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SOCIAL IMPACTS OF BIOGAS PLANTS ON RURAL COMMUNITIES OF SINDH, PAKISTAN

Asif Sajjad, Liaqat Ali Khan, Arif Hamid Makhdum, Asad Imran
Sustainable Agriculture Program, WWF-Pakistan

ABSTRACT

Biogas is a very important alternate renewable energy source for the Pakistan where more than 60% population lives in rural areas having no access to natural gas. Government aims to exploit the maximum potential of biogas plants within next 10 years. In conjunction with the efforts, United Nations Development Program (UNDP) has installed 2,000 biogas plants in areas along Indus River which were affected by heavy flood during monsoon of 2010. Measuring social impacts of any development project is an important tool to understand its adaptability in any community. The social benefits of biogas plants have widely been accepted in different parts of the world but these may vary across the communities and geographical areas. Current study is a first empirical contribution towards understanding the social impacts of biogas plants on rural communities of Sindh, Pakistan. Besides improving kitchen environment and reducing the disease incidences, biogas plants also significantly reduced fuel wood consumption and its cost (ca. 48%) without consuming extra working hours.
Keywords: biogas plants, renewable, energy, social impacts, Pakistan.

INTRODUCTION

The renewable and sustainable energy resources are the best substitute to the conventional fuels and energy sources. Biogas is a fuel which can be used to contribute this need (Urmee *et al.,* 2009). This gas is produced from the bacterial anaerobic digestion of have a positive effect in the improvement of local environment and ecosystems (Bajgain and Shakya, 2005; Tsai, 2007).

Pakistan is an agricultural country with livestock farming as an important agriculture component. An estimate suggests about 159 million cattle and buffalo producing almost 652 million kg of manure daily; that can be used to generate 16.3 million m^3 biogas per day and 21 million tons of bio fertilizer per year (Amjid et al., 2011). While the daily gas consumption of the country is about 96.2 million m^3 per day (Anonymous, 2012). On the other hand the supply shortfall of natural gas ranged between 10 to 15 percent of demand during 2011 (Anonymous, 2011a).

There were around 16 million small-scale domestic biogas plants around the world in 2005 (Hamlin, 2012). Biogas technology in Pakistan has been tried with some success in the past but has yet to be widely adopted. Individual efforts towards domestic biogas plants were made during 1959 in Sindh (Amjid livestock manures, human excreta and agricultural wastes in an airtight underground chamber (Al-Masri, 2001) and can be used for heating, cooking, lighting, chicken brooding, hot water heating, in internal combustion engines, electricity generation, and chaff cutting etc. (Hamlin, 2012). Replacing firewood with biogas would *et al.,* 2011) while Government took initiative for a comprehensive biogas scheme in 1974 (Heegde and Pandey, 2008). Several successful projects of Government, Regional Support Programmes and NGOs have resulted in thousands of biogas plants in all the provinces of Pakistan. Currently, the largest biogas program is run by Rural Support Program Network (RSPN) in which 2920 domestic biogas plants have been installed up till August 2013 and this program aims to set up 300,000 biogas plants across the country within next 10 years (Anonymous, 2013).

There are so many benefits associated with the biogas plants such as production of energy (heat, light, electricity), high quality fertilizer, improvement of hygienic conditions (through reduction of pathogens, worm eggs and flies), reduction of workload, global environmental advantages (through protection of forests, soil, water and air), reduction of greenhouse effect and the demand for fossil fuels (Osei, 1993; Bajgain and Shakya, 2005; Heegde and Pandey, 2008; Hamlin, 2012). The byproduct of biogas production, known as bio-slurry, is a

*Corresponding author: e-mail: amakhdum@wwf.org.pk

high grade fertilizer that can be used for income generation and improvement in yield (6-10%), plant health, or growth (Ilyas, 2006; Hamlin, 2012).

The social benefits of biogas plants have widely been accepted in different parts of the world while their acceptance can vary across communities and geographical area. The current study contributes to the quantitative assessments of social impacts of biogas plants for the first time with reference to the rural communities of Sindh, Pakistan.

MATERIALS AND METHODS

Study location: This study was conducted in Sukkur and Ghotki districts of Sindh province of Pakistan. United Nations Development Program (UNDP) has installed 2000 biogas plants in the areas along Indus River which were affected by heavy flood during monsoon of 2010. The average size of each biogas plant was 6 cubic meter with a daily production of 2 kg of methane gas.

Survey:

Eighty two biogas plants were randomly selected and surveyed in Sukkur and Ghotki districts for the assessment of social and environmental impacts of biogas plants on flood affected communities. For this purpose 82 women were interviewed on a standard questionnaire by a single interviewer. Only those women were selected for this purpose who were directly involved in cooking and maintenance of biogas plants. Four to five households were relaying on a single biogas plant (2132 household members in total). The questionnaire was aimed to collect information regarding (i) reduction in quantity and cost of fuel wood consumption, (ii) reduction in time spent in kitchen management activities, (iii) improvement in kitchen environment and (iv) reduction in disease incidences after the installation of biogas plants. The survey lasted for two months, from first week of November, 2012 to last week of December, 2012.

Statistical analysis:

Frequency distribution test was applied on reduction in amount and cost of fuel wood consumption by 2132 household members. Two sample comparison test (t-test at alpha 0.05) was applied to compare the average quantity and cost of firewood consumed per household member per day. Average reduction in time of activities (work load) related to kitchen and dung disposal before and after installation of biogas plants was compared by using two samples comparison test (t-test at alpha 0.05). Percentages of respondents were calculated for assessing the impact of biogas plants on different social issues e.g. reduction in time spent in kitchen management activities, improvement in kitchen environment and reduction in disease incidences after the installation of biogas plants.

RESULTS AND DISCUSSION

The maximum number (1333) of household members reduced their fuel wood consumption and its cost by 40-60%. Only 205, 175, 375 and 44 farmers were able to reduce 80-100%, 60-80%, 20-40% and <20% fuel wood consumption and its cost, respectively (Fig 1). On an average, the fuel wood consumption per house hold member was reduced significantly from 1.15 ± 0.148 kg/day to 0.6 ± 0.233 kg/day (*ca*. 48%) while its cost was also reduced significantly form 8.64 ± 1.106 Rs/kg to 4.48 ± 1.750 Rs/kg (*ca*. 48%) (Table 1). When applied these rates of reduction to 2132 household members, an overall reduction of 1199 kg in fuel wood and Rs. 9024 in cost was obvious.

A similar survey was conducted for biogas users in Vietnam during 2010-2011. The results suggest that after acquiring a biogas plant, households reduced their average expenses from 388 to 102 thousand Vietnamese Dongs (VNDs) (*ca*. 70% reduction) for energy purpose. There was also some additional saving of 84 thousand VNDs per month on account of utilization of the bio slurry as fertilizer and animal feed (Anonymous, 2011b). The difference in the compliances of fuel wood reduction among the users is mainly due to the difference in usage efficiency because several factors affect the biogas production i.e. potential of feedstock, design of digester, inoculum, nature of substrate, pH, temperature, loading rate, hydraulic retention time (HRT), C : N ratio, volatile fatty acids (VFA), etc. (Nagamani & Ramasamy, 2007).

The activities for which the management/operational time was reduced significantly after the installation of biogas plants included (i) fire wood collection, (ii) preparing hearth and burning stove, (iii) baking bread, (iv) cooking other than bread baking and

(v) dung collection (Fig 2). Dung disposal/feeding were the only activity for which the operational time was significantly higher after installation of biogas plant. On the other hand, slurry management was the only activity which was additional after biogas installation plant and took an average of 20.48±6.75 minutes per day. The overall analysis suggests no significant difference in work load before and after the installation of biogas plant (Fig 3).

A case study from Nepal (Wargert, 2009) suggests that installation of biogas plants reduced firewood collection time which often takes several hours every day besides other social, health and environmental problems i.e. children education (Gautam *et al.*, 2009), back and neck pain (Gautam *et al.*, 2009) and heavy deforestation (Topa *et al.*, 2004). Similar findings were reported from Georgia where the use of biogas reactors freed a lot of time of rural women by reducing the need for wood felling and stockpiling (Anonymous, 2006). According to another report from Vietnam (Anonymous, 2011b), biogas users saved 2.4 hours per day and 11 percent of these users utilized free hours for other income generating activities.

Regarding the impacts of biogas plants on kitchen environment, 43.53%, 97.65%, 97.65%, 88.88% and 96.47% of women respondents reported biogas as a safer fuel (with less burn risks), with smokeless kitchen, with smokeless utensils, involving less physical and mental stress and clean hands, respectively. Moreover, disease incidences i.e. cough, sore eyes and headache were also agreed to be reduced by 68.24%, 84.71% and 78.82%, respectively.

The environmental and social impacts of biogas plants have widely been accepted but only few studies quantify the levels of satisfaction of biogas users. For example in Vietnam, 86%, 84%, 99%, 96%, 85%, 58% of biogas users mentioned biogas responsible for reduction in pollution, easiness in cooking, reduction in household insect pests, smokeless kitchen, reduction of bad odors from pig farming and clean utensils, respectively (Anonymous, 2011b).

In conclusion, besides improving kitchen environment and reducing the disease Incidences, biogas plants significantly reduced fuel wood consumption and its cost (*ca.* 48%) without consuming extra working hours for rural communities of Sindh, Pakistan. The study favors the exploitation of huge biogas potential (about 16.3 million m³ of biogas per day) of Pakistan in the form of about 159 million cattle and buffaloes as a strategy to meet the supply shortfall of natural gas.

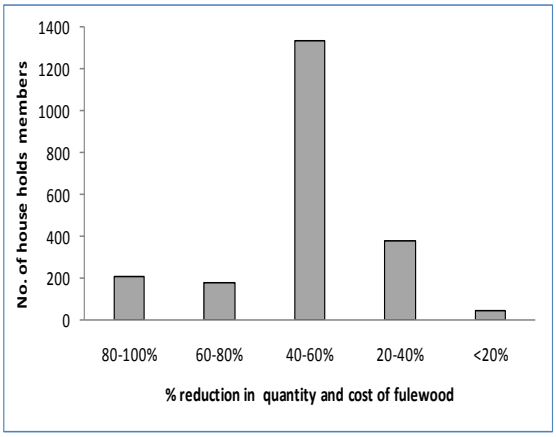
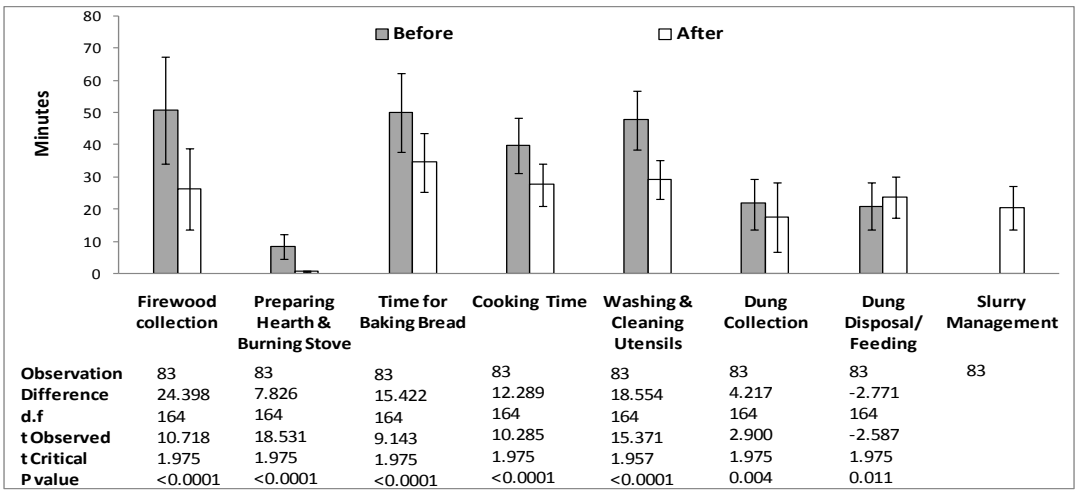


Fig 1. Percent reduction in quantity and cost of uel wood consumption by 2132 household members after installation of biogas plants at Sindh, Pakistan



	Firewood collection	Preparing Hearth & Burning Stove	Time for Baking Bread	Cooking Time	Washing & Cleaning Utensils	Dung Collection	Dung Disposal/ Feeding	Slurry Management
Observation	83	83	83	83	83	83	83	83
Difference	24.398	7.826	15.422	12.289	18.554	4.217	-2.771	
d.f	164	164	164	164	164	164	164	
t Observed	10.718	18.531	9.143	10.285	15.371	2.900	-2.587	
t Critical	1.975	1.975	1.975	1.975	1.957	1.975	1.975	
P value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.004	0.011	

Fig 2. Comparison of means in time involved in different kitchen management activities before and after installation of biogas plants. Error bars show standard deviations

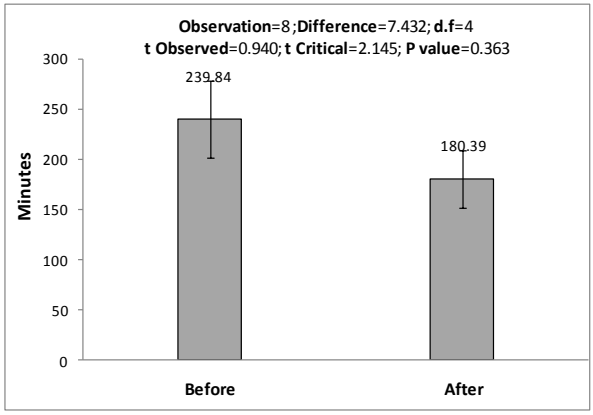


Fig 3. Comparison of means of overall time involved in different kitchen management activities before and after installation of biogas plants. Error bars show standard deviations.

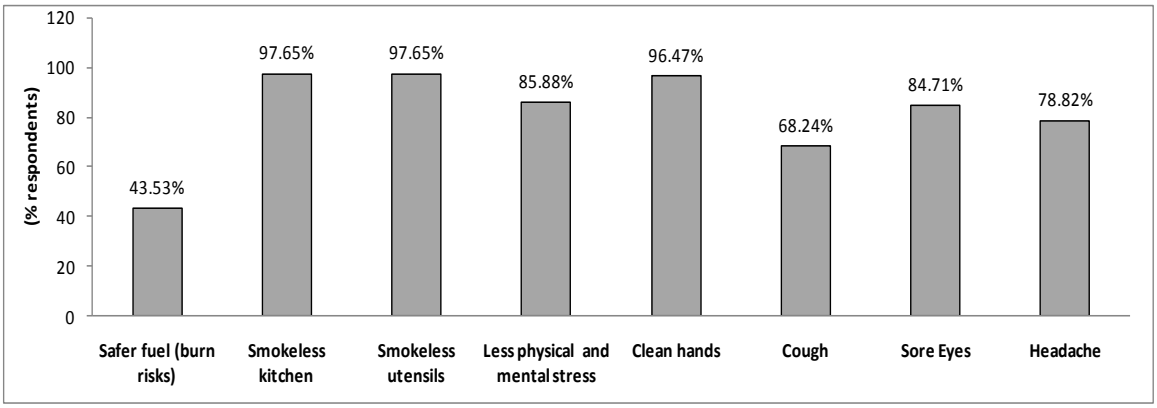


Fig 4. Percent compliance of 82 women respondents towards improved kitchen environment and reduction in disease incidences after the installation of biogas plants

Table 1. Comparison of quantity and cost of firewood consumption before and after installation of biogas plants

		Firewood consumption Per house hold (kg/day)	Firewood consumption cost Per house hold (Rs./day)
Before		1.15 ± 0.148	8.64 ± 1.106
After		0.6 ± 0.233	4.48 ± 1.750
Reduction (%)		48.53 ± 17.963	48.76 ± 17.976
T -test results	**Observations**	82	82
	Difference	0.55	4.163
	d.f	162	162
	t Observed	18.207	18.207
	t critical	1.975	1.975
	P value	<0.0001	<0.0001

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