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Household Biogas Technology to Improve Rural Livelihoods in Laos

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The government of Laos views biogas technology as a vehicle to reduce the poverty of rural smallholders, and as an alternative source of low-cost, renewable energy for rural households or low-income farmers. This study assesses the impacts of installing bio-digesters in the Biogas Pilot Project (BPP), and examines the contribution of biogas technology to improving livelihoods of biogas users. The analysis is based on a detailed survey of a representative sample of existing customers in the BPP pilot areas in Laos. Data on socioeconomic factors affecting farmers' livelihoods after the installation of bio-digesters were collected for 100 households within 29 districts in the five pilot provinces of Xiangkhuang, Vientiane, Khammouane, Savanakhet and Vientiane Municipality. The smallest size (4 m^3) of bio-digester was installed by 82% of the surveyed households. Reasons for installing the smallest size included the limited number of livestock owned by households and the high cost of the biogas plant construction. The limited financial resources of rural smallholders make the 2,379 thousand kip (about US$297.50) construction cost for the smallest 4 m^3 biogas plant size is the main constraint slowing adoption of this technology. Most biogas users (76%) were fully satisfied and 20% were partially satisfied by their bio-digesters. Due to in-sufficient supply of biogas for cooking and lighting, 4% of the households were not satisfied with the gas plants. In addition to reducing the amount and cost of firewood or charcoal, reported benefits included the use of dung residual as a substitute for chemical fertilizer that also reduced costs. Other reported benefits included reduced workload including reduced time collecting firewood, cooking and cleaning cooking utensils. In addition to installation cost, hurdles for adoption of bio-digesters include low cost of fuel wood and in availability of dung near digesters due to free roaming livestock.

Key words: biogas, smallholder, rural area, livelihood, fertilizer

1. Introduction

1.1 Background

In Laos, 79.7% of the total population is engaged in farming (Laos Agriculture, 2012). Agricultural production is mostly practiced with a mixed crop-livestock farming system. Livestock are often the only source of draught power and fertilizer for crops in mixed farming systems (Steinfield *et al*., 2006). Rapid growth in demand for meat and dairy products in Asia presents both opportunities and challenges for livestock development and poverty alleviation (Millar and Photakoun, 2006). Economic growth has reduced official poverty rates from 46% in 1992 to 26% in 2010 (Countries of the World, 2012). Almost all output, live animals and products, are from traditional small-scale production (Wilson, 2007). Cattle and buffaloes are grazed extensively in fallow upland fields, grazing areas and forests while pigs are normally kept either in a pen at home or roam freely around the house (Koopmans, 2006). Biogas is considered one of the lowest cost renewable energy sources for rural areas in developing countries (Bui, 2002) including Laos. Biogas technology helps improve the livelihoods of the poor in rural areas with cost saving from replacement of firewood and chem-

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ical fertilizers; it contributes to the reduction of manure smell where animal housing is located, protects air quality by reducing smoke from cooking and helps minimize carbon emissions from burning firewood (IFAD, 2007). Domestic biogas reduces the workload of women by reducing the need to collect firewood, tend fires and clean the soot from cooking utensils.

Proper application of bio-slurry instead of expensive chemical fertilizers improves soil structure and fertility, which boost the productivity of agricultural plots (IFAD, 2007). In addition, biogas conserves the natural environment by protecting threatened species and habitats. Improved and stable management of dung reduces groundwater pollution. In Laos, biogas production is currently too small to meet the needs of rural smallholders.

1.2 Biogas History and Current Projects

In 2005, a biogas program funded by the Yunnan (China) Government built 30 digesters in Ban Nongphouviang, Pak Ngum District, Vientiane province, Laos with a Chinese design. Farmer households appeared to be happy with the units although it was premature to draw meaningful conclusions at that time. However, this program influenced the government of Laos to view biogas technology as a vehicle to reduce the poverty of smallholders in rural areas and as alternative low-cost renewable energy source for rural households or low-income farmers.

The Lao Biogas Pilot Project (BPP) was established in November 2006; it was funded by the Netherlands Development Organization (SNV) and was operated under the Lao Department of Livestock and Fishery (DLF). The bio-digester model called the "Lao-Net" was made available in 4 different sizes: 4-, 6-, 8- and 10-m^3 digester volume. "No 8-m^3 units were reported in the survey, so this size is not considered further in this report". Currently, BPP has been implemented in the five pilot provinces of Xiangkhuang, Vientiane, Khammouane, Savanakhet and Vientiane Municipality. By 2011 year end, 2680 household biogas plants had been installed around Laos (Biogas Pilot Program Annual Report, 2011).

The goal of this study was to evaluate the performance of the Biogas Pilot Project in the five pilot provinces based on the results of the 2011 Biogas User Survey (Synthesis, 2011). The study examines the contributions of biogas technology to improving the livelihoods of biogas users. Potential alternatives for sustainably promoting household biogas technology to improve agricultural production and benefit smallholder farmers in Laos are considered.

2. Materials and Methods

This study assessed the impacts of installing bio-digesters on BPP customers based on a detailed survey of a representative sample of existing customers. The survey was carried out between mid-October and mid-November 2011 and covered a sample of 100 interviewees in 29 districts in the five provinces.

The survey questionnaire was developed by the BPP and had 7 main sections: (1) livestock management, (2) system construction and functioning, (3) services of District Agriculture and Forestry Office (DAFO) and constructing masonry, (4) satisfaction of farmers, (5) energy consumption, (6) fuel price and fuel saving, and (7) use of slurry. The data collection also included review of related secondary data including reports, statistical data, maps, and documents. In addition, the National Project Director of BPP was interviewed to deepen understanding of the current situation for the promotion of biogas technology in Laos. Related data was analyzed and the results were reviewed to develop the final conclusions and recommendations.

3. Results

The smallest size (4 m^3) bio-digester comprised 82% of the units reported followed by the 6-m^3 size that comprised 14%. The 4-m^3 bio-digester was installed in all provinces while only four of the 10-m^3 bio-digesters were found, all in Vientiane Municipality (Table 1). Cooking related benefits for bio-digesters reported by interviewees included ease of cooking by 22%, fast cooking by 18% and clean cooking by 7%. Thirteen percent of biogas users stressed economic benefits including reduced costs for electricity, charcoal, firewood and fertilizer (Fig. 1).

The results of the survey show that installation of bio-digesters substantially reduced expenditures of farmers for cooking and lighting. Farmers saved an average for all interviewees of 318 thousand kip/month for cooking fuel (firewood, charcoal and LPG). Cost savings for lighting (candles, kerosene and electricity) were an average of 68 thousand kip/month (Table 2). In addition, the use of bio-slurry for fertilizer reduced average monthly cost for chemical fertilizer from 85.8 thousand to 65.2 thousand kip, a monthly reduction of 20.6 thousand kip (Table 3).

Table 1. Sample size for biogas plant-system sizes by province

Province	Digester size (m^3)			Sample Size
	4	6	10	
Vientiane Municipality	26	2	4	32
Savannakhet	28	0	0	28
Xiengkhuang	9	8	0	17
Vientiane	14	3	0	17
Khammouane	5	1	0	6
Total sample size	82	14	4	100

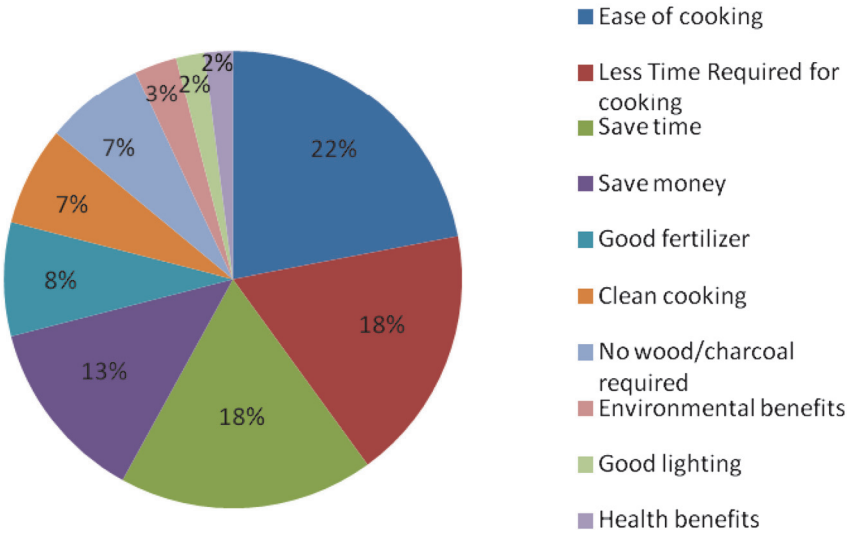

Fig. 1. Bio-digester benefits reported by interviewees

In comparison with firewood/charcoal stoves, 90.6 % of the interviewees stated that biogas reduced time for cooking (exclude time for collecting firewood) with the estimated daily time saved being an average of 37 min (Table 4).

Seventy-six percent of interviewees responded that they were fully satisfied with their bio-digesters while 20% replied that they were partially satisfied. Only 4% were totally dissatisfied with their bio-digesters (Table 5).

4. Discussion

One of the reasons that the smallest size of biogas digester (4 m^3) comprised 82% of the surveyed units is the small number of livestock owned by each household. In order to have enough dung to feed the smallest size of bio-digester, a household should have at least 5 cows, 3 buffaloes, 8 pigs, or a combination that produces a similar amount of dung. In general, households that install biogas digesters are not amongst the poorest of the poor, because very poor families often do not have a sufficient number of animals for a bio-digester to function. In addition, the high cost of the biogas plant construction has been the main constraint for rural households with limited financial resources. The households that constructed a large biogas plant may have higher income than others in our survey. Therefore, biogas may have a limited impact on extreme poverty.

Bio-digester construction is funded by three distinct components: farmer contributions, credit, and subsidy. The funds contributed by the farmers including credit ranges from about 22 to 40% of the bio-digester cost. BPP provided flat rate subsidy of 1,860 thousand kip

Table 2. Substitution values of biogas for cooking and lighting

	Before Bio-digester Consumption/day		After Bio-digester Consumption/day		Fuel saved	Cost saved (substitution value)
	Quantity	Cost ($\times 10^3$ k/m)	Quantity	Cost ($\times 10^3$ k/m)		($\times 10^3$ k/m)
Firewood	217.2 kg/m	140	73.2 kg/m	47	144.0 kg/m	93
Charcoal	80.1 kg/m	227	26.7 kg/m	76	53.4 kg/m	151
LPG	8.8 kg/m	79	0.6 kg/m	5	8.2 kg/m	74
For cooking						**318**
Candles	2 packs	10	0.4 pack	2	1.6 p/m	8
Kerosene	4.2 L/m	20	0	0	4.2 L/m	20
Electricity		128		87		41
For lighting						**69**

Remark: p/m=pack/month; L/m=liter/month; k/m=kip/month; kg/m=kg/month.

per household bio-digester. Construction costs vary depending on the bio-digester size with cost for a 4-m^3 unit being about 2,379 thousand kip (about US$ 297.50), a 6 m^3 about 2,936 thousand kip and a 10 m^3 about 3,100 thousand kip. Furthermore, construction cost varies from province to province due to the cost of the construction materials. Clearly limited financial resources are a major obstacle for farmers to become more active in producing biogas. In addition, the payback time for the investment in the bio-digester probably varies from district to district depending upon the cost of fuel and it appears that the payback time would be relatively short.

4 the conveniences and economic benefits (Fig. 1), 3% of the interviewees reported that by replacing firewood and charcoal for cooking, the kitchen became free of smoke and ash whereas 7% of the biogas users mentioned that cooking with biogas is clean and hygienic. Thus, biogas provides a healthier household environment.

After installation of the system, the quantity of firewood consumed was reduced from 217.2 kg/month to 73.2 kg/month). The quantity of charcoal used was reduced from 80.1 kg/month to 26.7 kg/month. Average monthly expenditures for firewood were reduced by 93 thousand kip, for charcoal by 151 thousand kip, and for LPG by 74 thousand kip; thus, the total average monthly cost reduction for using biogas instead of firewood, charcoal and LPG was 318 thousand kip. Thirty-three of the interviewees reported that biogas was used for all cooking; for these users, the potential average monthly savings would be 446 thousand kip if biogas replaced all firewood (140 thousand kip), charcoal (227 thousand kip) and LPG (79 thousand kip) used for cooking.

For lighting, the average household cost for candle use reduced from ten thousand kip per month to two thousand kip per month, kerosene use from twenty thousand kip per month to zero and of electricity cost from 128 thousand kip/month to 87 thousand kip/month. Average monthly cost savings per household were 8 thousand kip for candles, 20 thousand kip for kerosene and 41 thousand kip for electricity. Thus, the total average monthly reduction in cost for lighting due to biogas use was 69 thousand kip (Table 2).

The bio-digester also yields bio-slurry, which was reported by 8% of interviewees to be good fertilizer for application to their paddies and other fields. The application of bio-slurry instead of chemical fertilizers can improve soil fertility and structure, and therefore, increase crop yields. However, the exact amount of improvement has been investigated. Overall, the quantity of chemical fertilizer application has been reduced since the bio-digesters have been installed across the five provinces. For those households using bio-digesters, the average monthly decrease in chemical fertilizer use was about 4.4 kg per household, a reduction from 17.6 to 13.2 kg/household. The average monthly cost for chemical fertilizer decreased from 85.8 thousand to 65.2 thousand kip, a saving of 20.6

Table 3. Comparison of chemical fertilizer used before and after bio-digester installation

	Before		After		Cost saved
	kg/month	$\times 10^3$ kip/month	kg/month	$\times 10^3$ kip/month	$\times 10^3$ kip/month
Vientiane Municipality	26	128	21	106	22
Savannakhet	17	85	12	58	27
Xiengkhuang	13	63	8	38	25
Vientiane	14	63	10	48	15
Khammouane	18	90	15	76	14
Average	17.6	85.8	13.2	65.2	20.6

Table 4. Time saved cooking with biogas by province

	No %	Yes %	Estimated time saving (minutes/day)
Vientiane Municipality	3.1	96.9	29
Savannakhet	3.6	96.4	38
Xiengkhuang	—	100	56
Vientiane	23.5	76.5	27
Khammouane	16.7	83.3	34
Average	11.7	90.6	37

Table 5. Satisfaction of farmers with biogas system by province

	Fully satisfied	Partially satisfied	Not satisfied at all	Total
Vientiane Municipality	24	8	0	32
Savannakhet	24	2	2	28
Xiengkhuang	14	2	1	17
Vientiane	10	6	1	17
Khammouane	4	2	0	6
Total	76	20	4	100

thousand kip per household (Table 3).In comparison with firewood/charcoal stoves, 90.6% of the interviewees stated that biogas stoves greatly reduced the time spent preparing food. Note that all 17 interviewees in Xiengkhuang province said that biogas reduced time required for cooking. The surveyed households estimated that the average time saved per day was about 37 minutes (Table 4).

The total dissatisfaction of 4% of interviewees may be caused by incorrect loading of animal manure into digesters or not having the time to load animal manure into digesters. One of the interviewees reported that it was necessary to buy cow dung, which added to his daily expenses. The practice of letting livestock range free might have been the cause.

In addition, masons and district officials may not have responded promptly when lamp or burner problems occurred or when the digester did not produce gas due to the lack of experience and knowledge by farmers on system maintenance. Other issues include lack of supporting government policies and strategies, inadequately trained manpower such as biogas tech-

nicians and difficulty of access (bad road condition and long distances), which results in irregular visits by masons and district officials. However, the plant owners continued to use their bio-digesters.

5. Conclusions and recommendations

Biogas offers the potential for promoting sustainable small-scale agricultural production and provides a domestic fuel source; it can greatly reduce the use of firewood and contribute to conserving forest resources. Biogas-cropping-livestock integration has the potential to improve the livelihoods of smallholders in rural areas with lower costs for agricultural production and living expenses along with higher environmental quality. However, biogas technology is not widespread and factors slowing adoption include the weak rural economy and unstable livestock farming system, especially for poor smallholders keeping few animals. Insufficient financial support (subsidies) from the government and development agencies has been another factor slowing expansion of biogas technology in rural Laos. For subsistence agricultural production in Laos, the promotion of the household biogas technology may be a good option that can contribute to sustainable conservation of forests and food security, which are among the main goals of Ministry of Agriculture and Forestry.

The government of Laos needs to establish new policies that recognize the political and strategic agenda to support biogas technology and the transfer of economic, social, environmental knowledge to benefit smallholders engaged in mixed farming systems throughout the country. Small, low cost, and easy to construct and operate bio-digesters should be designed and developed to meet the needs of poor rural farmers. Increasing public awareness will be important; setting up a pilot digester in each region for demonstration is required to help residents to understand biogas. Appropriate financial support is needed to promote the improvement of agricultural production by smallholders. In addition, regular monitoring and enhancing maintenance skills of the district officers will be important to ensure that biogas digesters operate effectively and meet the needs of users and other stakeholders. Further research on social, economic impacts should be undertaken to assess the benefits from biogas technology in Laos.

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