Report on the Biodigester User Survey 2008

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Executive Summary

Since April 2006, the Ministry of Agriculture, Forestry and Fisheries of the Kingdom of Cambodia (MAFF) and The Netherlands Development Organisation (SNV) are cooperating in the implementation of a National Biodigester Programme (NBP), the overall objective of which is "the dissemination of domestic biodigesters as an indigenous, sustainable energy source through the development of a commercial, market oriented, biodigester sector in selected provinces of Cambodia". In order to assess the socio-economic structure of beneficiary households, and reception, acceptance and impact of biodigesters, the Programme, which is currently operational in seven provinces, commissioned a Biodigester User Survey (BUS). The survey was carried out in March 2008 (including enumerator training, field testing and data entry), and data processing and reporting took place in April 2008.

The survey team developed a questionnaire which was structured as follows:

- the current farming system as compared with the one before the plant was built,
- experiences during biodigester installation and start up, biogas production and use,
- motivation why farmers participated/are continuing/not continuing operations,
- subjective conclusions and recommendations of the farmers.

In the following, the major findings, conclusions and recommendations of the survey are summarized.

The survey found the average farm size above the national average. The general observations reported by the enumerators would allow for the hypothesis that most of the respondent households pertain, in their rural context, to the "better off". This hypothesis is supported by finding in other parts of the survey, e.g. density of livestock and the high percentage which used own savings.

The survey recorded a high degree of satisfaction on the part of the respondent households. All of the biodigesters were used, and the vast majority of the respondents judged "construction to be sound", stated that "results are convincing" and that "training was good". The performance of the plant was in line with the expectations of all of the respondents. No respondents considered the information received during promotion too optimistic about benefits or thought that costs turned out higher than expected and most were satisfied with the Program's brochures.

There was a high degree of participation of family members in the process of deciding on building a biodigester. However, in the final decision the male household was dominant, with the wife following at a distance, notwithstanding that convenience of cooking with biogas was found the most important determinant in making the decision (as motive to build the biodigester).

Almost 85% of the households financed the biodigester fully with "own savings", the remainder either fully by loan or by a mix of savings and loans[1]. All but one household received subsidies, and subsidies were appreciated by all. The uniform appreciation of the subsidy recorded before became more specific in retrospective: while responses showed very high levels of agreement on the amount of subsidy being sufficient and that it is paid quickly, the same respondents strongly agree that more plants would be built if subsidies were higher and easier available, for example involving less paperwork.

The amount of biogas produced was perceived "as expected" and "more than expected" by some 90% of the respondents. All respondents who bought dung from outside the farm used slurry as a fertilizer. A few farmers sold slurry, but none of them bought additional dung from outside the farm to increase slurry output in order to increase earnings. It appears, thus, that farmers don't use the potential of value added in slurry production.

[1] The lending facility, i.e. the PRASAC biodigester credit program became operational only in November 2007. Plants built after this date were excluded from the survey, thus commercial credit was used.

Correlation of sufficiency of biogas produced with the data on dung input shows, however, that if gas production was „always sufficient“, dung was bought from outside the farm in almost two thirds of the cases, while only 18% of those saying their gas production is only sometimes sufficient or even insufficient obtained external dung. This finding substantiates that, while overall gas production is obviously directly related to availability of dung in general, the sufficiency of biogas production is a function of additional dung input from outside the farm.

Biogas availability has changed the observed pattern of energy consumption of all but a few respondent households, with noticeable impact on overall household expenditure: the share of almost half of the households naming energy as a major cost factor before dropped to one third now. The absolute amount of money spent on cooking fuel decreased by an astonishing 92% (from 36366 Riel to 2626 Riel per month on average), and expenditure on energy for lighting by roughly 31% (from 15618 Riel to 10766 Riel per month on average) with the biodigester.

Use of biogas fuelled stoves has reduced both the number of traditional cooking devices and the average amount of money spent on firewood by roughly two thirds. Practically all households used biogas for cooking after the plant was built, while the relevance of conventional sources of energy for cooking dropped considerably. However, more than half of the households, if less regularly, still used firewood and/or charcoal for cooking, and total expenditure on electricity remained all but constant.

More than 90% of the households used biogas lamps, reducing the number of households using kerosene powered lamps as well as candles to a considerable extend. Electric lamps could not be substituted by biogas lamps on a significant level, however, with the use of batteries decreasing only slightly and the use of electricity (grid) remaining constant. Overall, absolute number of lamps (including candles) increased, suggesting that biogas lamps were used in addition to existing lamps.

Changes in time allocation after installation of the biodigester concerned time saved for cooking (time spent each day for this activity decreased by almost 20%) and less time spent for “collecting things outside the farm“, i.e. mainly firewood. With the biodigester, the number of households collecting firewood dropped by two thirds, reducing overall time spent for this activity by three quarters. This, and the fact that biogas lamps provide the opportunity to read after dark for about half of the households for the first time can be considered significant for the living conditions of respondent households.

When asked about changes in the use of chemical fertilizer in the context of the farming system at large, the number of respondents stating that they use chemical fertilizer decreased from 73% before to 53% now. In the ranking, bio-slurry replaced chemical fertilizer as most important fertilizer. However, this does not imply that chemical fertilizer was used less in absolute quantities or that its use was substituted by bio-slurry use. Rather, as use of farm yard manure (dung) as fertilizer dropped considerably both in absolute numbers and in the ranking after the installation of the biodigester, indications are that bio-slurry replaced dung, not chemical fertilizer.

When questioned in detail about the technical and economical performance of the biodigester, the above findings became more concrete. The respondents stated that with the application of slurry, use of chemical fertilizers decreased in about half of all cases with 6% discontinuing its use completely. These findings suggest that many of the farmers who had stated in the first data set that they had stopped using chemical fertilizer actually only decreased its use. Moreover, 31% of the respondents stated that they were not decreasing and 9% said that they were increasing their use of chemical fertilizer. These findings suggest that the reduction of chemical fertilizer use was less significant than the first set of data showed. In fact, and while chemical fertilizer use decreased in absolute terms, the major impact of bio-slurry is a change in the overall use pattern of fertilizers.

The continuing use of chemical fertilizer is not reflecting its overall low appreciation with respect to costs, impact on soil and taste of food (many regard it as dangerous for their health). In contrast, appreciation of bio-slurry showed a high standard deviation with respect to costs, yields and impact on soil, i.e. responses were highly polarized. Farmers attribute both bio-slurry and chemical fertil-

izer “optimum yields” but show little appreciation of the lower costs of bio-slurry and decreased expenditure for fertilizing. The fact that this dimension was overlooked by the respondents is in line with findings regarding the initial motivation to build a biodigester which showed that bio-slurry was not a major incentive influencing the decision.

Other than the above, the survey did not record any significant changes of farming systems due to installation of the biodigester. The cropping pattern remained unchanged, with rice production (80% of the cultivated area) the main component. There was no significant change in livestock kept, except that the average number of pigs decreased considerably though the number of households raising pigs remained constant. Reasons are most probably not related to the inclusion of the biodigester in the farming system but could reflect changes in terms of trade and/or decisions by households to sell pigs for immediate gain alternative to keeping them in order to increase biogas output (the price of pork increased considerably in 2007/08). Remarkable was the high percentage of animals being stabled, both before and after the installation of the biodigester, which could, however, be inflated if respondents included animals which are free roaming during daytime but kept penned up during the night as “stabled”. The assumption that the farmers would plant fodder crops in order to supplement traditional feed sources was not supported by the data.

There were some changes in the sanitary situation: households having water toilets in the house increased from 65% before to 74% now, households having no toilet decreased from 24% before to 18% now.

Generally speaking, the respondents described their decision to build the plant primarily as demand driven: We recorded a very high level of consent with the story of individuals being convinced about the plants objective advantages and therefore deciding to build it. Meanwhile, the data does not suggest a major influence of processes of peer grouping or secondary motivation[2]. Limiting the conviction argument is the fact, however, that only 26% would have built the plant if they haven't received a subsidy. About half of the respondents strongly agree that they wouldn't.

Convenience of and time saved by cooking with biogas (including “less work to collect firewood” and “less smoke”) was found the determining factor for building the biodigester (motivation) and the most important reason for the general content recorded. Convenience was more important for appreciation of benefits and general level of content than economic benefits, e.g. saving energy costs, both in prospective and in retrospective, and perceived relevance of cost reduction diminished even further in retrospective.

Lighting with biogas is valued at a lower level but appreciation tends to increase in retroperspective, i.e. after concrete experience with biogas lamps. Similarly, bio-slurry was appreciated more after concrete experience: 25% named “less fertilizer costs due to slurry use“ as a reason for building the biodigester, 60% state it as a reason why they would build it again today.

This conclusive interpretation, i.e. that the biodigester is valued, both in prospective and retrospective, more for added convenience and, with respect to bio-slurry, availability of more farming inputs than for economic benefits is supported by the finding that most respondents decided to build the biodigester regardless of their expenditure on energy and fertilizer.

Overall, combining these findings with other relevant variables, it can be concluded that the objective performance of the biodigesters with respect to provision of energy and bio-slurry resulted in a high level of content with most of the respondents but did not induce significant change in observed farming or livelihood patterns. Given the relatively limited experience the respondents had at the time of the survey (from 5 to 23 months), this was to be expected. To become fully integrated in the farming/livelihood system of the beneficiaries, more time and learning will be needed.

Therefore, and considering the appreciation of promotion efforts shown above, and the strong agreement of the respondents that more plants would be built if more people knew about the Biodigester Programme, to increase and improve assistance efforts is recommended. Focus of pro-

[2] I.e., normative pressure, mimetic incentives and/or social coercion.

motion should include economic benefits of bio-slurry use. Most farmers understand the interdependence of amounts of dung applied to the biodigester and the amount of bio-slurry produced, but do not change patterns of animal husbandry, e.g. increase numbers of animals or intensify production. A way to increase inputs of dung beyond on-farm manure could be the acquisition of dung from outside the farm, which is already an existing practice with more than one third of the farmers questioned in the course of the survey.

In this respect, it is also recommended to follow up the survey with case studies on comparative micro-economic advantages of biogas produced energy and bio-slurry, generating monetary information. Such studies should involve a limited number of representative households and produce, using a participating observation approach, a first set of micro-economic data which should then be monitored as part of general programme activities.

In addition it is recommended to facilitate, possibly with the help of a local NGO, on farm trials to investigate comparative advantages (economic, regarding fertilizing effect etc.) of using bio-slurry.

1. Introduction

Since March 2006, the Ministry of Agriculture, Forestry and Fisheries of the Kingdom of Cambodia (MAFF) and The Netherlands Development Organisation (SNV) are cooperating in the implementation of a National Biodigester Programme (NBP), the overall objective of which is “the dissemination of domestic biodigesters as an indigenous, sustainable energy source through the development of a commercial, market oriented, biodigester sector in selected provinces of Cambodia”.

In order to assess the socio-economic structure of beneficiary households, and reception, acceptance of and impact of biodigesters, the Programme, which is currently operational in seven provinces, has commissioned a Biodigester User Survey (BUS) to be carried out by a team of consultants. The study was incepted with a preparatory phase in the second half of February (desk study of pertinent documents, questionnaire design), the survey was carried out in March 2008 (including enumerator training, field testing and data entry), and data processing and reporting took place in April 2008).

The principal objective of the survey provided by the NBP was: “to evaluate the effect of domestic biodigester installations, as perceived, on 80 households in four provinces in Cambodia as well as how they have experienced the programmes activities such as promotion, construction, quality assurance, training and after-sales service. To this extent, the survey shall assess aspects of domestic biodigesters (energy, agriculture, health & sanitation, environment, financial, workload) for as far as they have a bearing on the biodigester households“(ToR of the survey as provided by the Programme in January 2008).

The survey follows an initial survey carried out by the Cambodia Institute of Development Study. However, as some 900 household have now extended experience with running and maintaining biodigesters, the survey presented here changed from the 2007 survey to expand the scope to include a more in depth impact assessment.

The survey was designed and coordinated by Mr. Ulrich W. Schmidt, an international consultant and socio-economist, and Mr. Andreas Jordan, a sociologist and political scientist, and the following report was produced by them. The survey team was recruited locally and was supervised by Ms Im Monychenda, MA in international development.

The survey team expresses their gratitude for the assistance rendered by the PBPO staff during the survey and by the NBP senior staff during preparation of the methodology and the questionnaire. The team also wishes to acknowledge their appreciation of time and effort spent by the respondent farming families during the interviews.

2. Approach and Methodology

2.1 Approach

The 2007 BUS was focused on reception of the programme's efforts and the level of satisfaction of the beneficiaries, e.g. with assistance in pre-construction, construction, operation, maintenance and financing modalities of the plant as well as socio-economic characteristics, motivation to participate in the Programme, determinants of decision makings, costs and benefits as perceived by the beneficiaries, and satisfactory levels regarding improvements in cooking and provision of light, i.e. the respective health and social effects. The survey concluded that „users are generally satisfied with their investment and the performance of their biodigester"; recommendations include additional training, technical improvements (biogas appliances), increased visibility and pro poor promotion of biodigesters.

Although the ToR for the 2008 BUS retain a certain focus on benefits of the biodigester as conceived by the beneficiary households, the length of the biodigesters being in operation now allowed for a more objective impact assessment as compared to the 2007 BUS. Therefore, the survey team proposed an adjusted a more comprehensive approach, which combined the evaluation of subjective reception and experiences of the beneficiaries with significant and objectively determinable impacts of the biodigester operation on livelihoods. The survey team's aspiration was to come up with recommendations for the further promotion and dissemination of the technology based on objectively verifiable, positive impacts as well as on subjective experiences of single households.

In order to do so and allowing for a more comprehensive evaluation and perspective, the survey team analysed the major components of the beneficiary farming system and their interaction. The survey built on and expanded the assessment of the socio-economic characteristics of the 2007 BUS but used a more holistic perspective because impacts and benefits of a technological innovation on an existing farming system (e.g. on income, labour and input use and respective trade-offs, quality of life, farm ecology etc.) need to be viewed in the context of the entire farming/livelihood system, i.e. farm level micro-economic, social and environmental changes brought about by the inclusion of a biodigester in the farming system.

Given the track record of the Programme to date, a retrospective dimension (lessons learned) was included. Assuming that performance, success and related efforts of biodigesters would vary from farm to farm, major influencing factors were ranked and scaled. The situation at the time when the biodigester was introduced, built and run initially was compared to the present situation.

As a further dimension, past and present motivation of the individual beneficiaries as to engage in /continue with the technology was investigated, distinguishing between primary and secondary motivation, and individual decision making as well as structural determinants of the decision making process. Here, the survey attempted to find information on whether farmers participated in the Programme because of (i) a felt need for alternative energy, (ii) successful and convincing introduction and follow-up, processes of normative pressure an/or mimetic isomorphism, status gained by the presence of authorities and/or foreign experts, subsidies, or a combination of these factors. Considering that respondents in general tend to describe their past actions as demand driven and themselves as rational actors, balancing the installation's pro and con, the survey team set great store by investigating the influencing factors in the decision making process in order to provide profound recommendations on promotional activities.

The questionnaire was divided into four major sections:

- the current farming system as compared with the one before the plant was built,
- experiences during biodigester installation and start up, biogas production and use,
- motivation why farmers participated/are continuing/not continuing operations,
- subjective conclusions and recommendations of the farmers.

Where methodologically possible, the survey report correlated the results of the survey with observations of the survey team and formulated hypotheses on the major factors determining biodigester performance to be monitored/investigated further.

2.2 Methodology

The survey involved eight enumerators and was assisted and supervised by two field coordinators to facilitate logistics and provide for quality control. The enumerators received training (one day) and participated in field testing of the methodology prior to undertaking the survey (two days). They were divided into four teams with each team being made up of a female and a male surveyor, combining one member with more experience with one with less and, where possible, comprising one member with a sufficient command of English.

Apart from assisting and supervising the team, the field coordinators provided liaison with MAFF/NBP provincial staff (selected respondents were informed by MAFF/NBP provincial officers of the tentative itinerary which was drawn up for each team) and conducted random cross checks on performance of the survey teams and results obtained from the interviews.

The survey team selected, by random sampling, 80 of the approximately 900 farming households in four provinces which had at least 5 months experience in biodigester operation using the data bank of the Programme with the assistance of Programme staff. Random sampling was preferred over stratified sampling because the time frame of the survey did not allow for the systematic compilation of the socio-economic and demographic data of all the population which is necessary for meaningful stratification. A sample size of 80 households with installed biodigesters, which corresponds to almost 10% of the population, was expected to provide a level of significance more than sufficient to arrive at conclusive results. At the same time, the sample size was small enough to allow for the in depth survey proposed above.

Data was collected using a structured questionnaire designed for the recording of quantified and qualified information. As to operationalise both the holistic perspective on impacts and benefits of the biodigester's technological innovation on an existing farming system and a significant motivation analysis, different methodological tools were applied, including single and multiple choice, ranking and scaling of results, and open questions. In addition, observations of the enumerators have been recorded separately for each farm. Thus, and in order to limit and control for inevitable bias due to social desirability and similar methodological problems, the methodological design made for a comprehensive questionnaire, which evaluates key aspects repeatedly in different contexts.

Ranking technique was in dubio preferred over absolute numbers as a methodological tool in the questionnaire, preventing to ask too much of the respondents. There is, however, still a high number of questions providing for scale variables.

2.3 Data processing, reporting

Data was entered as far as possible immediately after completion of interviews, and all completed questionnaires were subjected to quality control. A total of 3 households refused to answer the questionnaire or couldn't be met by the enumerators during the survey period. This results in a relatively high share of 96% of returned questionnaires.

Processing was done at home office using SPSS software. Some less important questions ("distance to next town", e.g.) didn't result in a sufficient number of processable answers (share of "missing values" too high). In this case, the corresponding variables have not been subjected to further statistical processing. A high share of multiple choice and ranking questions made for a very high number of computable variables. That is, not every processed variable can be discussed in this report. In many cases, however, only a more holistic perspective, combining a number of related variables, allowed for significant interpretation. A data sheet completing descriptive statis-

tics of all processed variables is shown in the annex to this report.

Processing the data, as usual for survey studies, the main focus was on descriptives. Considering the size of collected data, bivariate and multivariate analyses had to be restricted to the survey's key aspects. Guided by major hypotheses, the survey team conducted selected correlation tests and related statistical tools in order to provide reliable answers. The data available, however, would allow for more complex statistical processing which could be done if specific aspects are thought to merit this extra effort.

Doing the descriptive analyses, common measurements of centre, distribution, dispersion, skewness, kurtosis, variance and/or standard deviation were computed and displayed wherever applicable and conceived of as reasonable. As for the numerous ranked indicators, though ordinal variables, sometimes arithmetic means have been calculated, but only to rank those on their part. One has to be cautious, however, interpreting these aggregations. They may only be construed in relative terms, relative to other ranked indicators in the sample.

As mentioned above, the applied questionnaire is very comprehensive and key aspects are evaluated repeatedly in different contexts. Results of the survey allow now to exclude some aspects which were found not relevant for the farming systems/livelihood strategies. The survey team will produce a concise, consolidated and easier to use version for future use if requested.

3. The survey

In the following, the more significant findings and correlations are presented and discussed. A full set of the processed data is provided in an electronic version as an annex, together with the questionnaires in Khmer and English. Where acceptable with respect to information value, percentages are rounded. In a few cases, also absolute figures in monetary terms concerning costs/expenditures were recorded; however, because of the considerable variances shown by many responses, to use these figures for extrapolations, e.g. to project impact, would be methodologically hazardous.

3.1 The farming system: technical and socio-economic data

3.1.1 General information on respondent households

The respondent households surveyed were, by province: Kampong Cham 25, Takeo 26, Svay Rieng 12, and Kampong Speu 14. Average distance of the households from a main all weather road was 9,7km, and from the province capital 31,2km on average. Almost all were long term residents, with 67.5% of more than 30, 18.2% more than 20 and 7.8% more than 10 years of tenure, and 86.6 percent had land titles.

The average household size was 6.32 persons (standard deviation: 2,2; min 2, max 13). The majority of the household members were between 15 and 55 years old, only about 23% were below 15 and less than 10% were above 55 years of age.

Table 1: Household composition

Statistics

		male <15	male 15-55	male >55	female <15	female 15-55	female >55
N	Valid	76	76	76	76	76	76
	Missing	1	1	1	1	1	1
Mean		,74	2,46	,25	,62	2,05	,20
Std. Deviation		,885	1,390	,493	,765	1,176	,401
Minimum		0	0	0	0	0	0
Maximum		3	7	2	3	5	1

65% of the household heads gave their occupation as farmers, 8% as sellers (fish, pig), 8% as teachers, and 7% as civil servants (e.g. commune councillors). 71% said that their father was a farmer.

The educational level of the household members was comparatively high according to the observations of the enumerators. The results of the questionnaire are shown in the table below. Only 2% of the male and 8% of the female respondents were illiterate, 21% (male) and 29% (female) had primary, 40% (male) and 39% (female) had attended junior high school and 32% of the male respondents said they had completed high school.

Table 2: Educational level by gender and age group

	valid	missing	illiterate (%)	primary (%)	junior high school (%)	high school (%)	university degree (%)
male <15	49	7	31	49	18	2	-
male 15-55	173	14	2	21	40	32	4
male >55	17	2	6	41	53	-	-
female <15	45	2	13	62	22	2	-
female 15-55	139	17	8	29	39	23	4
female >55	9	6	44	-	33	23	-

Most of the respondents had a positive self assessment of their socio-economic situation, only 4% considered themselves poor and another 4% thought of them as “better off”.

The socio-economic self assessment of 67 households (87%) of “can make a living” as compared to three households each which regarded themselves as “poor” and “better off” may be biased by the fact that the enumerators were associated with a technical assistance program. The general observations reported by the enumerators and the findings regarding other assets discussed below would support the hypothesis that most of the respondent households pertain, in their rural context, to the “better off”.

3.1.2 The farming system before the installation of a biodigester and at the time of the survey

Farm size was 2.54 ha on average at the time of the survey (now), a decline from 2.71 ha before biodigester installation (before), with a high deviation (less than 0.5 ha to 30 ha). 2.49 ha are cultivated now, as compared to 2.53 ha before. The main component of the farming systems, rice, was produced on more than 80% of the cultivated area (75% of the paddy fields were rain fed, 25% irrigated), with no significant change from before to now. 19% grew other crops, 6% vegetables, 6% tree crops, and nobody planted fodder crops. There was some reduction of the land used for vegetable production from before to now (0.40 to 0.35 ha).

87% of the respondent households owned cattle, 68% pigs, 17% buffalos, 86% chickens. From before to now, the number of households owning small cattle increased from 34 to 45, the absolute number of small cattle rose from 73 to 92. The average number of big cattle, however, declined from 4,06 to 3,78 per household (owning at least one big cattle). Only one household bought cattle after installation for the first time.

The number of households growing pigs was constant, but there was a significant decrease in the number of pigs kept, especially big pigs, which declined, in absolute numbers, from 302 before to 211 now, and on average per household (owning at least one big pig) from 6,57 to 4,69. The decrease of small pigs followed this trend but was less pronounced. Four households bought pigs for the first time after installation of the biodigester, but another four households which had pigs before have abandoned pig raising.

To highlight the changes, all average numbers given above apply only to the corresponding group of households, that is, those respondents stating “0” have not been considered. Table 3 now shows the average distribution of animals per household in the whole sample:

Table 3: Average number of animals per household and totals (whole sample) now...

Statistics

		Cattle, big NOW	Cattle, small NOW	Buffalo, big NOW	Buffalo, small NOW	Pig, big NOW	Pig, small NOW	Chicken NOW
N	Valid	77	77	77	77	77	77	77
	Missing	0	0	0	0	0	0	0
Mean		3.29	1.19	.45	.31	2.74	1.88	52.10
Std. Deviation		2.163	1.225	1.273	.862	4.169	4.867	228.856
Minimum		0	0	0	0	0	0	0
Maximum		10	5	6	4	20	30	2000
Sum		253	92	35	24	211	145	4012

Table 4: ...as compared to the situation before the plant was built

Statistics

		Cattle, big BEFORE	Cattle, small BEFORE	Buffalo, big BEFORE	Buffalo, small BEFORE	Pig, big BEFORE	Pig, small BEFORE	Chicken BEFORE
N	Valid	77	77	77	77	77	77	74
	Missing	0	0	0	0	0	0	3
Mean		3.43	.95	.43	.30	3.92	2.10	53.16
Std. Deviation		2.648	1.337	1.292	.859	5.864	4.935	232.839
Minimum		0	0	0	0	0	0	0
Maximum		15	6	8	4	30	30	2000
Sum		264	73	33	23	302	162	3934

According to the respondents, 82% of the big cattle, 80% of the small cattle, 80% of the big buffalos, 67% of the small buffalos, 98% of big pigs, 100% of small pigs were stabled, 35% of the chickens were penned. There was only a change regarding stabled small cattle, which increased slightly from before to now.

There was no significant change in animal use, with draught the main use of buffalo, draught, sale of meat and meat home consumed about equally distributed for cattle and sale of meat first and home consumption of meat second for pigs.

Firewood still is the most important non farm product (collected outside of the farm). It was ranked 1st on average, before and after the plant's installation However, the absolute number of households collecting firewood declined significantly from 39 to 12. There was no change with respect to other collected items.

The slight decline in farm size is insignificant and most probably not linked to the biodigester (it may reflect overall decrease in average small and medium farm sizes). There is a high standard variation due to the fact that some households had no or little agricultural land. Cropping patterns remained constant with the absence of fodder crops remarkable but in line with the overall findings.

There was no significant change in livestock kept, except that the average number of pigs decreased considerably though the number of households raising pigs remained constant. Reasons are most probably not related to the inclusion of the biodigester in the farming system but could reflect changes in terms of trade and/or decisions by households to sell pigs for immediate gain alternative to keeping them in order to increase biogas output. Remarkable is the high percentage of animals being stabled (which could, however, be inflated if respondents included animals which are free roaming during daytime but kept penned up during the night as "stabled").

3.1.3 Income and expenditure before the installation of a biodigester and at the time of the survey

The most important source of income is the sale of rice. Number of households selling rice rose from 47 before to 54 now. The second most important source of income is the sale of meat. The

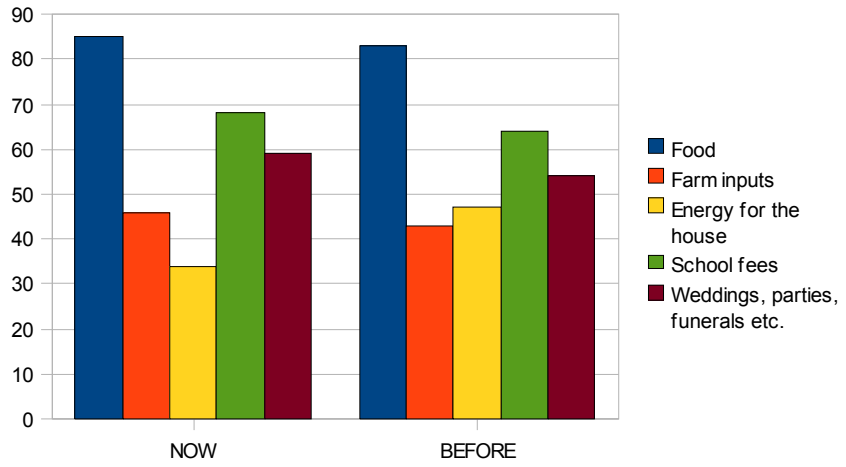
number of households selling meat rose from 35 before to 41 now. Only 7% of the households sell fruit, but those doing so rank the sale of fruit it as the second most important source of income, before sale of meat. Rankings did not change significantly from before to now.

With respect to farm products eaten at home, rice ranks first, before and now. Similar numbers of household ate vegetables, meat, eggs and fruit produced on the farm and more than 25% included small animals collected from fields in their diet such as fish, crabs, snails and frogs. There were no changes in absolute numbers and ranking from before to now.

With respect to expenditure for food items not produced on the farm, fish ranked first, with 75% of the respondent households buying fish regularly, followed by meat, vegetables and condiments. About 15% bought rice; the households which procured rice from the market ranked it second on average. Although many households bought pra hoc (29%), it was not regarded as a very important product. No significant changes after the plant's installation have been recorded.

As for total expenditure, food was the most important item. 85% of all households stated it as a major expenditure item and ranked it first on average, both before and after the plant's installation. As the table below shows, no significant changes have been recorded with “farm inputs”, “school fees” and “weddings, parties, funerals etc.”, either. The share of those households naming “energy for the house” a major cost factor, however, dropped from 47% before to 34% now.

Figure 1: Frequencies (%) of mention as one of the five most important expenditure items over the year



None of the recorded changes in expenditure patterns can be attributed to the installation of the biodigester except the reduction of expenditure for energy, which can be considered a direct result of biogas production.

3.1.4 Allocation of labour for farming activities

Over the year, 77% of the husbands (almost synonym to male family members of the 15 to 55 age group) spend their time working on “growing rice“, 68% “caring for animals“ and 55% “working outside farm for money“, and respondents ranked time allocation in this order. No significant changes of this allocation pattern both in absolute numbers and attached priority as compared to the situation before the plant was built have been recorded. Only with respect to “collecting things outside the farm“ we observed that a share of 8% stating that activity as a major factor before dropped to zero now.

As for the wives, 65% stated “growing rice”, 56% “going to market”, 53% “caring for animals “ as major working activities and ranked them in this order. When they “work outside the farm for money” (21% do), they rank it first. The same is true for “make/sell handicraft”, but only a minority of 6% is engaged in this. As with the husbands, there is no significant change in work time allocation except for a slight increase of about 7% of wives “caring for animals”. We also recorded a decrease of wives “collecting things outside the farm” (from 7% to 3%), but on a very low level of both engagement and attached piority (ranked fourth on average) and, as with the husbands, it hasn’t been a big deal before, either.

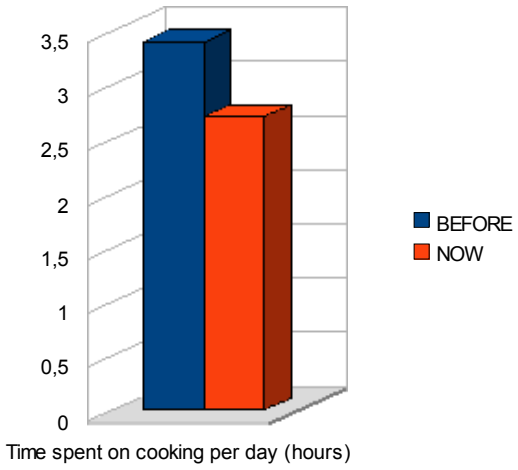
74% of the children gave “school“ as their main occupation and 98% stated school attendance first in the ranking. There was no change in absolute numbers or ranking before and after. As for the time they spent working on the farm (omitting school attendance), 62% named “caring for animals” and 46% “growing rice” as equally important on average and ranked it thus. A small number of five respondents saying their children “collected things from outside the farm“ before dropped to zero.

Of the household members above 55 years of age, about half gave “growing rice” and “caring for animals” as their main contribution to their family’s livelihoods and rank these activities first and second respectively. There were no changes from before installation of the biodigester and now.

Few households were growing vegetables and/or selling handicraft but those who did gave it a high ranking.

Changes in time allocation after installation of the biodigester concern less time spent for “collecting things outside the farm“, which would be mainly firewood according to 3.1.2, and more time spent“caring for animals”. With the biodigester, the number of households collecting firewood dropped from 68 to 22 (88% to 29%), reducing overall time spent for this activity from 3 hours/day on average to about 45 min/day now. The survey also recorded considerable time savings with respect to cooking: time spent each day for this activity decreased by almost 20%.

Figure 2: Time spent on cooking per day on average (hours)

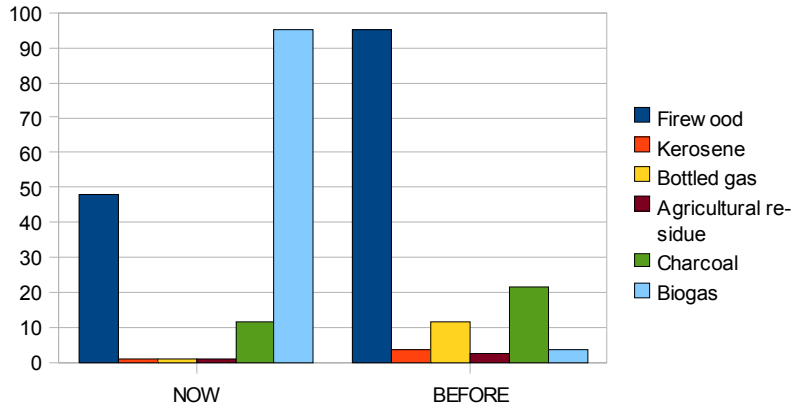


3.1.5 Energy sources and use

Main energy sources for cooking of meals underwent changes after the installation of the biodigester, both in ranking and distribution. Before having a biodigester, firewood, bottled gas and

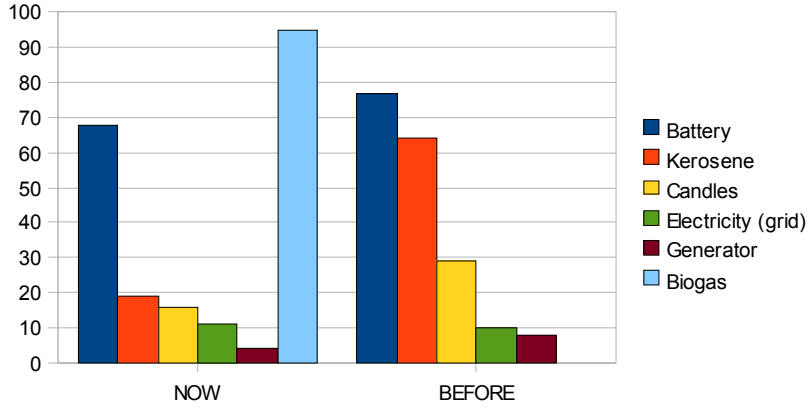
charcoal were ranked in this order on average. 97% of the households used firewood, 22% charcoal and 12% bottled gas. In comparison, importance of energy sources was ranked now in the order of biogas first, firewood second, and charcoal third, while 98% of the households used biogas, 48% firewood, and 13% charcoal. All other cooking fuels (agricultural residue, kerosene, electricity grid) were very rare, both now and before. While their number still declined after the plant's installation, they are given high importance if used.

Figure 3: Percentages of energy sources used for cooking



Main energy sources for lighting before were battery, electricity grid, generator, kerosene, and candles, and were ranked in this order on average. 77% of the households used battery, 64% kerosene, 29% candles, 10% electricity grid and 8% a generator. After the installation of the biodigester the ranking changed to biogas first, electricity grid second, battery third, kerosene fourth and candles fifth. Now: 95% of the households use biogas, 68% battery, 19% kerosene, 16% candles, 11% electricity (grid) as major energy sources for lighting. The use of batteries decreased only slightly, from 77% to 68%, use of electricity (grid) remained constant, and generator use dropped by half.

Figure 4: Percentages of energy sources used for lighting



While the absolute number of traditional cooking devices has been reduced by two thirds, more than half of the households still use firewood and/or charcoal for cooking, if less regularly. The finding that the portion of farmers cutting trees for firewood dropped from 70% to 13% after installation may to some extent reflect the simple fact that in many locations there are no trees left to cut: there was also an even more pronounced decline in the portion of those cutting trees in order to obtain

building material.

3.1.6 Use of fertilizer

The ranking of types of fertilizers before the installation of the biodigester resulted in the following order: dung from stabled animals first, chemical fertilizer second, dung left by animals in the fields third, and compost fourth. 73% of the households used chemical fertilizer, 68% dung from stabled animals, 27% dung left by animals in the field, 20% compost, and 4% green manure. After installation, bio-slurry was ranked first, chemical fertilizer second, compost third, dung from stabled animals fourth, and dung left by animals in the field fifth. Now, 87% of the households use bio-slurry, 53% chemical fertilizer, 35% dung from stabled animals, 19% dung left by animals in the field.

These rankings are of relative importance, however (see 2.3 above). They do not indicate a significant decrease in chemical fertilizer use or a replacement by bio-slurry. Rather, as use of dung as fertilizer dropped considerably both in absolute numbers and in the ranking, indications are that bio-slurry replaced dung, not chemical fertilizer. More than one third of all farmers, however, still use dung directly as a fertilizer.

Therefore and notwithstanding the changes in observed patterns of fertilizer use after biodigester installation recorded, the data so far do not support a significant decrease of chemical fertilizer use but a trade off between dung used as fertilizer and dung used for the biodigester, producing, apart from gas, bio-slurry. It would be interesting to analyse whether and to what extent the conversion of dung to bio-slurry produced value added in terms of fertilizing value and, considering the production of biogas, incremental value. The discussion of data recorded with regard to the use of the plant's outputs will shed some light on this issue (see 3.2.2.2 below).

3.1.7 Allocation of labour for non farming activities

Sources of water of the respondent households were, in the dry season, wells (72% of households) river/canal/lake (58%), and rain water (13%), with ranking following this order. During the wet season, 100% state rain water, 58% wells and 43% river/canal/lake as main sources of water and rank them in this order. On average, to fetch water needed 2,7 hours per day in the dry season and 1,1 hours per day in the wet season. There were no significant changes with respect to water sources and time allocation after the installation of the biodigester.

Time spent on cooking decreased from 3,4 hours to 2,7 hours/day after the installation of the biodigester. Overall, a vast majority of households stated that they had more time available now. More than 90% agreed that they have more time now to "listen to radio/music", "watch TV", "visit/talk to friends" and to "do nothing", while no one complained about less spare time at all. Other activities spent more time now on include "housework" (8 statements), "caring for animals" (8), "sell things (6) and "care for children" (3).

The latter finding, e.g. time savings resulting from cooking with biogas and the fact that biogas lamps provide the opportunity to read after dark for 39 households for the first time can be considered significant for the living conditions of respondent households. However, biogas lamps did not replace electric lamps and use of electricity from the grid for lighting has not been affected by biogas installation at all. An additional finding, i.e. that the absolute number of light sources excluding candles increased from 236 to 300 (27%) suggests that households apply biogas lamps in addition to light sources used before the installation of the biodigester.

3.1.8 Sanitary situation

The segment of households having water toilets in the house increased from 65% before to 74% now, households having no toilet decreased from 24% before to 18% now. Most common types of

sickness now were cold (88%), stomach trouble (38%), lung infections (9%), worms (7%), and skin problems (4%). There were no significant changes after installation of the biodigester.

3.1.9 Self assessment of the most important problems in the house

According to the respondent households, major problems with respect to living conditions (in the house) underwent considerable change with operating a biodigester. “Smoky kitchen” as a major problem decreased from 73% to 1%[3], “house difficult to clean“ from 63% to 11%, “to dark to read“ from 56% to 3%, “not enough clean water“ from 12% to 9%, and “toilet not nice“ from 4% to 1%. Two households stated that pots are still black and difficult to clean. The finding that a “smoky kitchen“ was not regarded as a major problem now is not corroborated by any significant decrease in respiratory problems and lung infections, however.

3.1.10 Major findings

The major finding of the survey with respect to the above is that the installation and operation of the biodigester had not resulted in any significant changes of farming systems. The cropping pattern remained unchanged, with rice production the main component. There was no significant change in livestock kept (except that the average number of pigs decreased considerably though the number of households raising pigs remained constant). This was in spite of the obvious and acknowledged correlation between number of livestock kept with dung availability and biogas production and the overall satisfaction with the performance of the biodigester recorded throughout the survey.

One of the possible interpretations of this finding is that the lack of impact on the farming system at large is due to the novelty of the innovation, with the possibility that changes may occur when significant and sustained benefits become evident. Another could be that farmers see the biodigester as a welcome opportunity to add to overall output of the farm but don’t attach importance to the benefits produced to the extent necessary to change the production system in the long term. To verify these hypotheses should be subject to the impact monitoring recommended above.

3.2 The Biodigester: technical and economic information

3.2.1 General information

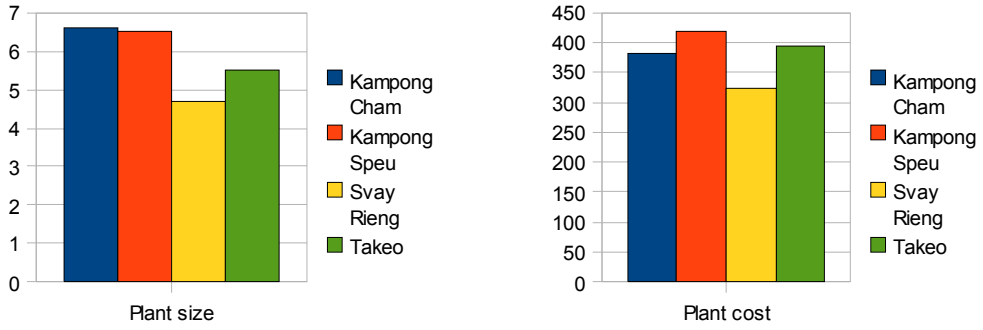
3.2.1.1 Costs and size of the biodigesters, construction time and financing

The biodigesters had an average cost of app. 380 USD and an average size of close to 6 cubic meters, with a high standard deviation. In absolute numbers, size varied from 4 to 15 cubic meters, and costs were given with a variation from 120 to 800 USD accordingly[4]. The average construction time was given as 11 days, again with a high standard deviation probably because of the different sizes. Almost 84% of the households financed the biodigester fully with “own savings”, 7% fully by loan and another 9% had used a mix of savings and loans. Of the respondents which had taken a loan, 75% had paid the loan already or repaid the remaining debt regularly (9 households), almost 17% had some payments overdue (2 households) and the remaining 8% (1 household) stated default of the loan.

[3] This could be inconsistent with the recordings on firewood and/or charcoal use for cooking. One reason that smoke isn’t conceived of as a major problem after installation of the biodigester could be that still existing stoves are used less intensely, thus producing less smoke, and/or are used mainly for cooking outside the house, for example preparing animal feed.

[4] The lower figure appears questionable but refers to one case only.

Figure 5+6: Average plant size and plant cost by province



3.2.1.2 Technical assistance, training

Almost all respondents said that they had received technical information about the plant from the constructor (mason). All except 1 household received some documentation, but with marked variations: 38% didn't receive leaflets/brochures, 62% didn't receive an „information folder“ and 57% did not get a „poster“; 27% didn't get a „user manual“, only 50% remembered to have received a „warranty certificate“, 16% didn't get a „T-Shirt“, 30% didn't receive a „home poster“. These data are not entirely conclusive: respondents may have forgotten or, which is more probable, enumerators may not have recorded numbers correctly. No significant variations among provinces have been recorded, however.

55% thought that the conditions of the warranty certificate were “very clear” and for another 25% “somewhat clear”. 15% “didn’t know”.

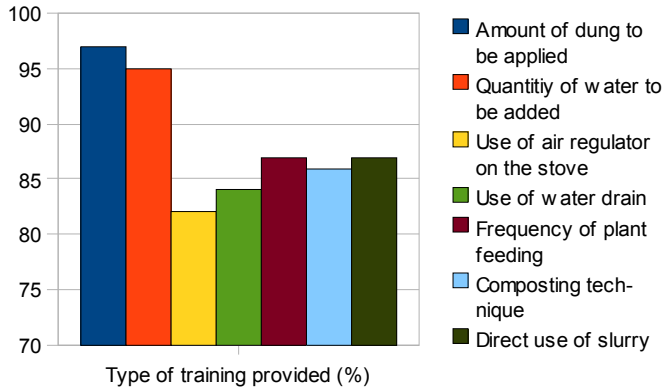
Quality of the materials provided was judged very positive. On a scale from 1 to 5 (1 very useful, 5 useless), leaflets/brochures scored 1,35, the information folder 1,36, the poster 1,34, the user manual 1,17, the warranty certificate 1,38, the T-Shirt 1,32 and the home poster 1,27.

Table 5: Training provided by province

		Training provided	
		yes	no
		Count	Count
Province	Kampong Cham	21	4
	Kampong Speu	13	1
	Svay Rieng	12	0
	Takeo	24	2

The Table to the right shows training provided by province. Overall, less than 10% stated that they had not received training. Of the remaining 90%, 40% received training from mason/constructor, 75% from Provincial Biodigester Program Offices (PBPO), 4% from friends/relatives who also own a biodigester, 31% attended a „biogas user training day“, and the remainder had assistance from others like “commune leader“ or cannot remember. Topics covered are shown in the following figure:

Figure 7: Type of training provided (%)



3.2.1.3 Reception of assistance and training

Overall, the survey recorded a high degree of satisfaction on the part of the respondent households. 99% of biodigesters were in operation. 83% of the respondents judged “construction to be sound“; 89% stated that “inputs are available“, 79% that “results are convincing“ and 66% that “training was good“. About 30% don't remember a “good training“ and 20% didn't agree that „results are convincing“ (which, because of the formulation of the question asked, does not apply that they judge results disappointing, however). Reasons for their disagreement were not queried here but appear in other parts of the survey results below.

When encountering a problem with the biodigester, 57% of the respondents contacted the PBPO and 62% the constructor. About 80% stated that the mason comes for regular supervision; only 6 requests for supervision (by 4 households) were recorded.

3.2.1.4 Reception of performance of the biodigester

The amount of biogas produced was received “as expected” or “more than expected” by some 90% of the respondents. Only 13% of the respondent households had problems with biogas production in the past, for technical reasons (two said that “design and construction were faulty“, for input related reasons (3 said “not enough feed available“, 2 “not enough water available“), and one said that there was “not enough time (labour) available“. Three respondents didn't know for what reason not enough gas was produced.

62% had experienced failures (at least one) because of broken appliances, mostly with biogas lamps.

Table 6: Failures of biogas lamps (frequencies)

Biogas lamp break-downs were mostly repaired by the respondent; only 13% were repaired by the constructor. In more than 20% of the cases, the broken down lamp was not repaired. The type and number of failures of other parts of the system are shown in the table below:

Biogas Lamp

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	40	51,9	51,9	51,9
	1	12	15,6	15,6	67,5
	2	7	9,1	9,1	76,6
	3	6	7,8	7,8	84,4
	4	5	6,5	6,5	90,9
	5	2	2,6	2,6	93,5
	6	1	1,3	1,3	94,8
	8	1	1,3	1,3	96,1
	10	1	1,3	1,3	97,4
	15	2	2,6	2,6	100,0
	Total	77	100,0	100,0	

Table 7: Breakdown of other appliances

Appliance	No of households reporting break-downs	Range of break-downs	Repaired by
main valve	4	1-2	100% mason
gas pipe	3	1-3	33% mason, 66% own
rubber hose	1	1	100% mason
gas taps	1	1	100% mason
stoves	4	1-2	25% mason, 50% own, 25% not repaired
outlet taps	1	3	100% mason
pressure gauge	0	-	-
water drain	0	-	-

Only very few cases of break downs of part of the physical structure of the biodigester were recorded (one each for inlet pit, dome, drain pit and outlet). Overall, 63% said that repair services had been provided in time, 26% said "not always in time", and 11% replied "no", i.e. not in time. The amount spent on repairs since installation was given at less than 3000 Riel, with a very high standard deviation (71% of the respondents spent 0 Riel as they repaired failures by themselves).

3.2.2 Biodigester operation

3.2.2.1 Inputs: Dung

On average, 40kg/day of dung were applied to the biodigester by the respondent households, again with a high standard deviation (min 10 to max 180kg/day). Some 40% bought dung from outside the farm (with considerable variations among provinces, see figure below), only one household had a toilet attached to the biodigester; one household applied domestic waste manually. About 75% of all available dung derived from cattle and 19% from pigs, with buffalo and chicken adding the remainder. Among the farmers who used cattle dung, the average amount applied was about 34kg/day, while the farmers who used pig manure applied 11kg/day on average, with both showing high levels of variance. More than 90% fed dung into the biodigester once a day, one household did twice the day and the remainder every second or third day. All respondents who bought dung from outside the farm used slurry as a fertilizer, and nobody that sold slurry bought additional dung from outside the farm.

Figure 8: Households (in %) buying dung from outside the farm per province

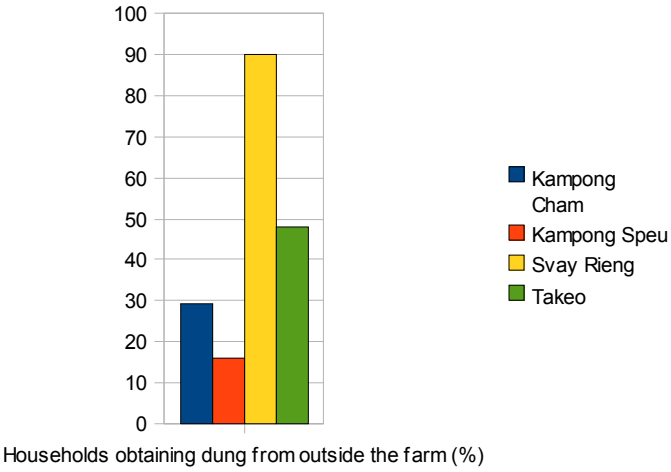
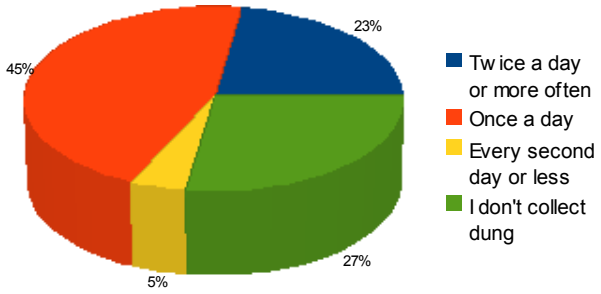


Figure 9: Frequency of dung collected

95% of the households stated that all the available dung is used for the biodigester; only three did not (reasons given were "gas is sufficient as it is", "too much work", one did not respond to the question). 11 households said that they don't have enough animals to feed the biodigester properly, with one household stating that this was because all pigs were sold, and another two giving as reason that their animals don't have enough fodder to produce sufficient dung. Asked how often dung is collected from free roaming animals, responses were highly variable, as shown in the figure to the right.



Stable/shed conditions were observed (by the enumerators) as follows: cattle and buffalo 100% „smooth earthen floor", pigs 64% „smooth earthen floor" and 36% „smooth concrete floor".

Labour inputs for the operation of the biodigester were distributed as follows: household head including one female headed household 83%, sons 64%, wife 50%, daughters 22%. The household heads are ranked first (as those who are primarily responsible for feeding the plant) in 65% if stated. Wives have their peak at position number 2 with 63% of the rankings. Sons are also ranked second in most cases, but their ranking is more uniformly distributed. Daughters are, if stated, ranked third in about half of the cases; in 29%, however, they are the most important family members to feed the plant. Only three households employed male workers; in these cases, they were ranked first. Two households employed female workers and rank them last. Labour inputs with respect to fetching water for the biodigester were recorded as follows: on average 6,6 trips to well/week and 6,1 trips to river, canal, lake/week, with a standard deviation of 2,4 and 2,5 respectively. Changes in water consumption are shown in the diagram to the left.

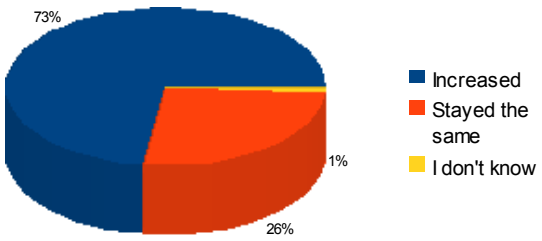


Figure 10: Water consumption after installation of biodigester

There are some inconsistencies in the data regarding application of dung. Some respondents claimed to feed a large amount of chicken manure into the plant without having the large number of chicken necessary to produce that amount of manure, according to on the spot observations by the enumerators. There are two possible explanations: either the enumerators erred in recording the information given, or the respondents were not able to recall amounts of dung applied in retrospective. Given the validity of most of the recorded data found during processing, the latter explanation appears more probable, also because no uniform pattern was observed with respect to dung application, with overall high standard deviations in most of the data sets.

3.2.2.2 Outputs: Bio-slurry

87% of the respondent households use the bio-slurry their biodigester produced, 13% did not. Of the 10 households who don't use it gave as reason “wouldn't know why to use it“, “wouldn't know how to use it“, “too difficult to transport it to the fields“ (one each), two were „not convinced of its fertilizing value“ and one “cannot tell why”. Another four stated that they haven't used bio-slurry yet because the plant is only recently built. No respondent said that slurry was dumped.

Bio-slurry is predominantly used as fertilizer (95%), 9% was in fish ponds and 5% was sold. 57% of the respondents used it in liquid form, 8% composted, 53% dried not composted (multiple choice). According to the respondents, bio-slurry used as a fertilizer resulted in the following changes in crop yield.

Table 8: Crop yields with bio-slurry as fertilizer

Type of crop	yield increased (%)	yield decreased (%)	no change (%)
paddy, rainfed	95	0	5
paddy, irrigated	90	0	10
other crops	100	0	0
Vegetables	100	0	0
Tree crops	100	0	0
Fish culture	100	0	0

As shown in the table above, a considerably high share of yield enhancement has been recorded wherever the slurry is applied. Since 92% of the respondents used bio-slurry in addition to chemical fertilizer, however, increases in yields might be due to this additional input. No differences were observed in fertilizing effect (increased yield) in correlation with the form the slurry is applied (liquid, composted, dried).

The data recorded on the use of chemical fertilizer in the context of the farming system (see 3.1.6) became more concrete in the context of this chapter. The respondents stated that with the application of slurry, use of chemical fertilizers decreased in about half of all cases with 6% discontinuing its use completely. These findings suggest that many of the farmers who had stated in the first data set that they had stopped using chemical fertilizer actually only decreased its use[5]. Moreover, 31% of the respondents stated that they were not decreasing and 9% said that they were increasing their use of chemical fertilizer. These findings suggest that the reduction of chemical fertilizer use was less significant than the first set of data showed. In fact, and while chemical fertilizer use decreased in absolute terms, the major impact of bio-slurry recorded was a change in the overall use pattern of fertilizers.

Overall (low standard deviation), respondents showed a low appreciation of chemical fertilizer with respect to costs, impact on soil and taste of food, and many regard it as dangerous for their health. This, however, is not reflected in decreases in use. In contrast, appreciation of bio-slurry showed a high standard deviation with respect to costs, yields and impact on soil, i.e. responses were highly polarized. Farmers attribute both bio-slurry and chemical fertilizer “optimum yields” but show little appreciation of the lower costs of bio-slurry. Overall, however, appreciation of bio-slurry is very positive on average.

Statistics

		Minimum work, maximum outcome.	Minimum cost, maximum outcome.	Optimal yield.	Uniform crop growth.	Soil is loose and easy to work with.	Food is tasty.
N	Valid	62	62	63	60	63	61
	Missing	15	15	14	17	14	16
Mean		2,89	4,10	2,73	3,30	4,78	4,33
Std. Deviation		1,505	1,376	1,417	1,225	,659	,944
Minimum		1	1	1	1	1	2
Maximum		5	5	5	5	5	5

Table 9: Appreciation of chemical fertilizer (1=”I agree”, 5=”I disagree”)..

[5] Further substantiation of this notion was provided by observations of the enumerators, who found empty fertilizer bags on many farms where the farmer had claimed that he discontinued the use of the chemical fertilizer completely.

Table 10: ...as compared to bio-slurry (1="I agree", 5="I disagree")[6]:

Statistics

		Minimum work, maximum outcome.	Minimum cost, maximum outcome.	Optimal yield.	Uniform crop growth.	Soil is loose and easy to work with.	Food is tasty.
N	Valid	62	77	76	61	77	63
	Missing	15	0	1	16	0	14
Mean		1,58	2,42	2,62	1,79	2,49	1,32
Std. Deviation		1,001	3,002	2,993	1,035	2,981	,668
Minimum		1	1	1	1	1	1
Maximum		5	9	9	5	9	3

Most farmers (43%) received information about bio-slurry only after construction of the biodigester, 32% said they received information at the beginning of construction and 21% said they were informed during workshops, presumably also after construction (only 4% said they received information beforehand, through promotions).

3.2.2.3 Outputs: Biogas

The installation of the biodigester changed the ranking of the importance of energy sources of the respondent households considerably. Asked what source of energy they would you miss most, respondents placed firewood first, electricity (battery) second and kerosene/petrol third before installation. After installation biogas was placed first by 75 households in absolute numbers. All households used biogas for cooking, 92% used it for lighting, and 17% for generating electricity for other use.

Table 11: Importance of energy sources before...

Statistics

		Electricity (Grid)	Electricity (Battery)	Charcoal	Firewood	Bottled gas	Kerosene/petrol	Dried cow dung
N	Valid	10	57	9	49	8	42	0
	Missing	67	20	68	28	69	35	77
Mean		1,90	1,51	2,56	1,41	3,12	2,31	
Std. Deviation		1,287	,601	,527	,610	1,356	,749	
Minimum		1	1	2	1	1	1	
Maximum		4	3	3	3	5	4	

Table 12: ...and after installation of the biodigester

Statistics

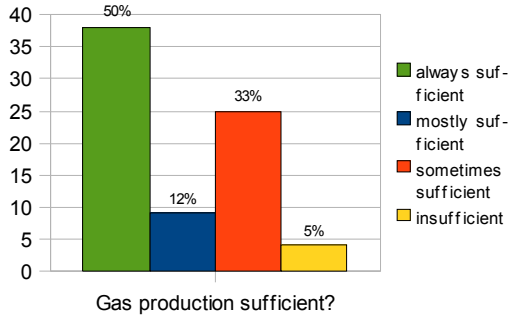
		Electricity (Grid)	Electricity (Battery)	Charcoal	Firewood	Bottled gas	Biogas	Kerosene/petrol	Dried cow dung
N	Valid	5	25	2	15	2	75	9	1
	Missing	72	52	75	62	75	2	68	76
Mean		1,00	2,12	3,00	2,53	3,50	1,13	2,11	4,00
Std. Deviation		,000	,440	1,414	,640	2,121	,414	1,054	
Minimum		1	1	2	2	2	1	1	4
Maximum		1	3	4	4	5	3	4	4

After installation 25 households still consider batteries as an important source of energy and ranked it second on average. Firewood is still considered important by 15 farmers, who ranked it third on average. Electricity (grid) was considered most important by 5 households, while kerosene/petrol is regarded as important source of energy by 12%; those households ranked it second

[6] Number "9" identifies "missing value".

most important on average.

Figure 11: Sufficiency of gas production



Responses as whether gas production was considered sufficient are shown in the diagram to the left. Half of the respondents named their gas production "always sufficient", with the other half reporting some restriction. For a share of 38% of all households, the production of biogas is only sometimes sufficient or even insufficient.

As the following table shows, however, the sufficiency of gas production is to a large degree dependent on the availability of additional dung from outside the farm. Correlation with the data on dung input indicates that if gas production is „always sufficient", dung was bought from outside the farm in 63% of the cases, and only 18% of those saying their gas production is only sometimes sufficient or even insufficient get dung from outside the farm.

Table 13: Availability of dung and sufficiency of gas production

%	Get dung from outside the farm	
	yes	no
Gas production „always sufficient"	63	18
Gas production „only sometimes sufficient" or „insuffiicent"	37	82

Operating a biodigester resulted in the installation of 125 biogas stoves. At the same time, the number of traditional cooking devices decreased from 149 to 52 and the number of conventional gas stoves from 13 to 3. However, 53% of all households still use traditional cooking devices.

The use of biogas had a significant impact on expenditure on cooking fuel, with the absolute amount of money spent on cooking fuel decreasing by some 92% (from 36366 Riel to 2626 Riel per month on average). Major factors were a sharp decrease of households buying firewood for cooking by almost 90% and of households buying kerosene/petrol, charcoal and bottled gas which decreased by some 75% on average. The average amount of money spent on firewood was reduced by two thirds, and expenditure on energy decreased overall. The tables below show the changes in expenditure (in Riels per month):

Table 14: Expenditure on cooking fuel before...

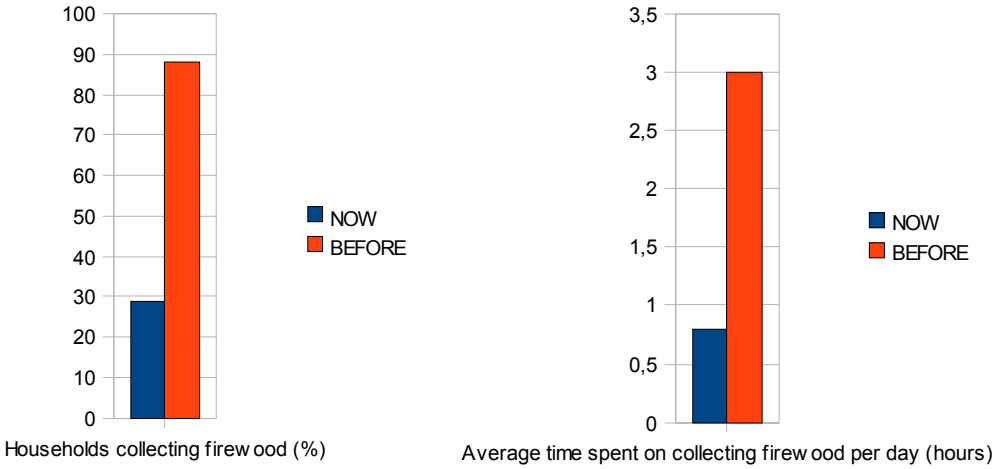
	Firewood	Kerosene/petrol	Charcoal	Bottled gas
Number	44	8	9	7
Mean	43234	16111	30911	63831
Std. Deviation	55692	12310	27556	91006

Table 15: …and after installation of the biodigester.

	Firewood	Kerosene/petrol	Charcoal	Bottled gas
Number	6	3	2	1
Mean	21220	8800	22000	4500
Std. Deviation	17210	720	15000	-

Likewise, time spent for collecting cooking fuel (firewood) decreased significantly, as did the number of households which collected firewood.

Figure 12+13: Households collecting firewood (%) and time spent on that activity per day (hours) now and before the installation of the biodigester



70 households had biogas stoves (Cambodian model), 7 had imported models. 65 of the Cambodian models were single burners, the remainder double burners. All the imported models were double burners. The following table shows use patterns of biogas stoves.

Statistics

		No of biogas stoves used in the morning	Average hours of cooking per stoves in the morning	No of biogas stoves used in the afternoon	Average hours of cooking per stoves in the afternoon	No of biogas stoves used in the evening	Average hours of cooking per stoves in the evening
N	Valid	73	73	75	75	73	73
	Missing	4	4	2	2	4	4
Mean		1,37	,6334	1,65	,7432	1,62	,8256
Std. Deviation		,486	,44467	,479	,40421	,490	,43596
Minimum		1	,05	1	,03	1	,11
Maximum		2	2,00	2	2,00	2	2,00
Sum		100	46,24	124	55,74	118	60,27

Table 16: Use of biogas stoves:

After installation of the biodigester, 92% of the households use biogas lamps, reducing the number of households using kerosene and battery powered lamps as well as candles. Lamps powered by the electric grid have not been replaced by biogas on a significant level, with 13% of the households using these lamps (4 lamps on average per household). Together with battery powered lamps, the use of electricity powered lamps didn't drop to a large extend (70% of households still use them). Overall, absolute numbers of lamps (excluding candles) increased from 236 to 300 (27%) over the period before installation of the biodigester and now, suggesting again that biogas lamps were used in addition to existing lamps.

Statistics

		Lamp 1	Lamp 2	Lamp 3	Lamp 4	Lamp 5	Total
N	Valid	71	59	36	11	3	71
	Missing	6	18	41	66	74	6
Mean		2,8169	2,2881	2,8100	3,1209	5,8333	6,8590
Std. Deviation		1,95893	1,36837	2,75789	3,18541	5,39290	6,06715
Minimum		,50	,50	,33	,33	2,00	,50
Maximum		12,00	8,00	12,00	12,00	12,00	41,00
Sum		200,00	135,00	101,16	34,33	17,50	486,99

Table 17: Average use (hours/day) of biogas lamps

Expenditure on lighting fuel declined by roughly 31% (from 15618 Riel to 10766 Riel per month on average) in absolute terms. In relative terms, only the average amount spent for electricity (grid) went down, while expenditure on electricity (battery) went up by 24%. The tables below show the changes in expenditure on light sources (in Riels per month):

Table 18: Expenditure on lighting fuel before…

	Kerosene	Electricity (Grid)	Electricity (Battery)	Candles
Number	44	12	62	12
Mean	7259	26416	8577	2875
St. Deviation	13142	23861	7649	3191

Table 19: …and after installation of the biodigester

	Kerosene	Electricity (Grid)	Electricity (Battery)	Candles
Number	18	10	42	6
Mean	8905	17100	11338	3583
St. Deviation	13471	12196	24238	3513

3.2.3 Major findings

Overall, the survey recorded a high degree of satisfaction on the part of the respondent households. The amount of biogas produced was received “as expected” and “more than expected” by almost all of the respondents and almost all “fed” the biodigester at least once a day.

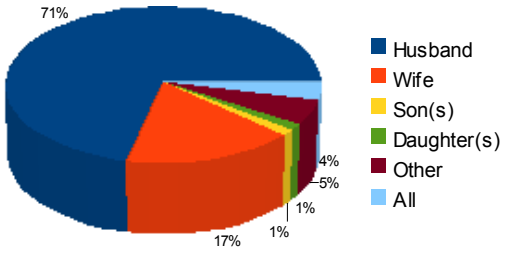
A major finding is that the biodigester had no major impact on the use of chemical fertilizer. While the data suggest a slight overall decrease of chemical fertilizer use, this implies changes in use patterns of fertilizer overall, with bio-slurry replacing the direct application of dung. This is in spite of the fact that, overall, respondents showed a low appreciation of chemical fertilizer with respect to costs, impact on soil and taste of food, and many regard it as dangerous for their health: although appreciation of bio-slurry is very positive on average, respondents attribute both bio-slurry and chemical fertilizer “optimum yields” but show little appreciation of the lower costs of bio-slurry.

3.3 Motivation and decision making

3.3.1 Decision making

The multiple choice question “who was involved in the decision that the plant was built?” showed comprehensive participation of the family in the decision making process, with the husband involved in 99%, the wife in 95%, son(s) in 58%, daughter(s) in 53% and grandparents in 4% of the cases. Dominant in making the decision was the husband, however (72%), followed by the wife (17%). Only in one case the husband voted against the installation, in one other the wife.

Figure 14: Final decision on building the plant



The decision on the size of the plant (multiple choice) was based on family size (66%), on number of livestock (46%), on the amount of dung available (38%), on land available (18%), on the amount of money available (18%), on the proposal by programme staff/mason (12%), on the plant sizes in the neighbourhood (7%) and on the amount of gas produced 7%.

3.3.2 Motivation

Slightly more than half of the respondents (53%) had knowledge about biodigesters before knowing about the National Biodigester program. 91% of the respondents considered this information correct, 8% “some correct, some not”. Further, more detailed information was provided by the PBPO (76%), neighbours/friends (19%), masons/constructors (48%) and local authorities (24%). This information was considered correct by 85%, “some correct, some not” by 5%, and the remainder responded with “I don’t know (2 households) or did not respond (6 households). 65% considered the contract conditions “very clear”, and 19% “somewhat clear”.

The following table shows the motivation for the decision to build a biodigester as given by the respondents:

Table 20: Main reasons for the installation of the biodigester

Statistics

		Less work to collect firewood (etc.) for cooking	Less costs for cooking (charcoal, firewood, kerosene, gas etc.)	Less costs for lighting (kerosene, gas, battery, candels etc.)	Easier to cook	Less smoke in the kitchen	Less costs for fertilizer due to slurry use	Increased yield due to slurry use	Enjoy more and better lighting	Pride of using new, advanced technology	Less pressure on natural resources	Get subsidy
N	Valid	59	43	25	66	37	19	11	14	3	25	2
	Missing	18	34	52	11	40	58	66	63	74	52	75
Mean		2,12	1,74	2,56	2,14	2,97	3,21	4,00	3,14	3,67	3,96	4,00
Std. Deviation		1,161	1,026	,870	1,065	,957	1,134	,632	1,167	,577	1,274	,000
Minimum		1	1	1	1	1	1	3	2	3	1	4
Maximum		5	5	4	4	5	6	5	6	4	7	4

Easier, cheaper and less work for cooking are the principal reasons for the plant's installation. 56% of the respondents name „less costs for cooking“, 77% „less work to collect firewood (etc.) for cooking”, and 86% „easier cooking“ as a major reason and rank these statements in this order. Regarding biogas lamps, “less costs“ was given some priority by roughly one third of the respondents. The quality of lighting was only given minor importance with 18% of the households stating it as a reason. After more convenient cooking and costs for lighting, “less smoke in the kitchen“ was ranked next by 48% of the households.

In contrast to the high level of appreciation recorded above, bio-slurry is given only limited importance as a reason to construct a biodigester. 25% name “less fertilizer costs due to slurry use“, and 14% “increased yield due to slurry use” as a reason but do not attach too much importance (priority) to it. “Saving time“ in general and “obtain feed for fishes“ (as additional answers not shown in the table) is stated by a few, with medium priority.

One third of the respondents stated “less pressure on natural resources“ as a major factor, but also gave it low priority. Correlated with data from 3.1, however, we can detect that concern for the environment is not reflected in coherent behavioural change. While the share of respondents cutting trees for firewood dropped by 81% after the plant's installation for the whole sample, only a 69% reduction for the group stating less pressure on natural resources as a major reason for installation has been recorded. Also, no changes with the share of those collecting firewood have been observed within this group, as with the whole sample.

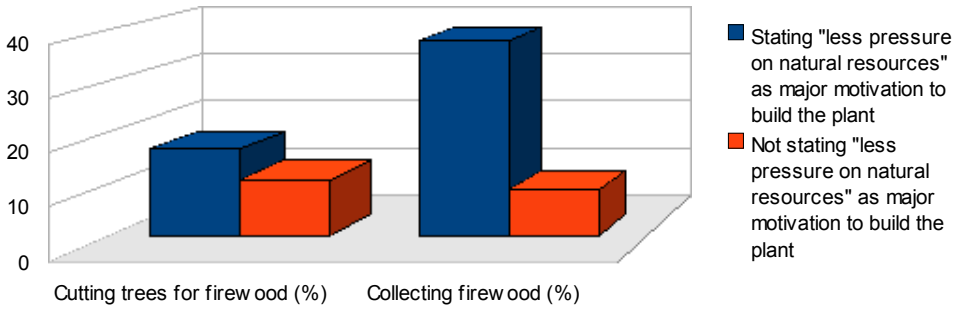


Figure 15: Environmental concern (talk vs action)

In summary, the convenience of cooking with biogas (including “less smoke”) was given as the main motivation for installing the biodigester. Light from biogas lamps and particularly the availability of bio-slurry can be beyond doubt conceived of as minor incentives of building a biodigester. As for all these motivational factors, the cost reduction potential is, if stated, given higher priority than other output capabilities.

75% of the respondents were aware of the possibility to receive a subsidy, 9% learned about the subsidy when negotiating the contract and 16% after signing the contract. All except two respondents stated that they received USD 100 as subsidy; of the other two one said USD 200 and the other USD 240[7]. Some 30% said they had problems obtaining the subsidy, compared to 67% who had no problem. Time to receive the subsidy varied from one to 30 days (average 6.4 days).

The question “do you agree with the following? (1: agree; 5: disagree) was answered as shown in the following table.

[7] The survey did not cover the origin of additional subsidies.

Table 21: Factors of deciding on a biodigester

Statistics

		I built the biodigester, because promotion of authorities was convincing.	If foreign experts advise to build biodigesters, one should do so.	If they haven't had paid subsidies, I wouldn't have built the plant.	Thanks to introduction by mason/constructor, I decided to build the plant.	Irrespective of promotion, I wanted to build a biodigester anyway.	I was curious of using a new, advanced technology.	I needed biogas, so I decided to build the plant.
N	Valid	77	76	76	76	76	76	75
	Missing	0	1	1	1	1	1	2
Mean		2,99	3,41	2,54	2,16	2,83	1,87	1,33
Std. Deviation		1,705	1,525	1,747	1,265	1,784	1,193	,794
Minimum		1	1	1	1	1	1	1
Maximum		5	5	5	5	5	5	5

The respondents gave the need for biogas as the most decisive factor, reflecting the very high level of consent on the objective advantages of a biodigester recorded. The attraction of using a new, advanced technology was also given as an important factor by most respondents (75% agree or strongly agree (see table 18). We know, however, that this curiosity has not been a principal reason for actually building the plant. We should therefore be cautious interpreting this data, particularly when we recognise, that only 26% would have built the plant if they haven't received a subsidy. About half of the respondents strongly agree that they wouldn't. As shown with these measures of attitude towards motivational aspects in the decision making and supported by additional obervations in the questionnaire, e.g. the enumerators' observations, the data does not suggest a major influence of processes of peer grouping, normative pressure, mimetic incentives and/or social coercion facilitated through authorities, foreign experts and additional promotional activities.

Table 22+23: "New, advanced technology" and "Subsidy" as motivating factors

I was curious of using a new, advanced technology.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	42	54,5	55,3	55,3
	2	15	19,5	19,7	75,0
	3	10	13,0	13,2	88,2
	4	5	6,5	6,6	94,7
	5	4	5,2	5,3	100,0
	Total	76	98,7	100,0	
Missing	no response	1	1,3		
Total		77	100,0		

If they haven't had paid subsidies, I wouldn't have built the plant.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	37	48,1	48,7	48,7
	2	9	11,7	11,8	60,5
	3	2	2,6	2,6	63,2
	4	8	10,4	10,5	73,7
	5	20	26,0	26,3	100,0
	Total	76	98,7	100,0	
Missing	no response	1	1,3		
Total		77	100,0		

The constructor's introduction had more weight in the decision making process than the promotion of local authorities. Overall, a correlation analysis suggests that about half ascribe their decision on building the plant to successful promotion; the other half says to have built the plant irrespective of its promotion.

Further information on motivation to build the biodigester regarded influence of neighbours or relatives, which resulted in 53% of the respondents agreeing that such a recommendation would have been relevant and 42% stating the opposite. Asked whether they would have built the plant if they had had cheap electricity, 86% agreed and 11% disagreed. Answers were similar with respect to chemical fertilizer and charcoal/firewood: 93% would you have built the biodigester if chemical fertilizer had been cheaper, 5% would have not, and 95% would have done so if charcoal and firewood had been easy and cheap to get, 5% would have not. These indicators are correlated: Whoever agreed that he/she had built the plant even "if electricity had been easy and cheap to get" also agreed that he/she would have build even "if chemical fertilizer had been easy and cheap to get"

and “if firewood and charcoal had been easy and cheap to get”. Overall, the high levels of agreement with these statements indicate that the motivation to build the plant was not built on the expectation to substitute neither chemical fertilizer nor existing energy sources.

Only 5% said they regretted to have built the plant, 95% did not. Asked why not, respondents gave the following answers: (The only reason recorded for regretting was “It's too small, I want a bigger one“, however.)

Table 24: Reasons for not regretting having built a biodigester

Reason	Level of agreement (%)
Easier to cook	96
Less work to collect firewood (etc.) for cooking	80
Less smoke in the kitchen	76
Less costs for cooking (charcoal, firewood, kerosene, gas etc.)	63
Less costs for fertilizer due to slurry use	60
Less pressure on natural resources	59
Less costs for lighting (kerosene, gas, battery, candles etc.)	53
Enjoy more and better lighting	47
Increased yield due to slurry use	35
Get subsidy	33
Pride of using new, advanced technology	28

The table shows that in retrospective, the benefits of the biodigesters are seen to a major extent in making cooking convenient, as a combination of easier work, saving labour for firewood collection and “less smoke”, with reduction in costs considered of secondary importance. The appreciation of biogas fueled lighting, if still on a fair level in absolute terms, rises once applied. There is, moreover, a significant rise in the level of of bio-slurry's appreciation, particularly regarding its cost reduction potential: 25% named „less fertilizer costs due to slurry use“ as a major reason why the plant has been built; 60% state it as a reason why they would build the plant again today. Its fertilizing value, supporting our interpretation above (see 3.2.2), cannot be regarded as a major factor of neither prospective motivation nor retrospective approval, however.

3.2.3 Major findings

A major finding of this chapter is that “convenience of cooking with biogas” including factors like “less work to collect firewood” and “less smoke” was the most important motive to build the biodigester. In retrospective (reason for appreciation of benefits and general level of content), the convenience of cooking provided by biogas stoves is appreciated considerably more than economic benefits (saving energy costs). In both prospective and retrospective, lighting by biogas and benefits arising from the availability of bio-slurry were ranked less important.

Another finding is that biodigesters were built because of primary motivation: farmers describe their decision to build the plant as demand driven, on the basis of the plants objective advantages. This finding is not contradicted but somehow put in relation by the fact that only 26% would have built the plant if they haven't had received a subsidy, while about half of the respondents strongly agreed that they wouldn't.

Surprisingly, data show relatively low levels of appreciation of economic benefits, e.g. reducing expenditures on energy and fertilizer, which is supported by the finding that most respondents decided to build the biodigester regardless of their previous expenditure on energy and fertilizer.

3.4 Lessons learned as conceived by the respondents

3.4.1 Subjective conclusions of the farmers

All of the respondents (100%) said that, overall, the performance of the plant matches their expectations, 84% of them considered the information provided by the National Biodigester Programme correct, and 47% agreed that the information of the National Biodigester Programme was sufficient. None considered the information "too optimistic about benefits" or thought that "costs turned out higher than expected. Also, 90% were satisfied with the Program's brochures (5% said that information was missing, another 5% never received one).

The skills of the mason/constructor were judged satisfactory by 74% of the respondents, "more or less satisfactory" by 24,7% and not satisfactory by only 1% (one household). Overall, all but one household were satisfied with the subsidy. The following table provides details of reception of and reflections upon subsidies by the respondents (1: agree, 5: disagree).

Table 25: Respondents' assessment of subsidy

Statistics

		The subsidy was paid quickly.	I had to do a lot of annoying paperwork.	Overall, the amount of subsidy is accurate.	If higher subsidies were paid, more farmers would build biodigesters.	If subsidies were easier available, more farmers would build biodigesters.
N	Valid	77	77	76	77	77
	Missing	0	0	1	0	0
Mean		1,29	2,65	1,09	1,35	1,32
Std. Deviation		,916	1,596	,495	,757	,751
Minimum		1	1	1	1	1
Maximum		5	5	5	5	5

The table contrasts with (but not contradicts) the uniform appreciation of the subsidy recorded before, which resulted from a yes or no question. Using a scaled multiple choice approach as above, the picture becomes more diverse and less consistent. While the table still shows very high levels of agreement on the amount of subsidy being sufficient and that it is paid quickly, the same respondents strongly agree that more plants would be built if subsidies were easier available and higher subsidies were paid. We may interpret it this way: For them (the respondents) – whether for reasons of individual conviction of the plants factual advantages or rather of social desirability or a combination of both – the amount and the accessibility of the subsidy was accurate. For others (e.g. future biogas users) – maybe less convinced of the technique's advantages – a higher amount and easier accessibility of subsidy is conceived of (by the respondents) as a major incentive to build a biodigester.

The respondents' majority more or less agreed that a lot of annoying paperwork was necessary to receive the subsidy. There is a high level of standard deviation of responses, however, which reflects high concentration at the extreme values (34% strongly agree, 23% strongly disagree).

With respect to formal credit, again 100% (only 8 households out of 77 took up credit, see above[8]) say that they are overall satisfied with it. They uniformly agreed that it was paid quickly, interest rate were fair and repayment time realistic. 75% (6 households) thought that there was a lot of annoying paperwork, however.

91% of all households were satisfied with the plant size, only 6 households (9%) responded that the plant was too small. When correlated with the results of the question how the plant size was

[8] The lending facility, i.e. the PRASAC biodigester credit program became operational only in November 2007. Plants built after this date were excluded from the survey, thus commercial credit was used.

decided (see above), 100% satisfaction (highest) were recorded when the decision was based on the proposal of programme staff/mason, 93% satisfaction when decision based on number of livestock, and 86% satisfaction (lowest) when decision based on family size (average rate of satisfaction: 91%). The majority based the decision primarily on family size, however.
Practically all of the respondents were satisfied with cooking with biogas. Reasons were given as follows:

Table 26: Reasons of satisfaction with cooking on biogas (ranked)

Statistics

		Less smoke in the kitchen/house	Cooking is faster	Meals are tastier	Easy to clean pots	Stove does not need constant attention	Cheaper than previous method
N	Valid	63	66	28	60	32	36
	Missing	14	11	49	17	45	41
Mean		2,92	1,53	3,14	2,90	4,38	3,42
Std. Deviation		1,235	,881	1,380	,838	1,408	1,811
Minimum		1	1	1	1	2	1
Maximum		6	5	6	5	6	6

The table shows that by far the most important reason why people are satisfied with cooking on biogas is that it saves time, which 99% of the respondents stated with65% ranking it first (Percentages due to 10 missing values). Ranked next by more than 90% of the respondents, but with a large gap in terms of importance, are both “less smoke“ and “pots easy to clean“. Smoke reduction, however, is more polarizing: at least 10% rank it first. 42% agreed with the option that meals are tastier when cooked on biogas and 54% name “cheaper than previous method“ as a reason, but giving it low priority on average (for 12% respondents, however, it is the most important reason for satisfaction). 4 respondents stated, as primary reason for satisfaction, “saving time because no need to collect firewood“. There is only one respondent not satisfied with cooking on biogas because of insufficient gas supply.

Again, virtually all of the respondents are satisfied with biogas lamps. Reasons are given in the following table.

Table 27: Reasons for satisfaction with biogas lamps (ranked)

Statistics

		Bright light	Easy to use	Cheaper than previous method	Can have light longer in the evening
N	Valid	60	56	33	31
	Missing	17	21	44	46
Mean		1,72	1,48	2,21	3,35
Std. Deviation		,846	,603	,893	,661
Minimum		1	1	1	1
Maximum		4	3	4	4

81% and 87% of the respondents respectively give “easy to use“ and “bright light“ as main reason for being satisfied with biogas lamps and ranked reasons in this order. About half of the respondents say it's “cheaper than previous method“ and rank it next. 45% value to “have light longer in the evening“ but don't regard it as of major importance. Standard deviations were low with all options, indicating overall uniform appreciation. However, the finding that lighting on biogas plays only a minor role in the decision making while improving its appreciation, if still on a fair level, once applied, remains unaffected. Only if asked directly, relatively high levels of appreciation of biogas lamps have been recorded.

Asked what expectations they had regarding performance of the biodigester respondents answered as follows (multiple choice):

Table 28: Expectations regarding future performance of the biodigester

Expectation	Agreement (%)
Easy to operate	92
Long life span	87
Reliable and sufficient gas production	69
Low costs	55
Labour requirements low	51
Low maintenance required	48
Easily available spare parts	44
Continuing assistance by National Biodigester Programme	29

Easy to operate and a long live span were ranked a distant first and second, followed by low operating costs and other aspects of operating the biodigester. Somehow surprisingly, continuing assistance by National Biodigester Programme was ranked last. This could indicate, however, that respondents feel that they can operate independently, or that locally available assistance (mason) is sufficient.

96% of the respondents were, overall, satisfied with the assistance and service received. To get a more in depth picture, respondents were given different option (1: agree, 5: disagree). Results are shown in the following table.

Table 29: Assistance and service: Do you agree with the following?

Statistics

		There should be more regular visits.	Assistance is available quickly.	I'm satisfied with the quality of assistance.	Everyone should have a quality assurance like I do.
N	Valid	77	77	77	75
	Missing	0	0	0	2
Mean		1,26	1,34	1,55	1,47
Std. Deviation		,637	,852	,953	,794
Minimum		1	1	1	1
Maximum		5	5	5	5

The answers reflected the high level of satisfaction with assistance and service recorded above but provided more detail. The uniform patterns of approval, however, suggest a low level of attention to the question. The high level of agreement with “there should be more regular visits“ should be balanced against this background.

Asked whether respondents would recommend construction of a biodigester to others answers were as follows:

Table 30: Readiness to recommend biodigesters to others

Will you recommend plant construction to others? (choose one)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	74	96,1	96,1	96,1
	Yes, if assistance and service is improved	2	2,6	2,6	98,7
	No.	1	1,3	1,3	100,0
	Total	77	100,0	100,0	

Results confirm the high level of consent regarding the objective advantages of operating a biodigester. In order to understand why respondents would recommend biodigesters, they were given options to agree or disagree (1: agree, 5: disagree):

Table 31: Attitudes regarding biodigester performance

Statistics

		If more people knew about the Biodigester Programme, more plants would be built?	More animals to provide dung for biodigesters will improve farm incomes.	More farms having a biodigester will slow down deforestation.	Saving work time will allow my children to spend more time in school?	Operating the biodigester would be easier for me, if more people in the village had one.
N	Valid	77	77	77	77	77
	Missing	0	0	0	0	0
Mean		1,35	1,23	1,06	1,05	1,26
Std. Deviation		,644	,510	,248	,223	,571
Minimum		1	1	1	1	1
Maximum		3	3	2	2	3

“More time to study“ and “less deforestation“ are strongly agreed upon, as well as the effects of animal dung production on farm incomes. The latter, the same as “less deforestation“ is neither reflected in the actual numbers of animals grown (see the changes in pigs raised above) nor in less numbers of trees cut as recorded before. On the other hand, there is reason to expect synergetic effects when density of biodigester installations increases. Also, considering the appreciation of promotion efforts shown above, and the strong agreement of the respondents “more plants would be build if more people know about the Biodigester Programme“, to increase and improve these efforts appears appropriate.

However, the last sets of responses could be biased considering that the attention span of respondents may have been exhausted at the end of interviews but also because of the cultural tendency towards complacency in Cambodia, e.g. demonstrated by the lack of disagreement on any of the options given.

3.4.2 Major findings

A major finding of this chapter reflecting the overall appreciation of the performance of the biodigester was that most respondents would recommend biodigesters to friends and neighbours. Reasons given included “more time to study“ and “less deforestation“, as well as the effects of animal dung production on farm incomes. The latter, the same as “less deforestation“ is however neither reflected in the actual numbers of animals grown (changes in number of pigs raised, see above) nor in less numbers of trees cut as recorded before. As with patterns of fertilizer use, there was a marked divergence of talk and action, i.e. the attitudes towards certain topics and related actions.

Findings also suggest that there is reason to expect synergistic effects when density of biodigester installations increases. Considering the appreciation of promotion efforts by the NBP found, as well as the strong agreement of the respondents “more plants would be built if more people know about the Biodigester Programme“, to increase and improve these efforts appears appropriate, possibly increasing focus on bio-slurry and economic benefits.

3.5. Summary and interpretation of major findings

The survey found the average farm size above the national average The socio-economic self assessment of 67 households (87%) of “can make a living” as compared to three households each which regarded themselves as “poor” and “better off” may be biased by the fact that the enumerators were associated with a technical assistance program. The general observations reported by the enumerators would support the hypothesis that most of the respondent households pertain, in their rural context, to the “better off”. This hypothesis is supported by finding in other parts of the survey, e.g. density of livestock and the high percentage which used own savings.

The survey recorded a high degree of satisfaction on the part of the respondent households. 99% of the biodigesters were in operation, 83% of the respondents judged “construction to be sound“; 89% stated that “inputs are available“, 79% that “results are convincing“ and 66% that “training was good“. The performance of the plant was in line with the expectations of all of the respondents. No respondents considered the information received during promotion “too optimistic about benefits” or thought that “costs turned out higher than expected. Also, 90% were satisfied with the Programme’s brochures.

There was a high degree of participation of family members in the process of deciding on building a biodigester. However, in the final decision the male household was dominant, with the wife following at a distance, notwithstanding that convenience of cooking with biogas was found the most important determinant in making the decision (as motive to build the biodigester).

Almost 85% of the households financed the biodigester fully with “own savings”, 7% fully by loan and about 9% had used a mix of savings and loans. Of the respondents which had taken a loan, 75% had paid the loan already or repaid the remaining debt regularly, only 17% had some payments overdue and one household had defaulted on the loan. All households received subsidies, and subsidies were appreciated by all. The uniform appreciation of the subsidy recorded before became more specific in retrospective: while responses showed very high levels of agreement on the amount of subsidy being sufficient and that it is paid quickly, the same respondents strongly agree that more plants would be built if subsidies were higher and easier available.

The amount of biogas produced was perceived “as expected” and “more than expected” by some 90% of the respondents. All respondents who bought dung from outside the farm used slurry as a fertilizer, and nobody that sold slurry bought additional dung from outside the farm. Correlation of sufficiency of biogas produced with the data on dung input shows that if gas production is „always sufficient“, dung was bought from outside the farm in 63% of the cases, while only 18% of those saying their gas production is only sometimes sufficient or even insufficient obtained external dung. This finding confirms that the sufficiency of biogas production is a function of availability of dung from outside the farm.

Biogas availability has changed the observed pattern of energy consumption of all but a few respondent households, with noticable impact on overall household expenditure: the share of 47% of the household naming energy as a major cost factor before dropped to 34% now. In relative terms, the amount of money spent on cooking fuel decreased by an astonishing 90%, and expenditure on energy for light by roughly 30% with the biodigester.

Use of biogas fuelled stoves have reduced both the number of traditional cooking devices and the average amount of money spent on firewood by roughly two thirds. Before having a biodigester, firewood, bottled gas, charcoal, electricity (battery) were ranked in this order on average, and 98% of the households used firewood, 22% charcoal, 12% bottled gas, and 8% batteries. In comparison, with the biodigester ranking of importance of energy sources put biogas first, firewood second, and charcoal third, and practically all households used biogas. However, more than half of the households still use firewood and/or charcoal for cooking.

More than 90% of the households used biogas lamps, reducing the number of households using kerosene powered lamps as well as candles to a considerable extend. Electric lamps could not be substituted by biogas lamps on a significant level, however, with the use of batteries decreasing only slightly from 77% to 68% and the use of electricity (grid) remaining constant. An additional finding, i.e. that the absolute number of light sources excluding candles increased from 236 to 300 (27%) suggests that households apply biogas lamps to some extend in addition to light sources used before the installation of the biodigester. Nonetheless, biogas lamps provided the opportunity to read after dark for 39 households for the first time.

The number of farmers saying to use chemical fertilizer decreased form 73% before to 53% now and bio-slurry replaced chemical fertilizer as most important fertilizer in the ranking. However, this does not imply that chemical fertilizer was used less in absolute quantities or even that its use was substituted by bio-slurry use. Rather, as use of dung as fertilizer dropped considerably both in absolute numbers and in the ranking after the installation of the biodigester, indications are that bio-slurry replaced dung, not chemical fertilizer.

A second set of data on bio-slurry recorded in chapter 3.2 concretises these findings. Questioned about their operation of the biodigester (in abstraction from the farming system), respondents stated that with the application of slurry, use of chemical fertilizers decreased to some extend in 52% of all cases, while only 6% brought it to a complete stop. These findings show that a fair share of those stating above that they had stopped using chemical fertilizers, did actually only decrease its amount. This notion is in accordance with the enumerators' observations. Overall, a share of 40% not decreasing (31%) or even increasing (9%) their use of chemical fertilizer does not support any major impact of the bio-slurry in terms of chemical fertilizer reduction. These findings, in fact, while suggesting a slight overall decrease of chemical fertilizer use, rather imply changes in use patterns of fertilizer overall.

The continuing use of chemical fertilizer is not reflecting its overall low appreciation with respect to costs, impact on soil and taste of food (many regard it as dangerous for their health). In contrast, appreciation of bio-slurry showed a high standard deviation with respect to costs, yields and impact on soil, i.e. responses were highly polarized. Farmers attribute both bio-slurry and chemical fertilizer "optimum yields" but show little appreciation of the lower costs of bio-slurry. This is in spite of the considerable yield enhancements respondents claimed wherever bio-slurry was applied. Increases in yields due to bio-slurry used in addition to chemical fertilizer would decrease overall costs of fertilizer, but this dimension was apparently overlooked by the respondents. In line with this observation, findings in 3.3 suggest that bio-slurry was not a major incentive influencing the decision to build a biodigester.

Changes in time allocation after installation of the biodigester concern less time spent for "collecting things outside the farm", i.e. mainly firewood, and some more time spent "caring for animals". With the biodigester, the number of households collecting firewood dropped from 68 to 22, reducing overall time spent for this activity from 3 hours/day on average to about 45 min/day now. Most important with respect to time saving as conceived of by the respondents: time spent each day on cooking decreased by almost 20%. This, and the fact that biogas lamps provide the opportunity to read after dark for 39 households for the first time can be considered significant for the living conditions of respondent households.

Other than the above, the survey did not record any significant changes of farming systems due to installation of the biodigester. The cropping pattern remained unchanged, with rice production (80% of the cultivated area) the main component. There was no significant change in livestock kept, except that the average number of pigs decreased considerably though the number of households raising pigs remained constant. Reasons are most probably not related to the inclusion of the biodigester in the farming system but could reflect changes in terms of trade and/or decisions by households to sell pigs for immediate gain alternative to keeping them in order to increase biogas output (the price of pork increased considerably in 2007/08). Remarkable was the high percentage of animals being stabled (which could, however, be inflated if respondents included animals which are free roaming during daytime but kept penned up during the night as "stabled") and that nobody planted fodder crops.

There were some changes in the sanitary situation: households having water toilets in the house increased from 65% before to 74% now, households having no toilet decreased from 24% before to 18% now.

Convenience of and time saved by cooking with biogas (including “less work to collect firewood” and “less smoke”) was found the determining factor for building the biodigester (motivation) and the most important reason for the general content recorded. Convenience was more important for appreciation of benefits and general level of content than economic benefits, e.g. saving energy costs, both in prospective and in retrospective; and perceived relevance of cost reduction diminishes even further in retrospective.

Lighting with biogas is valued at a lower level but appreciation tends to increase in retroperspective, i.e. after concrete experience with biogas lamps. Similarly, bio-slurry was appreciated more after concrete experience: 25% named “less fertilizer costs due to slurry use“ as a reason for building the biodigester, 60% state it as a reason why they would build it again today.

Generally speaking, the respondents described their decision to build the plant primarily as demand driven: We recorded a very high level of consent with the story of individuals being convinced about the plants objective advantages and therefore deciding to build it. Meanwhile, the data does not suggest a major influence of processes of peer grouping, normative pressure, mimetic incentives and/or social coercion, indeed. Limiting the conviction argument is the fact, however, that only 26% would have built the plant if they haven't received a subsidy. About half of the respondents strongly agree that they wouldn't.

Overall, the contribution of the biodigester is valued, both in prospective and retrospective, less for economic benefits; e.g. reducing expenditures on energy and fertilizer, than for added convenience and, with respect to bio-slurry, availability of more farming inputs. This conclusive interpretation is supported by the finding that most respondents decided to build the biodigester regardless of their expenditure on energy and fertilizer but still surprising considering the considerably reduced cost for energy recorded above.

Most respondents would recommend biodigesters to friends and neighbours. Reasons given included “more time to study“ and “less deforestation“, as well as the effects of animal dung production on farm incomes. The latter, the same as “less deforestation“ is however neither reflected in the actual numbers of animals grown (changes in number of pigs raised) nor in less numbers of trees cut as recorded before.

Overall, combining these findings with other relevant variables, it can be concluded, that the objective performance of the biodigesters with respect to provision of energy and bio-slurry resulted in a high level of content with most of the respondents.