1		
		☐ 2		
		☐ 3		
		☐ 4		

240	**On-farm fodder production**	
242	Do you grow fodder trees.	☐ 1 Yes ☐ 2 No
3	**Biogas plant information**	
323	Do you currently use a pressure cooker	☐ 1 Yes ☐ 2 No
340	**Water**	
341	What is the main source of water for the hh.	☐ 1 Tap ☐ 2 Tube well / borehole ☐ 3 Dug well ☐ 4 Spring ☐ 5 River / Canal / Rivulet ☐ 6 Rain water ☐ 7 Others: __________
342	How long does it take to fetch water from the source mentioned above.	________ minutes per single trip.

343	How many trips for water were made yesterday		**# of trips**	**Amount of water (litres) per trip**
		Children 5-14		
		Female adults		
		Male adults		

350	**Cooking**	
354	On average how much time is currently spent on <u>cooking</u> daily	_____hrs; _____minutes.
356	On average how much time is currently spent on <u>cleaning utensils</u> daily	_____hrs; _____minutes.

358	What types of food do you cook. **Tick as required**	☐ 1 Dal ☐ 2 Bhat ☐ 3 Tarkari (Jhol) ☐ 4 Tarkari (Dry) ☐ 5 Roti ☐ 6 Kundo ☐ 7 Milk and milkproducts ☐ 8 Large feast		
359	Do you boil your drinking water	☐ 1 Yes ☐ 2 No		
4	**Health and Sanitation**			
400	**Latrine**			
401	Type of toilet **Tick one only** **If answer is 1, continue with q 411**	☐ 1 no toilet facility ☐ 2 flush toilet ☐ 3 pan connected to sewerage ☐ 5 pan not connected to sewerage ☐ 6 pit toilet with door / window ☐ 7 other: ______________		
402	When was the toilet built	Year 20	Month	
403	How many hh members use the toilet.	**# of persons**	**Male**	**Female**
		Children 5-14		
		Adults		
404	Who motivated you to build a toilet	☐ 1 self ☐ 2 family; neighbours; friends ☐ 4 NGO programme staff		
410	**Kitchen**			
411	What kind of stove is currently used in the kitchen. **Tick as required**	☐ 2 LPG stove ☐ 3 Kerosene stove ☐ 4 Improved cooking stove ☐ 5 Traditional stove		
414	Is there a kitchen garden for growing vegetables.	☐ 1 Yes ☐ 2 No		
415	*If q 415 = yes:* Approximate size of the kitchen garden	Ropani /Anna: ________ Bigha / Khatta:		
416	*If q 415 = yes:* Variety of vegetables grown: **Tick as appropriate,** **Note approx production per season in kg**		**Summer**	**Winter**
		☐ 1 Rayo ko saag		
		☐ 2 Cabbage		
		☐ 3 Cauliflower		
		☐ 4 Onion		
		☐ 5 Potato		
		☐ 6 Tomato		
		☐ 7 Cucumber		
		☐ 8 Pumpkin		
		☐ 9 Eggplant		
		☐ 10 Lady's finger		
		☐ 11 Beans		
		☐ 12 Fruits (list) __________		
		☐ Others		
417	The produce of the kitchen garden is used for:	☐ 1 Strictly own consumption ☐ 2 Sale at the market ☐ 3 Both sale and own consumption		
418	For the kitchen garden the following is used as fertilizer: **Tick as required**	☐ 1 Farm Yard Manure ☐ 3 Chemical fertilizer		
420	**Eye infections**			
421	Members of hh suffering from eye infections over the last six months: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Person that cooks		
		Other adults > 14		

422	Incidence of eye infection over the last 3 years has:	1 Increased 2 Remained the same 3 Decreased		
423	Members of hh currently under medical treatment for eye infections: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Person that cooks		
		Other adults > 14		
430	**Respiratory diseases**			
431	Children under five suffering from cough and cold over the last **two weeks.**		**Male**	**Female**
432	Members of hh suffering from cough and cold over the last six months: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Person that cooks		
		Other adults > 14		
433	Incidence of coughing and colds over the last 3 years has:	1 Increased 2 Remained the same 3 Decreased		
434	Members of hh currently under medical treatment for coughing and colds **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Person that cooks		
		Other adults > 14		
440	**Diarrhoea**			
441	Children under five suffering from diarrhoea over the last **two weeks.**		**Male**	**Female**
442	Members of hh suffering from diarrhoea over the last six months: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
443	Incidence of diarrhoea over the last 3 years has:	1 Increased 2 Remained the same 3 Decreased		
444	Members of hh currently under medical treatment for diarrhoea: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
450	**Other intestinal diseases**			
451	Members of hh suffering from dysentery over the last six months: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
452	Incidence of dysentery over the last 3 years has:	1 Increased 2 Remained the same 3 Decreased		
453	Members of hh currently under medical treatment for dysentery: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
454	Members of hh suffering from parasite infection over the last six months: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
455	Incidence of parasite infection over the last 3 years has:	1 Increased 2 Remained the same 3 Decreased		
456	Members of hh currently under medical treatment for parasite infection: *Note number of incidences*		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		

460	**Other diseases**			
461	Members of hh suffering from <u>encephalitis or malaria</u> over the last six months: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
462	Incidence of <u>encephalitis or malaria</u> over the last 3 years has:	1 Increased 2 Remained the same 3 Decreased		
463	Members of hh currently under medical treatment for <u>encephalitis or malaria:</u> *Note number of incidences*		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
464	Members of hh suffering from <u>tuberculosis (T.B.)</u> over the last six months: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
465	Incidence of <u>tuberculosis (T.B.)</u> over the last 3 years has:	1 Increased 2 Remained the same 3 Decreased		
466	Members of hh currently under medical treatment for <u>tuberculosis (T.B.):</u> *Note number of incidences*		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
467	Members of hh suffering from <u>in-house burning accidents</u> over the last six months: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
468	Incidence of <u>in-house burning incidents</u> over the last 3 years has:	1 Increased 2 Remained the same 3 Decreased		
469	Members of hh currently under medical treatment for <u>in-house burning accidents</u>: **Note number of incidences**		**Male**	**Female**
		Children under 5		
		Children 5-14		
		Adults > 14		
470	**Safety**			
471	Has their been any accident related to cooking over the past year	Note if any:		
5	**Energy use.**			
500	**Sources of energy for cooking**			
501	Current energy source for cooking. *Tick as required, note amount in appropriate unit.*		**Amount**	
		Energy source	**Summer**	**Winter**
		☐ 1 Firewood [bhari per day]		
		☐ 2 Kerosene [litre per day]		
		☐ 3 Agric waste [bhari per day]		
		☐ 4 Dung cake [bucket per day]		
		☐ 5 LPG [cylinder/year]		
503	Time spend on collecting cooking fuel. **Note in hours per day in column of collecting sex**	**Hrs/day**	**Male**	**Female**
		Firewood		
		Dung		
		Agric. residue		
		Firewood		
		Dung		
		Agric. residue		
505	Type of firewood collected. *Note approximate share in % of total collection.*		*% of collection*	
		☐ 1 Dead leaves and small branches		
		☐ 2 Dead bigger branches		
		☐ 3 Live smaller branches		
		☐ 4 Live bigger branches		
		☐ 5 Trees		

506	Local fuel prices *Please note approximate value of local units in kg:* *1 Bhari = ____ kg* *1 Bucket = ____ kg*	**Fuel**	**Price**	**Unit**
		1 Firewood		/ bhari
		2 Kerosene		/ litre
		3 LPG		/ cylinder
		4 Dung		/ bucket
		5 Electricity		/ unit
		6 Candles		/ piece
510	**Sources of energy for lighting**			
511	Current energy source for lighting. *Tick as required, note amount in appropriate unit.*	**Source**	**Quantity**	
		☐ 1 Kerosene [litre per day]		
		☐ 2 Electricity [units per month]		
		☐ 3 Candles [NPR per month]		
6	**Time allocations**			
600	**Time allocation**	*Minutes per day*		
601	Time to collect dung and clean stable	*Minutes per day*		
602	Time to feed cattle	*Minutes per day*		
603	Time to collect firewood	*Minutes per day*		
604	Time to collect fodder for animals	*Minutes per day*		
605	Time to process and apply FYM.	*Minutes per day*		
104b	Interview end time	. hrs.		

C: Checklist for Community Level Discussion (PRA)

A. Effect of bio-gas on forest condition:

1. Has the collection of fuel wood from the nearby forests incased or decreased in the last three years?

   A. Increased by ...... percent
   B. Decreased by ....percent
   C. Has remained the same

2. Has the type of wood you collected from the forest changed over the past three years?

Type of wood	Decreased Increased
Dead leaves and small branches	
Bigger dead branches	
Smaller, live branches	
Bitter live branches and whole trees	

3. Has the availability and collection *of non-timber forest products* (NTFPs) from the nearby forests increased or decreased in the last five years?

NTFP type	Increased (%)	Decreased (%)	Remarks
1 Food (roots, tubers and fruits)			
2 Medicinal purposes (herbs and spices)			
3. Making utensils and implements			
4. Other purposes			

Note: Note the names of a few dominant items in each category as applicable

B. Deforestation:

1. How much forest land (Ha/Ropani/ Bigha) in your settlement was convened to agriculture in the past three years?

2. Is the trend increasing or decreasing, and why?

3. How frequent are forest tires?

   A. Frequent (occurs every year)

   B. Occasional (once every 2 to three years)

   C. Rare (once in five years or more)

4. Approximately how much forest land (Ha/Ropani/Bigha) was irreversibly damaged by such fires?

5. To what extent is forest encroached by urbanization and road building?

6. What is the extent of forest degradation (in the last ten years) due to the collection of timber and fuel wood?

C. Soil fertility

1. What is the general fertility status of land in your area?

Land type	Fertility status	
	High Medium	Low
Khet		
Bari		
Pakho (marginal land)		

2. Have the uses of the following chemical fertilisers increased or decreased in the last three years, and to what extent?

Fertilizer type	Change in use	
Increased (%}	Decreased (%)	Remarks
Urea		
Ammonium Sulphate		
Complex		
ISP		
MoP		
Others(specify)		

3. How have the yields of the following crops chunked in the past three years?

Crop	Current yield (Muri/Ropani (Munds/Bigha)	Increased (%)	Change in 5 years Decreased (%)	Remarks
Rice				
Maize				
Wheat				
Millet				
Vegetables fruits				
Cash erops				
Others				

4. Have the incidence of pests and diseases of crops increased or decreased in the past three years, and to what extent?

Increased ----------------- percent

Decreased ---------------- percent

Remained the same

D. Land Use:

1. How have the lands under the following uses changed over the past three years?

Land use	Approximate Area in the ward (Ropani/Bigha)	Change in 5 years		
		Increased (%)	Decreased (%)	Remarks
Cultivated Khet				
Cultivated Bari Forest Grazing				
Waste land				
Others				

E. Livestock situation:

1. How has the average number of animals owned by households changed over the past three years?

Animal type	Average number per household		
	3 years back	Now	% change
Cattle: local			
Cattle: improved			
Buffaloes: local			
Buffaloes: improved			
Goats/sheep: local			
Goats/sheep: improved			
Others			

2. What is the situation of fodder availability as compared to five years back?

Increased ....percent

Decreased.....................percent

Remained the same

3. What is/was the major source of fodder ?

	3 years back	Now
Public Forest		
Private forest		
Bunds and risers of cultivated land Cultivated grasses		
Crop residues		
Others		

4. How has livestock feeding system changed over the past 10 years?

	Percentage of animals subjected lo	
	Free grazing	Stall feeding
10 Years hack		
Now		

F. social, Economic and Health issues:

1. In which way was indoor air pollution {smoke in the kitchen) affecting you and your family?
Note: For biogas households, situation in the past is relevant, for non-biogas households refer to current situation

2. For biogas households only: Regarding to indoor air pollution, which benefits did you experience?

3. Did the introduction of biogas induce am changes in the following aspects of your life:
[ ] Daily habits within the household
[ ] Division of roles between men and women within the household
[ ] Educational status (of men and women) of the household members
[ ] The status (of men and women) within the community
[ ] The degree of involvement in social activities (clubs, classes, politics etc) in the community of the household members.

4. Did the introduction of biogas induce any changes in:
[ ] The amount of time the women can devote to their siblings
[ ] The type of food prepared for the family.
[ ] The quantity or amount of medicines used.

1. Did the introduction of biogas in the village change the accessibility to free resources for poor/ landless people?
Note: Only for high biogas penetration areas.

Resources	**Decreased**	**Increased**
Fuel wood		
NTFPs		
Land		
Dune		
Other		

2. Did the introduction of the biogas plant change your pattern of spending money regarding the following issues:

Items	**Decreased**	**Increased**
Food for the family		
Medicines		
Education		
Alcoholic drinks		
Other		

APPENDIX V
RESULTS OF STATISTICAL ANALYSIS

Appendix V

Results of Statistical Analysis

Table	Component of the Variable	with biogas n_1	without biogas n_2	with biogas f_1	without biogas f_2	with biogas p_1	without biogas p_2	P^	Q^	p_1-p_2	Decision Variable Z	Remark (Significant at Z>= 1.96)
Table 4.1	No Toilet	587	590	63	237	10.7%	40.2%	0.2549	0.7451	0.2944	**11.587**	Significant difference
	Septic Tank	587	590	119	0	20.3%	0.0%	0.1011	0.8989	0.2027	**11.535**	Significant difference
	Biogas Attached	587	590	355	0	60.5%	0.0%	0.3016	0.6984	0.6048	**22.603**	Significant difference
	Sewerage	587	590	0	172	0.0%	29.2%	0.1461	0.8539	0.2915	**14.157**	Significant difference
	Pit Latrine	587	590	45	142	7.7%	24.1%	0.1589	0.8411	0.1640	**7.696**	Significant difference
	Others	587	590	5	39	0.9%	6.6%	0.0374	0.9626	0.0576	**5.207**	Significant difference
Table 4.2	Self	520	348	321	310	61.7%	89.1%	0.7270	0.2730	0.2735	**8.864**	Significant difference
	Biogas Company	520	348	144	0	27.7%	0.0%	0.1659	0.8341	0.2769	**10.749**	Significant difference
	Family Member	520	348	41	27	7.9%	7.8%	0.0783	0.9217	0.0013	**0.068**	NS
	NGO	520	348	14	11	2.7%	3.2%	0.0288	0.9712	0.0047	**0.405**	NS
Table 4.4	Yes	597	595	457	440	76.5%	73.9%	0.7525	0.2475	0.0260	**1.040**	NS
	No	597	595	140	155	23.5%	26.1%	0.2475	0.7525	0.0260	**1.040**	NS
Table 4.5	Presence of eye infection	528	577	75	103	14.2%	17.9%	0.1611	0.8389	0.0365	**1.647**	NS
	Absence of eye infection	528	577	453	474	85.8%	82.1%	0.8389	0.1611	0.0365	**1.647**	NS
Table 4.6	Increased	67	103	20	42	29.9%	40.8%	0.3647	0.6353	0.1093	**1.446**	NS
	Same	67	103	40	53	59.7%	51.5%	0.5471	0.4529	0.0825	**1.055**	NS
	Decreased	67	103	7	8	10.4%	7.8%	0.0882	0.9118	0.0268	**0.602**	NS
Table 4.7	Presence of resperatory	600	599	50	73	8.3%	12.2%	0.1026	0.8974	0.0385	**2.199**	Significant difference
	Absence of resperatory	600	599	550	526	91.7%	87.8%	0.8974	0.1026	0.0385	**2.199**	Significant difference
Table 4.8	Increased	600	599	123	140	20.5%	23.4%	0.2193	0.7807	0.0287	**1.202**	NS
	Same	600	599	275	384	45.8%	64.1%	0.5496	0.4504	0.1827	**6.359**	Significant difference
	Decreased	600	599	202	75	33.7%	12.5%	0.2310	0.7690	0.2115	**8.686**	Significant difference
Table 4.9	Yes	600	594	59	55	9.8%	9.3%	0.0955	0.9045	0.0057	**0.338**	NS
	No	600	594	541	539	90.2%	90.7%	0.9045	0.0955	0.0057	**0.338**	NS
Table 4.10	Increased	52	45	14	19	26.9%	42.2%	0.3402	0.6598	0.1530	**1.586**	NS
	Same	52	45	32	22	61.5%	48.9%	0.5567	0.4433	0.1265	**1.251**	NS
	Decreased	52	45	6	4	11.5%	8.9%	0.1031	0.8969	0.0265	**0.428**	NS

Results of Statistical Analysis

Table	Component of the Variable	with biogas n_1	without biogas n_2	with biogas f_1	without biogas f_2	with biogas p_1	without biogas p_2	P^	Q^	p_1-p_2	Decision Variable Z	Remark (Significant at Z>= 1.96)
Table 4.11	Presence of dysentery	600	599	33	63	5.5%	10.5%	0.0801	0.9199	0.0502	**3.201**	Significant difference
	Absence of dysentery	600	599	567	536	94.5%	89.5%	0.9199	0.0801	0.0502	**3.201**	Significant difference
Table 4.12	Increased	27	52	7	13	25.9%	25.0%	0.2532	0.7468	0.0093	**0.090**	NS
	Same	27	52	18	27	66.7%	51.9%	0.5696	0.4304	0.1474	**1.255**	NS
	Decreased	27	52	2	12	7.4%	23.1%	0.1772	0.8228	0.1567	**1.730**	NS
Table 4.13	Increased	29	43	3	9	10.3%	20.9%	0.1667	0.8333	0.1059	**1.182**	NS
	Same	29	43	21	30	72.4%	69.8%	0.7083	0.2917	0.0265	**0.242**	NS
	Decreased	29	43	5	4	17.2%	9.3%	0.1250	0.8750	0.0794	**0.999**	NS
Table 7.8	Thatched Roof	598	598	56	95	9.4%	15.9%	0.1263	0.8737	0.0652	**3.395**	Significant difference
	Corrugated sheet	598	598	273	260	45.7%	43.5%	0.4457	0.5543	0.0217	**0.756**	NS
	Tile/Slated roof	598	598	117	114	19.6%	19.1%	0.1931	0.8069	0.0050	**0.220**	NS
	Mixed roof	598	598	31	31	5.2%	5.2%	0.0518	0.9482	0.0000	**0.000**	NS
	RCC/RBC	598	598	121	98	20.2%	16.4%	0.1831	0.8169	0.0385	**1.720**	NS
Table 7.9	Yes	600	595	426	401	71.0%	67.4%	0.6921	0.3079	0.0361	**1.350**	NS
	No	600	595	174	194	29.0%	32.6%	0.3079	0.6921	0.0361	**1.350**	NS
Table 7.10	None	600	600	19	140	3.2%	23.3%	0.1325	0.8675	0.2017	**10.303**	Significant difference
	Radio	600	600	67	427	11.2%	71.2%	0.4117	0.5883	0.6000	**21.117**	Significant difference
	TV	600	600	265	32	44.2%	5.3%	0.2475	0.7525	0.3883	**15.586**	Significant difference
	Radio + TV	600	600	249	1	41.5%	0.2%	0.2083	0.7917	0.4133	**17.628**	Significant difference
Table 7.11	None	600	600	346	365	57.7%	60.8%	0.5925	0.4075	0.0317	**1.116**	NS
	Motorcycle	600	600	27	8	4.5%	1.3%	0.0292	0.9708	0.0317	**3.259**	Significant difference
	Tractor	600	600	11	5	1.8%	0.8%	0.0133	0.9867	0.0100	**1.510**	NS
	Other (Bicycle)	600	600	216	222	36.0%	37.0%	0.3650	0.6350	0.0100	**0.360**	NS

Note

1 by significant difference we mean there is significant difference in the percentage of the components between HHs with- and without biogas

2 The symbol NS stands for Not significant, that is no significant difference is observed in the percentage of the components between HHs with- and without biogas