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Objectives

This 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 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 study dealing with integrated environmental impact assessment (IEIA) will be conducive to clearly understand and define the positive as well as the negative impacts of biogas technology in Nepal. Furthermore, the outcome of the study is intended to serve as a basis for providing sound recommendations for the fourth phase of BSP.

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 (HHs) were selected from BSP computerised database, while the same number of non-biogas HHs (600) were sampled in the field. Out of 600 HHs, 278 HHs (46%) were in the Terai and the rest 322 HHs (54%) were in the Hills.

Main Findings

Impact on Energy Use

Around 97 percent of the installed biogas plants are found in operational. The average biogas plant size in Terai is 7.85 m³ and in case of the Hills, it is 6.49 m³, the overall average size being 7.12 m³. The average biogas stoves per plant in case of Terai is 1.76 and 1.23 in case of Hills. Majority of the BGHs in Terai have 2 biogas stoves per plant, whereas most of the biogas households (BGHs) 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.

The average quantity of dung available per day per biogas plant (BGP) for Terai and the Hills are 41.71 kg and 27.21 kg respectively, the average being 33.5 kg. Majority of the total surveyed BGHs feed their plants once a day (46.5%) or twice a day (45.9%). The prescribed dung feeding per day is 58.87 kg for Terai and 38.94 kg for Hills. However, the results of survey show that the feeding percentage in case of Terai and Hills is 70.85 percent and 69.88 percent, respectively indicating underfeeding of plants.

The production and consumption figures of biogas 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 litres per day whereas in the Hills the production exceeds from 65 - 175 litres per day. However, during winter there seems to be a deficiency of 45 - 155 litres of gas in a day in the Terai and of 155 - 265 litres per day in the Hills.

In Terai, there has been a decrease of 3.39 kg fuelwood per household 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.

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. Similarly, the BGHs in the Hills have experienced a decrease by 0.36 litres per day per household in summer and 0.37 litres in winter.

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%). Because of biogas installation, the traditional and the kerosene stoves were substituted to a great extent by biogas stoves.

Impact on Health Situation

Around 90 percent of biogas HHs has built their own toilet compared to non-biogas HHs (60%). About 60 percent biogas HHs has attached their toilets with BGP. 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 effort.

85 percent biogas HHs perceived a remarkable decrease in smoke after they have had the biogas plants. The result of survey indicated that introduction of biogas has impact on the control of cough, *symptomatic eye infection*, incidence of dysentery and *tapeworm infestation* as the percentage of non-biogas respondents reporting the presence of these diseases was found to be 4 to 5 percent higher than biogas HHs.

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 was exposed to this problem. Further analysis of data showed that there is a high danger of burning cases in the households without biogas plant. More than 95 percent of biogas HHs reported a very high degree of safety on the use of biogas stove after they have had the biogas plants.

About 70 percent of biogas HHs reported an increase in mosquito breeding as a result of biogas installation.

Impact on Agriculture and Sustainable Land Use

The average biogas user households possessed about 37 percent more land than the non-biogas ones. No perceptible change was observed in the cultivation of crop as a result of biogas use. 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 fertiliser was found reduced by about 9 percent.

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

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 and other types of wood use for fuel reduced sharply after the installation of biogas plants. After the installation of the biogas plants, daily consumption of fuelwood was found to be reduced by more than 50 percent.

Impact on Climate Change

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.

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.

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.

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.

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.

Impact on Socio-economic Conditions

Among the sampled biogas households, there was the dominance of Brahmin (53.2%) and Chhetri (17.8%) compared to other ethnic groups. Average size of biogas family is found slightly larger than that of non-users. Regarding the ownership of the surveyed plants, males owned 91 percent biogas plants, while the females owned only 9 percent.

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 illiterate household head was 4.2 percent higher in case of non-biogas HHs than biogas HHs.

The average biogas HHs in the hills is a medium farmer, while it is small farmer in case of non-biogas HHs. 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 HHs is one step forward compared to Non-biogas HHs so far as possession of landholding is concerned. The average annual income of biogas households from different sources ranges from Rs 77,000 to Rs 86,000, which is fairly higher than the average national household income of the country (around Rs 42,000).

It appeared that biogas HHs were comparatively well off than non-biogas HHs so far as the possession of improved type of houses are concerned. Thus the non-biogas HHs possessed 6 percent more thatched roof than those of biogas HHs, while in case of RCC/RBC roof, the position was quite reverse.

The percentage of HHs having access to electricity in their houses was 4 percent higher than non-biogas HHs. 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. 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 than non-biogas HHs.

Biogas HHs own more cattle, buffalo and goats/sheep than non-biogas HHs. There seems a decreasing trend of livestock after plant installation. 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. The condition of cattle sheds improved significantly after the installation of biogas plants.

Water consumption by the cattle was reported to increase by about 4 liters per day per household after the installation of biogas plants. Slightly greater quantity of milk production per household per day was reported in the biogas households than in the non-biogas households.

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%). In biogas HHs, females' contribution amounted to about two-thirds compared to male members so far as responsibility of feeding the digester is concerned.

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 utilised the saved time in adult education. They utilised the saved time by taking rest, cleaning their house, regularising household affairs and taking care of the children.