Cambodia HARVEST Aquaculture Program Evaluation

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1. Introduction

Cambodia's fisheries play an important role in supporting household food security throughout the country. Cambodians have the highest rate of freshwater fish consumption in the world (Baran et. al, 2013), and the country holds the world record for freshwater fish capture per inhabitant (King, 2003). Cambodia's fisheries provide employment for more than six million people, and fish make up 81.5% of animal protein consumed by Cambodians and providing essential vitamins and micro-nutrients (Kingdom of Cambodia, 2010). Cambodians are among the highest consumers of freshwater fish in the world, with annual per capita fish consumption estimated at 52.4 kg (Hortle, 2007).However, concern is growing that declining natural fish catches will have immediate consequences for rural food security and aquatic ecosystems in Cambodia.

Aquaculture in Cambodia is practiced in both freshwater and marine environments, and occurs at multiple scales, from small-scale, subsistence production to large-scale, commercial production (FAO, 2015). Aquaculture production has a long history in Cambodia but has typically contributed a relatively small share of overall fish production, due to the historical abundance of wild fish. In recent years, capture fisheries have declined, and aquaculture has been identified as playing an important role in rural food security and income generation. Fish resources are threatened by illegal fishing, which has resulted in a decrease in wild populations of fish and the declining availability of an essential source of protein for the Cambodian people. Aquaculture development has the potential to contribute to conservation of fish resources and habitat and to the enhancement of rural food security in Cambodia.

Aquaculture production is still relatively low compared to capture fisheries, and the aquaculture practices are predominately small-scale. However, production from aquaculture has been increasing rapidly, and the potential for future growth is significant (Khim, 2010). According to official government statistics, aquaculture production in Cambodia has increased from approximately 26,000 metric tons in 2005 to 120,055 metric tons in 2014 (Fisheries Administration, 2014). Most of the growth is in freshwater aquaculture, as coastal aquaculture production has increased only gradually (Khim, 2010).

The Strategic Planning Framework for Fisheries (2010–2019), developed by the National Fisheries Administration, aims to expand aquaculture production by approximately 15% per year to more than185,000 metric tons by 2019 to maintain the annual per capita consumption levels for a growing population and stabilize wild fish capture production (Kingdom of Cambodia, 2010). To meet this growing demand, a significant increase in total aquaculture production is needed.

It is in this setting that USAID developed the Helping Address Rural Vulnerabilities and Ecosystem STability (HARVEST) program, implemented by Fintrac. The HARVEST program was part of the USAID Feed the Future initiative to combat global hunger and increase food security through country-driven approaches. The HARVEST program used a variety of interventions in Cambodia to address this goal; one of the interventions involved the promotion of small-scale aquaculture through semi-intensive pond management (Fintrac, 2015). The program provided assistance in multiple phases for smallholder aquaculture farmers in four provinces in Cambodia (Pursat, Battambang, Siem Reap and Kompong Thom). The first stage consisted of assistance in providing start-up materials, input assistance, and extension services related to small-pond aquaculture. Subsequent assistance was provided in the form of extension services and gradually decreasing input assistance until finally farmers no longer received input support and continued to receive only extension services. The aim of the interventions was to support a transition to small-pond aquaculture that is sustainable, but it is not clear whether farmers will adopt the practices and continue to engage in aquaculture after the input subsidies were terminated.

There has been a rapid increase in the number of extensive homestead ponds used for aquaculture in Cambodia, but the contribution of ponds to overall aquaculture production appears limited because of low productivity. Extensive household pond culture is the most common fish culture approach promoted by donor projects aiming at improving food security and livelihoods. Pond sizes vary between about 80 and 300 square meters, and depths are usually maintained at two meters. Ponds usually have no permanent access to water and are mostly rain-fed, with fish being stocked during the rainy season (May to October). Depending on the species, pond aquaculture farmers can obtain two to four harvests per year, with the final harvest of the year often dictated by a shortage of water in March or April.

The ponds are densely stocked mostly with fingerlings that are produced in fish hatcheries and are commonly fed a commercially produced feed product or homemade feed made of ground grains or other on-farm products (e.g., rice bran, duckweed). Climbing perch, silver carp and walking catfish are native species that are well adapted for the growing conditions in central Cambodia. These fish are also best suited for local markets because the regional households are familiar with these fish as a food source. They also grow rapidly, and some even fetch a premium price at market.

The objective of this study is to examine farmers' perceptions of aquaculture and perspectives on household food security, as part of the evaluation of the HARVEST Aquaculture and Fisheries program component. The study draws from focus group discussions and a rural household survey to examine the farmers' perceptions of aquaculture, identify the constraints and barriers to adoption faced by farmers, and develop conclusions about the viability of small-scale aquaculture to contribute to rural household food security.

2. Project Background

Cambodia HARVEST is a program on integrated food security and climate change. The program seeks to reduce poverty and malnutrition by diversifying and increasing food production and income for up to 70,000 rural Cambodian households. Cambodia HARVEST works to develop sound, agriculture-focused solutions to poor productivity, postharvest losses, malnutrition, lack of market access, environmental degradation and the effects of climate change on vulnerable rural populations (Fintrac, 2015). Implemented by Fintrac Inc. and with funding support by USAID, this five-year program will come to an end in the middle of 2016.

With the goals of improving food security, strengthening natural resources management and resilience to climate change, and increasing the capacity of public and private sectors and civil society to support agricultural competitiveness, the Cambodia HARVEST program worked in five major areas:

- Agribusiness value chains.
- Aquaculture and fisheries.
- Natural resources management, biodiversity and climate change.
- Social inclusion, business development services and capacity development.
- Policy and enabling environment.

To achieve its goals, Cambodia activities were guided by the following five objectives:

- Increase incomes for 70,000 rural households.
- Accrue economic benefits for 140,000 people.
- Develop income-generating activities for 7,000 extremely poor households.
- Diversify cropping systems for 31,500 households.
- Generate US $20 million in incremental new agricultural sales.

The Cambodia HARVEST program was implemented in four target provinces: Pursat, Battambang, Siem Reap, and Kompong Thom. Its main target population was smallholder agricultural producers. The primary aim of the Cambodia HARVEST Aquaculture and Fisheries program component was to transfer sound, viable technologies with input support and extension services to enhance the adoption of recommended technologies. The HARVEST program used a variety of interventions in Cambodia to address this goal, including the promotion of small-scale aquaculture through semi-intensive pond management and the institutional strengthening of community fisheries. Access to quality fingerlings is one of the key factors for promoting sustainable small-scale aquaculture, so the Cambodia HARVEST Aquaculture Program converted some of its potential clients (mostly lead clients) who have suitable farm size to be fingerling producers. In some cases, the program worked with existing local fingerling producers to supply fingerlings to the Cambodia HARVEST's clients in the region.

3. Evaluation Objectives and Framework

This evaluation focuses only on interventions related to the promotion of semi-intensive, small-scale pond aquaculture production, which is one of the components of the income-generating activities mentioned above. With the purpose of promoting sustainable small-scale aquaculture development in rural areas, this study had four main objectives, which were to:

1. Understand how aquaculture technology is being promoted;
2. Examine clients' perspectives about technical support from the Cambodia HARVEST aquaculture program;
3. Examine the drivers of adoption of aquaculture technologies; and
4. Identify the barriers and constraints to aquaculture technology adoption.

With the goal of identifying pathways for small-scale aquaculture sustainability, the evaluation as a whole looked into the Cambodia HARVEST Aquaculture Program development process: client recruitment, means of technology transfer, types of inputs support, adoption of technologies, and program outcomes/impacts. The evaluation logic is presented in the diagram below (Figure 1).

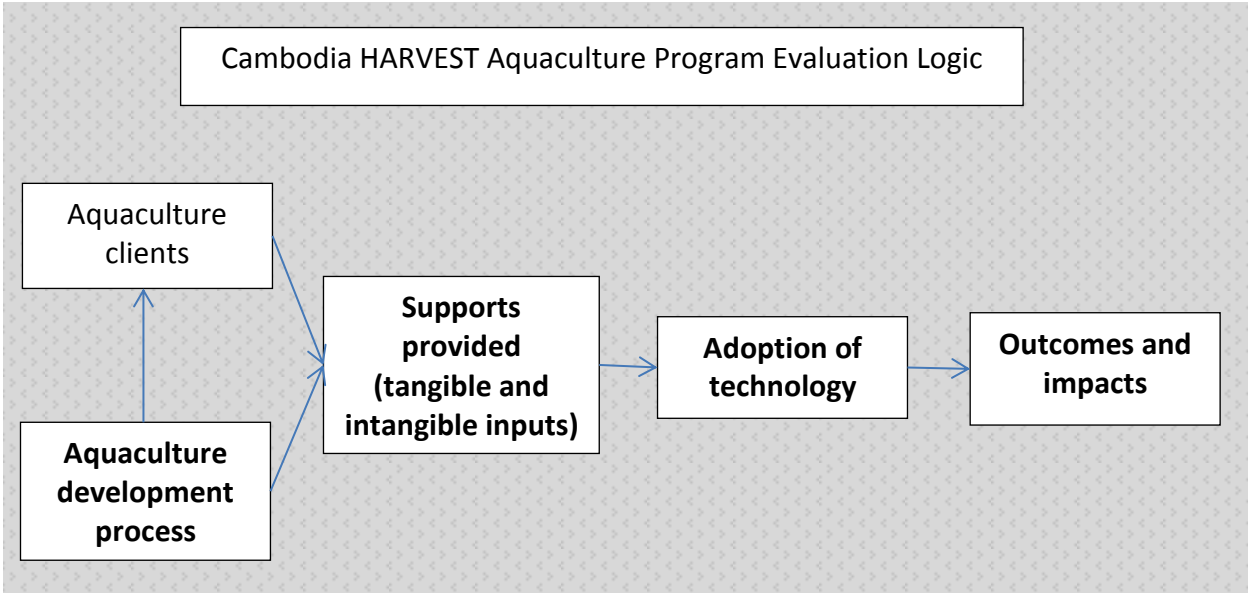

Figure 1. Evaluation logic

The Cambodia HARVEST Aquaculture Program chose the work model of having local organizations in each province as local partners in implementing aquaculture development at the community level. Within this model, the Cambodia HARVEST Aquaculture Program provided technical and financial support to its local partners, which were then responsible for recruiting clients, managing clients, and assisting in follow-up activities.

Each client was recruited on a voluntary basis, and despite having access to existing ponds, the majority of clients had no prior experience with aquaculture. To be able to participate in the program, each volunteer farmer had to have a pond suitable for raising fish, including a pond that can store water for a couple of months for raising at least one cycle of fish per year. The pond had to be near the farmer's home, and the farmer had to commit to contributing required amounts of inputs during the project life cycle.

The next step was client training, provided by the Cambodia HARVEST Aquaculture Program through its local partners. The program provided training and extension services to teach clients pond management and fish-raising techniques, as well as farm planning and budgeting skills. The program also provided inputs support such as pond fencing materials, lime, water quality measuring tools, commercial fish feed, and other important inputs to each client. After the training sessions, clients were allowed time to practice the technologies at their own farms. Later, trainers provided follow-up visits to each farm site to guide farmers in technology application. The follow-up sessions were conducted regularly (i.e., once per week), and trainers provided technology advice and also monitored the progress of each client. Therefore, during the Cambodia HARVEST Aquaculture Program lifecycle, each client technical advice from the program in multiple formats, both periodically and also on demand.

4. Study Design

The Cambodia HARVEST Aquaculture Program evaluation was designed in two phases. Phase One involved collection of qualitative data using focus group discussions in all four provinces. The aim of the focus group discussions was to understand specific aquaculture practices, the input supply and value chain for aquaculture, the barriers and constraints to aquaculture adoption, and the general views and perspectives of farmers engaged in the Cambodia HARVEST Aquaculture Program. Phase Two involved collection of quantitative data with a household survey. With the mandate of covering all of the four target provinces of the Cambodia HARVEST Aquaculture Program, the study team used a stratified cluster sampling for data collection. The study design for each phase is described below.

4.1 Focus Group Discussions

The study utilized focus group discussions (FGDs) for collection of qualitative data related to adoption of small-pond aquaculture in Cambodia. In particular, this study aimed to address the following research questions:

1. How are small-scale aquaculture technology adoption patterns evolving? What is the level of continued practice of small-scale pond aquaculture by farmers after they complete the HARVEST interventions?
2. What are the main challenges associated with small-scale pond aquaculture? What are the barriers to adoption of small-scale pond aquaculture technologies?
3. What are the perceived needs of farmers to increase aquaculture production and income? What are the main challenges associated with increasing aquaculture production and income?
4. Who provides aquaculture extension services to farmers? How adequate are these services?
5. What are the major sources and channels of information used by farmers? What information sources are credible?

The focus group discussions for this phase of the study were carried out for the purpose of understanding the agricultural practices, inputs supply, value chain of local aquaculture fish, and barriers and constraints to aquaculture adoption, as well as understanding the general view and recommendations of farmers engaged in the Cambodia HARVEST Aquaculture Program.

Field data collection

One FGD was conducted in each of the four target province: Pursat, Battambang, Siem Reap and Kompong Thom. Participants were not randomly selected, and generalization of

findings is unfeasible as the level of representativeness and the diverse sets of opinions and experiences in each FGD were limited.

The FGDs were conducted in February 2015. Samonn Mith was the FGD facilitator, and Bora Sreng was the field assistant. The FGD facilitator used a carefully designed discussion guide to ensure that the salient topics were covered during each session. The focus group discussion guide is provided in Appendix 1. The FGD sessions were audio recorded, and transcripts of the FGDs were subsequently produced in the local language and then translated into English. The English-language transcripts generated were reviewed for accuracy with the help of bilingual professionals.

Sample selection

In Pursat province, the FGD involved eight participants (two were graduated clients, two were second-cycle clients, two were first-cycle clients and two were Community Fishery members).The FGD took place at the office of one of the HARVEST local partners (EPDO office) at the Pursat provincial capital.

In Battambang province, there were 11 participants (four graduated farmers, six who were both seed (fingerling) producers and fish raisers, and one purely seed producer). The FGD took place at a farm of one of the clients who is both a fish seed producer and a fish raiser. The location was about 6 km from the MoungRusey district (about 30 km south of Battambang town).

In Siem Reap province, there were nine participants (two graduated clients, four second-cycle clients, two Community Fishery committee members and one fish seed producer). The FGD took place in a village at one client's farm, which lies about 8 km west of the provincial capital.

In Kompong Thom province, there were seven participants (two graduated farmers [husband and wife], two second-cycle clients, two first-cycle clients and one fish seed producer). The FGD took place in a meeting room of the HARVEST field office in Kompong Thom provincial capital.

Table 1 below summarizes the types of FGD participants. References to "graduated" clients are related to farmers who completed all cycles of the HARVEST Aquaculture Program interventions. References to "active" clients are related to farmers who were currently participating in the interventions, including subsidized inputs and extension training.

Table 1.Characteristics of FGD participants

Province	Total clients	Types of clients			
		Graduated	Active	Fish seed producer	Community Fishery members
Pursat	8	2	5	0	1
Battambang	11	7	3	1	0
Siem Reap	9	2	4	1	2
Kompong Thom	7	2	4	1	0
Total	35	13	16	3	3

Note: some of the FGD participants were both fish raisers and fingerling producers.

4.2 Household Survey

The study utilized a rural household survey for collection of quantitative data related to adoption of small-pond aquaculture in Cambodia. In particular, this study aimed to address the following research questions:

1. What are the characteristics of HARVEST client households?
2. What are the primary sources of information and extension services?
3. What are the primary drivers of adoption of small-scale aquaculture practices?
4. What are the barriers to adoption of small-scale aquaculture practices?
5. What are the primary reasons for disadoption of aquaculture practices?

The household survey for this phase of the study was carried out for the purpose of understanding client household characteristics, levels of fish production, barriers and constraints to aquaculture adoption, and the reasons for disadoption.

Survey questionnaire development

The questionnaire was drafted based on literature, survey research practices, and a number of Cambodia HARVEST reports. Insight from the initial visit to the Cambodia HARVEST Aquaculture Program also contributed to the first round of questionnaire drafting. To ensure that the questionnaire covered important aspects of the Cambodia HARVEST Aquaculture Program, the team conducted pre-testing involving focus group discussions in all target provinces in mid-February 2015.Results from this activity were carefully integrated into the questionnaire. Finally, the questionnaire was reviewed by a panel of experts and eventually translated into the Khmer language. To ensure proper translation and proper language usage, the questionnaire was reviewed by a professional with significant experience in project monitoring and evaluation. The survey questionnaire is provided in Appendix 2.

Sample selection

This evaluation survey utilized the cluster sampling method. The population for the sampling frame is comprised of the total number of 1,571 Cambodia HARVEST Aquaculture Program clients across all four target provinces. For statistically meaningful results, the minimum sample size is at least 450 clients. To minimize standard error as much as possible, this study assigned 10 households to each cluster; 45 clusters with 10 households each would provide a sample size sufficient to detect Minimum Detectable Effect Size (MDES) of .35*SD with a statistical power of 80 percent (i.e., Beta=0.8). The number of clusters was allocated proportionally among the four provinces with an adjustment to those with lower and higher numbers of clusters.

With the proportion of clients per province and with the adjustment to those with lower and higher number of clusters, the sample clusters per target province were:

Pursat:	15 clusters
Battambang:	15 clusters
Siem Reap:	7 clusters
Kampong Thom:	8 clusters

Clusters were selected using the simple random sampling method. With this method, every village had an equal chance of being selected. A list of all target villages of the Cambodia HARVEST Aquaculture Program out of the four target provinces was prepared. Villages were given random numbers, and then the villages were selected as a cluster. For selected villages with fewer beneficiaries, the evaluation team collapsed the beneficiaries from one or two neighboring villages (based on the real geography).

The survey sample from the beneficiary list was selected using the random method. Every household in the selected villages was given a random number, and the top 10 households were chosen. A reserve sample list was prepared using the same method. If by chance any sample household was absent or no one was available for interview, a household in the reserve list would be selected to replace it.

Data collection

Enumerators were selected from a group of senior students from the Fishery Faculty of the Royal University of Agriculture. Ten students were recruited, and all attended the two-day training that was held July 4-5, 2015. The training focused on two aspects: understanding the meaning of each question correctly, and understanding the language used. Each question was read through carefully, and the group of enumerators practiced

interviews with each other. Before the end of the training, feedback was collected from them for improving the Khmer language usage. During the training, both versions of the questionnaire (Khmer and English) were used to avoid any misinterpretation of questions.

For the data collection, the team of 10 enumerators was divided into two teams of five members each. Each team was led by a team leader who had substantial experience in conducting field surveys. The survey was initiated in Pursat and Battambang provinces, and enumerators worked in two teams. During this period, both teams came together every evening to share their field experience and prepare for any improvement for the next day. After they finished interviewing clients of these two provinces, the team went on to the other two provinces separately, with one team conducting interviews in Siem Reap province, and the other team in Kompong Thom province.

Data entry was done through a template designed by using Microsoft Access as the platform. One experienced staff member of the Royal University of Agriculture and one staff member of the Royal University of Phnom Penh served as the data encoders. After the data entry was completed, the formal data cleaning process was conducted. First, the data was imported to SPSS, then the cleaning was started by examining frequency and cross-tab, and cross-checking hardcopy of the data for consistency and accuracy.

Of the 451 households contacted, 11 clients declined an interview because they were busy cultivating rice or engaging in other livelihood activities; two clients indicated that they never participated in the Cambodia HARVEST Aquaculture Program; and one indicated he was raising fish on his own. Therefore, the actual sample consisted of 436 households, and their responses were used for data analysis.

5. Results

Results of the focus group discussions are presented below, followed by results from the household survey.

5.1 Results of Focus Group Discussions

The substantive results and findings of the FGDs are presented below. They are organized and presented by discussion themes. Each discussion topic/theme is presented as a header (e.g., 7.1 -- Training and Development) followed by statements that capture the information learned during the FGD. The information reported is an accurate depiction of what respondents reported, although it may not be accurate in terms of what actually happened or how the program was actually administered. That is, if respondents are misinformed or inaccurate, their perceptions (and misperceptions) are reported as presented and are not "corrected". Direct quotations of participants are also included and typically appear in *italics*. In instances where regional differences were observed, the presentation of the results reports those differences.

Generally, the FGD results related to each thematic area are presented province by province. However, if the context/issue is similar in two or more provinces, the FGD results are not presented separately.

Training and development

Each client was recruited on a voluntary basis, and each had to meet selection criteria: own a pond near their house; the pond must at least be able to retain water that can raise fish for one cycle per year; and each client must be able to contribute to certain required inputs.

Because recruitment was on a voluntary basis, the number of clients per each target village varied. Furthermore, clients in each village were not formed into a group. In each village, a client accepted by the other clients was appointed to serve as the lead client. His/her role was to inform other clients in the same village about meetings, trainings and/or client field days, and other gatherings.

After recruitment of clients was completed, the Cambodia HARVEST Aquaculture Program provided overall training on basic fish-raising techniques and farm management skills to lead clients and/or other clients (depending on how many participants the training sessions could accommodate). In general, the training contents covered four main skills: (i) pond preparation, (ii) fish feeding, (iii) water quality management, and (iv) farm planning and budgeting. The training activities were usually conducted at the provincial level.

Normally, the training experience was a full day of instruction followed by a study tour or site visit to see how technologies are applied.

The Cambodia HARVEST Aquaculture Program set up two demonstration farms in Battambang province. In Siem Reap and Pursat, the project worked with some clients who were quite successful and used those farms to demonstrate the technologies to clients on the study tour. Clients from Pursat, Siem Reap, and Kompong Thom provinces visited different farms than those visited by the clients in Battambang province. Likewise, a group of clients in Battambang province visited some farms in Siem Reap province during their trainings or during the early stage of joining the project.

The next step in the training process, after the class session and demonstration farm visit, was having a trainer begin to visit target villages once a month to deliver a series of technologies and instructions through events called clients' field days. These field days were on-site technical orientations and demonstrations that took about 1 to 1 ½ hours. The content delivered in each of these events was extracted and extended from the materials presented during the basic fish-raising skills sessions conducted at the provincial level at the beginning of the activity.

When asked about one of the best parts of the program, one participant said:

> *"Fish pond demonstration day…we were invited to visit a demonstration pond, we learned about pond preparation."* [Battambang FGD participant]

The attendees in the clients' field days were both program clients and other farmers in the village who were interested in learning about the technologies. Participants were given handouts, and the trainer used flipcharts and posters as their training materials. The training was delivered by employing various methods of active learning.

Occasionally, the program organized cross-village training sessions, which were held at the provincial town.FGD participants indicated that they found the training to be useful in sharing general information about aquaculture and their own experience in fish raising. Clients in Kompong Thom province indicated that the training was not frequent enough. They requested to have this kind of training every quarter:

> *"We had cross-village training two or three times [during the project period]…"* [Siem Reap FGD participant]

> *"We want that in one year we are able to have a cross-village training for three to four times."* [Kompong Thom FGD participant]

During their field visits, all of the clients observed the same technologies that they learned about in their class training. They observed the process by which the various technologies

can be put into practice. One study participant from Siem Reap province shared that she had asked the farm owner of the demonstration farm about how to make profit from raising fish. The answer she received from that farmer was to carefully follow all the steps of the technology implementation. This firsthand exposure to fish farming technologies seen as a powerful experience. Almost all of the FGD participants attending the four sessions indicated a high level of appreciation for what they observed and learned during the study tour:

> *"I asked a lot of questions. I asked how to be successful in fish raising. He told me everything…. He said he just followed the instructions from HARVEST by digging a pond, pumping the water to dry up the pond, applying lime, change the water and so on…"* [Siem Reap FGD participant]

Technology implementation, demonstration, and technical support

After each training session and throughout each cycle, clients reported receiving technical support from the trainer in the form of client visits and on-demand support in special circumstances (e.g., when a client unexpectedly experienced fish diseases). Generally, the follow-up visits were conducted once a week. The clients in each of the four FGDs reported follow-up visits for technical support to be useful and appeared to be satisfied with the frequency of such visits:

> *"When we face challenges, they come and help support with techniques and just give us advice. We receive support such as how to observe fingerlings' behavior, how to feed our fingerlings correctly, etc."* [Pursat FGD participant]

> *"The follow-up visit [for technical support] was very often. It was more often than community meetings."* [Siem Reap FGD participant]

Respondents said that the follow-up visits were conducted in ways to advance the technology application. For instance, during the visit, the trainer asked the client to check water quality, to do fish sampling and so on, to ensure that the client knew how to do it properly.

Importantly, FGD participants reported that at first they could not understand all of the lessons/technologies and therefore could not apply all of them. So, they felt that the follow-up visits for technological support were really important for them. The follow-up visit for technological support guided those clients in implementing each of the technologies correctly and made them more confident and more familiar with the technology:

> *"Yes [they] followed up…followed up the technology. They came and guided us in applying the technology."* [Battambang FGD participant]

> *"… if trainers did not visit us providing [technical] support during the technology application, some clients really could not do it. We did get the training, but even though we took notes, we still did not understand everything."* [Kompong Thom FGD participant]

Of the clients in the FGDs, only five (three from Pursat and two from Battambang province) had raised fish before participating in the Cambodia HARVEST Aquaculture Program. Each of these clients said that they just practiced what they thought was important to make their fish grow fast.

Because almost all of the FGD participants from all four provinces had never been trained on aquaculture, they indicated that all of the technologies brought to them by the Cambodia HARVEST Aquaculture Program were new to them.

The Cambodia HARVEST Aquaculture Program also worked with some existing hatchery stations and also established new fish-seed-producing farms. Three experienced hatchery station owners from Battambang, Siem Reap and Kompong Thom provinces joined the FGDs. These entrepreneurs acknowledged that they had firsthand experience in fish hatchery and fish raising and reported learning new techniques from HARVEST. For instance, they reported that the fish-feeding regime/formula was new to them.

The fish-feeding regime, participants reported, helped them save money on commercial fish feed. Before, these respondents reported just feeding their fish without thinking of the maximum amount of feed their fish could eat at each stage of their development. They just assumed that the more they fed the fish, the faster and bigger their fish would grow:

> *"… before I did not feed them in a regular schedule [and I did not concern about fish feeding regime]. I observed that I lost a lot [of money] from this feeding practice..."* [Siem Reap FGD participant]

A fish seed producer mentioned two strict rules of the project – they were not allowed to apply antibiotics in treating fish diseases, and they were not allowed to feed fish with other feed besides the commercial fish feed. Another fish seed producer pointed out that these rules were a good way to raise fish because "We care about consumers' health, and feeding fish with only a commercial fish feed is the best way to control fish growth rate."

Technology adoption

Technology adoption among clients of all four provinces was not much different. Therefore, the results are not presented province by province.

After each training, the first step in technology adoption involved the trainer visiting each client's farm to provide support to ensure that all of the clients applied the technology correctly. The second step was that, after receiving good results in the first cycle, clients were happy to adopt the technology unconditionally from the second cycle onward.

In general, FGD participants reported that they followed all of the technologies recommended to them by the Cambodian HARVEST Aquaculture Program on pond preparation, fish feeding and water quality management. During the FGDs, these participants made the point that, since they had not been trained before on aquaculture technology, they simply followed what they were trained to do by the Cambodia HARVEST Aquaculture Program:

> *"… I used to raise fish without getting any training and I lose a lot of profit, and I was hopeless. During that time I did not know any technique [in fish raising], but after I have been trained by the Cambodia Harvest Aquaculture Program, I put it into practice and I followed the guidelines."*[Pursat FGD participant]

One participant from Battambang province mentioned his experience with not cleaning his pond well enough before releasing fingerlings. His crop failed because some wild meat-eating fish like snakeheads ate almost all of his 8,000 fingerlings. Another participant from the same province had a similar experience. He said he released 800 fingerlings; at the end, only 200 fingerlings remained in his pond. They acknowledged that these were good lessons that drove them to success.

> *"Before participating in the Cambodia HARVEST Aquaculture Program, I'd never been trained in aquaculture at all. But I did try raising fish by myself. That time I failed."*[Battambang FGD participant]

One participant indicated that, when he followed the recommendations by the Cambodia HARVEST Aquaculture Program, he was successful. Another participant also mentioned the same thing. He further said that if someone asks him about his experience (failure and success), he is happy to share with them:

> *"… When I followed all of the technologies for the first cycle, I raised between 7000 and 8000 tilapia. Once I harvested, all of the income minus all of the expenditures, including the inputs provided by HARVEST [Cambodia HARVEST Aquaculture Program], I gained more than 1000 US dollars..."* [Battambang FGD participants]

In those cases of clients who were not successful, FGD participants mentioned clients not strictly following the technologies as instructed. They went on to point out that this includes not feeding the fish in the right way (e.g., feeding with too much or too little feed, and not feeding the fish regularly):

> *"… he fed his fish too much. Then he ran out of the feed. The fish became stunted, small, and not growing at all. Among 2,000 fingerlings [he released into his pond], only 10 fish could grow well… the yield was only 60 kg for the period of three months."* [Kompong Thom FGD participant]

However, it was learned from these participants that many fish farmers who had disappointing results were reluctant to spend their own money for the required 50 percent contribution to the cost of commercial feed for fish feeding. Some fish farmers fed their fish only the commercial fish feed supplied by the Cambodia HARVEST Aquaculture Program. Labor was also mentioned as a constraint to following the recommended technology. It seems that some program participants were not willing to invest their money to buy extra fish feed or hire extra labor:

> *"They did not feed their fish with sufficient feed. So these kinds of farmers do not take risks as they may not succeed."* [Battambang FGD participant]

FGD participants mentioned that they had found no reason for modifying or taking shortcuts in some steps in applying the technology. They kept applying the same process, and for those with some experience in raising fish before joining the project, they also insisted that they did not mingle the so-called new technology with their traditional technology at all. They were concerned that failing to apply any certain part of the technology would have negative impacts.

At the end of the discussion about this topic, the Battambang participants concluded that success in raising fish (by following the technology) all depends on the client's livelihood conditions: those who could follow the technology were those who could afford fish feed and could continue the activity. For the poor farmer, it might be harder:

Barriers and constraints to aquaculture improvement

Because issues are similar across all of the four provinces, the presentation below does not separate the results by province.

Most if not all of the FGD participants stated that they were successful in applying the aquaculture technologies introduced by the Cambodia HARVEST Aquaculture Program. However, these respondents did mention a range of difficulties, including lack of water:

"*… there is a lack of water for only 3 or 4 months during the dry season because there is no water source like a stream or canal."* [Pursat FGD participant]

"… In that region, we do not have water for filling the pond. It's really hard. The water in the pond was bad, could not pump out and fill in with new water." [Battambang FGD participant]

However, program clients living around the Siem Reap urban area (about 10 to 15 km from the city center) and others from Kompong Thom province who lived near main water bodies did not face a lack of water for the whole year:

"No, we are not lacking water [for the whole year round]." [Siem Reap FGD participant]

"About lacking water, we have no problem. We face difficulty in drying up the pond…" [Kompong Thom FGD participant]

Lack of aquaculture extension services in their respective region was another difficulty. Those who did not benefit from the Cambodia HARVEST Aquaculture Program had no access to technology extension services:

"…Geographically, we are fine. But these farmers do not have technical knowledge. Kompong Thom FGD participant]

Lack of money to pay for having a pond dug and sustaining daily operational costs and costs of inputs is another problem (although the HARVEST program recruited participants who already had existing ponds):

"The important thing is that people cannot afford it, lack of money for digging new ponds is a reason and lacking of water sources is the other." [Pursat FGD participant]

"…fish feed price keeps increasing…for high protein fish feed, the price is 4,000 riels/kg but fish [aquaculture fish] price does not increase at all [4,500riels/kg]." [Battambang FGD participant]

"… they [farmers] have no ponds; suppose they have ponds, they have no money for sustaining daily operation." [Siem Reap FGD participant]

Farmers have choices in livelihood activities that may be better than aquaculture:

"… our farmers grow dry-season rice as their main livelihood activity. The other important factor is that those farmers have no money to invest.… Those farmers

observed there are jobs available somewhere outside the region. So, as they are poor, they decided to leave their village for job opportunity." [Kompong Thom FGD participant]

Aquaculture in Kompong Thom province is not as popular yet as in Pursat, Battambang and Siem Reap provinces:

"*... for our Kompong Thom province, aquaculture fish is not popular yet. That's why consumers still discriminate against aquaculture fish. Everyone loves eating fish captured from rice fields. They don't much love aquaculture fish yet..."* [Kompong Thom FGD participant]

Capacity building and sustainability

Most FGD participants indicated that they were going to continue raising fish even after the project pulls out. One graduated respondent said that he is now raising fish in two ponds without any support from the project:

"I continue raising fish in two ponds, on my own without support. I graduated, and now I have a new pond on my own." [Pursat FGD participant]

These clients want to continue raising fish because they worked hard with the project until they were successful and had good experience in raising fish. Another reason is that aquaculture provided them with substantial incomes. They also mentioned that natural fish from the Tonle Sap keep declining, so the supply of wild-captured fish cannot meet the demand. One respondent pointed out that they felt safe eating their own aquaculture fish, but they did not feel safe at all buying aquaculture fish without knowing the source of production because they assumed that those aquaculture fish from unknown sources would be contaminated by chemical substances that may be harmful to human health.

One respondent indicated that he thinks that about 20 percent of the farmers in his village want to dig ponds for growing fish:

"*The people living near my house are digging two new ponds, and the one living on the other side is also digging one pond. They said whether Cambodia HARVEST Aquaculture Program helps or not, they will go ahead on their own."* [Pursat FGD participant]

After training and going through at least two or three cycles with the Cambodia HARVEST Aquaculture Program, the fish farming clients reported getting used to growing fish, and their answers seemed to high levels of confidence in raising fish. FGD participants mentioned that, because fish raising is now familiar to them and the returns are good,

they will continue the activity after HARVEST stops providing support. Some indicated that they will not only continue the activity but will also be expanding their ponds.

Some FGD participants mentioned that they cannot rely on any government agency to promote and support aquaculture to rural areas because government does not have the budget to support this activity. The participants reported that they saw government aquaculture officials coming to their place and only providing training to local farmers on how to raise fish. These clients mentioned that without material or inputs support, these farmers could not do it because they were poor and had no income for the inputs needed to raise fish.

There appeared to be a geographical disadvantage for small-scale aquaculture development in Kompong Thom, as clients reported that there are more wild fish still available, and there are more options for alternative livelihoods in this region compared with Battambang. The FGD participants here agreed that there are relatively few farmers raising fish in Kompong Thom province.

Aquaculture value chain

There was a mixed reaction toward marketing of aquaculture fish among FGD participants. There was general agreement that there are accessible markets for local aquaculture fish. However, smallholder fish producers are unable sell their fish at the same price as medium-scale or commercial aquaculture producers because smallholder fish producers cannot guarantee the year-round supply of fish to markets:

> *"…We raise fish in small scale, so [our fish price] is cheaper than those who raise in large ponds. Their ponds are so big, and they have more ponds. Their fish price can be different from us 2 or 3 cents."* [Pursat FGD participant]

Some FGD participants mentioned that they sold their aquaculture fish at a market and at their farm gate to "middlepersons" who are retail fish sellers at local markets. These middlepersons typically buy only between 10 and 20 kg fish per day. Some participants reported having occasionally taken their fish to a market for sale, but most of the time they sold fish at the farm gate because it was easy, even though the price was lower.

Some FGD participants living in rural areas indicated that they could not produce more fish because it was hard to sell and the price was not fair to them. Clients agreed that the prices offered by middlepersons were fair, although the price at the farm gate was usually lower than the retail market price. For example, in Kompong Thom, the farm-gate prices for climbing perch were between 8,000 to 10,000 riels per kg, compared to the market price of 11,000 riels per kg. In Battambang, the wholesale price was only 5,500 riels per kg, but the retail price was 9,000 riels per kg, which is the same for tilapia. Therefore, they

asserted that middlepersons had made a lot of profit from them, and these clients felt that they were unfairly exploited. However, some participants from a region near a town said that no matter how many fish they produced, they could sell all of them.

Market access was reported as a problem among those clients who live farther from the provincial town or from a main road, as middlepersons did not travel to their villages. These farmers reported having brought their aquaculture fish to the nearby district market and sold it at a wholesale price to middlepersons over there. Those participants living about 40 km or more from the city reported challenges in selling their aquaculture fish, citing both lower demand and an absence of middlemen/brokers:

> *"The region that is far from a city, yes, they have problem of lacking of market."* [Siem Reap FGD participant]

In more accessible regions, middlepersons would come in to buy fish at the farm gate, and they would buy all of the fish available for sale.

In addition, some participants reported having sold fish to neighbors and fellow villagers. They reported having received the market price, but they could not sell much because fellow villagers had limited money to buy fish from them. Clients said they wanted to sell their fish in a larger quantity at one time so they can collect money faster.

FGD participants mentioned the advantage of local aquaculture fish over imported aquaculture fish. Local aquaculture is quite popular because the product is fresh and the quality (taste and cleanliness) is fine, though it is more expensive. And most of them sold their fish locally:

> *"I sold my fish by myself, not selling to a retail seller or middleperson at all. If consumers did not come to my farm, I would not sell them my fish… our fish is fresh. If they buy fish from a market, it is not fresh, but it was frozen."* [Battambang FGD participant]

On the negative side, another FGD participant who is a fingerlings producer indicated that the demand for aquaculture is not stable:

> *"… the demand for aquaculture fish consumption varies by season. Generally, in the wet season, the wild fish supply is high so the demand for aquaculture fish is low."* [Battambang FGD participant]

In rural areas, local aquaculture fish producers had difficulty competing with aquaculture fish imported from Vietnam:

> *"[It is] difficult to compete with those imported fish. The important point is that fish imported from Vietnam are cheaper."* [Battambang FGD participant]

In regions such as Battambang, where wild fish are not abundant, participants suggested that preferences for aquaculture fish have evolved:

> *"…previously most consumers said that aquaculture fish was not tasty. So, they preferred captured fish from a lake or from somewhere. But nowadays, captured fish are not abundant, so now it is clear that most consumers change their habits to eat aquaculture fish. They changed their preferences."*[Battambang FGD participant]

But even in regions such as Kompong Thom Province, where wild fish is still abundant, participants reported high demand for aquaculture fish, although there was some disagreement about the stability of demand in urban areas. During the period that wild-captured fish is abundant, the demand for aquaculture fish is reportedly low.

Some predicted that in the future, most consumers will not think much about the source of the fish supply, whether aquaculture or wild-captured fish. Consumers have begun to appreciate the quality of aquaculture fish, and participants reported consumer feedback about the flavor and quality, as compared to the quality of imported fish.

FGD participants agreed that there are accessible markets for aquaculture inputs, as all items are available locally. Cash flow was reportedly a problem for many farmers, as they may not have enough money on hand for purchasing inputs at necessary times in the production cycle.

Outcomes and impacts

Participants emphasized several positive outcomes and immediate impacts of small-scale aquaculture on their livelihoods.FGD participants all mentioned having more fish to eat, having enough fish to feed their visitors, and savings of money, labor, and time.
FGD participants pointed out that raising fish by applying the technology recommended to them by the Cambodia HARVEST Aquaculture Program enabled them to have fish for both household consumption and household income. Some clients explained that they could make profits from selling their fish. They further added that the household condition before and after raising fish was quite different. Before, they did not have much money for saving, but after raising fish, they could save more money. Clients added that income from selling their aquaculture fish can support their family well-being and they were able to send their children to school. Other clients mentioned that they had enough fish to support household consumption:

"Raising fish is better. We usually eat fish. We even eat them every day, and we want to eat it again and again." [Pursat FGD participant]

Because their expenditure on food declined, all clients mentioned that their family savings had increased. One client mentioned that if he bought fish from a market, it cost him 9,000 riels / kg for one day of food. But by having his own fish, sometimes his family could consume 2 kg of fish per meal, and:

" No! We are happier because I have money for sending my son to pursue his study in Phnom Penh after he graduated from high school..." [Pursat FGD participant]

"…we can save the money that we normally allocate for buying food." [Battambang FGD participant]

"We can keep this money for spending on something else." [Battambang FGD participant]

At one point, one client mentioned that if he needed to buy other foods, he used the money from selling fish to buy it.

"We would also say that sometimes when our relatives visit us, we serve them fish every day." [Battambang FGD participant]

Furthermore, clients agreed that aquaculture is relatively less labor-intensive than other activities. One male client in Siem Reap, who is in his 50s, mentioned that he used to work hard in wage labor for decades growing rice and as a laborer in the dry season, but he explained indicated that now he does not need to work so hard physically as he did before raised fish. Other FGD participants also agreed.

"Since raising fish, I feel that I my work is lighter [in terms of using physical power]." [Siem Reap FGD participant]

Participants also reported that aquaculture allowed them to save time, as compared to time required for catching fish:

"You know, we just clean the pot, put the water in, boil it and take the cast net or fishing rod, and you have fish. Before that we have to spend time coming to market buying food."[Kompong Thom FGD participant]

"Yes. I am more relieved. As I have just mentioned that we are one step better. First, we have our own homestead food, not difficult. We just buy a throwing net to be ready for catching the fish." [Kompong Thom FGD participant]

Participation in the HARVEST aquaculture program also reportedly contributed to the personal confidence of farmers. A female client from Siem Reap shared her experience in indirectly gaining from raising fish. She said that she is more confident in contributing to building her family. She did not think that aquaculture increased her work load:

> *"My husband works outside. I stay home taking care of children, washing clothes, cooking, raising fish, raising pigs. This makes me confident that I have my job."* [Siem Reap FGD participant]

Some farmers reported feeling more widely recognized within their respective communities. They reported having felt that they were perceived as proficient at fish raising in their community, and they noted that other farmers came to them for advice on fish raising. Three participants from Kompong Thom even mentioned that they have considered standing as a candidate in the commune council election because they had become well-known in their community through the aquaculture program. Some farmers claimed that everyone in the community had highly praised them for their success and wanted to learn technology from them:

> *"If anyone wants to dig a pond, they should ask me how to do it and I can draw the outline for them. How deep it is, I can observe and order the diggers to follow my instruction and we do not keep the bushes around the pond. It looks like I am already a local change agent in my village…"* [Pursat FGD participant]

Aquaculture reportedly encouraged farmers to be more proactive in integrated livelihood activities. For example, some farmers reported having set up their home gardening so that the water from the fish pond (when not needed for fish anymore) can be used to water vegetables. This would increase a farmer's food security as well as supplemental household income.

"… clients in this region practice integrated agriculture. This provides high income…" [Siem Reap FGD participant]

Case 1: Personal impact

Vean Sok lives in KaunKhaEk village, RobasMonkol commune in Moung district, Battambang province. He raises fish and also produces fingerlings.

He never raised fish or produced fingerlings before the Cambodia HARVEST Aquaculture Program.When the Cambodia HARVEST Aquaculture Program recruited him, he decided to do fish farming because he had observed that wild-captured fish in his region were declining and, in the dry season (March to May), almost non-existent.Imported aquaculture fish had been brought to his village, but until the Cambodia HARVEST Aquaculture Program, there was no aquaculture at all in his village and commune.Seeing that raising fish might be a good opportunity, he decided to join the project.He went through a hardship period at the beginning of the activity, which was an extraordinary business.His neighbor looked at him in a suspicious way.Once he was successful in the first cycle, however, all neighbors began to change their attitude toward him.

Though his farm is still small, he is well-known among his community.This newly successful smallholder fish raiser wanted to help other poor households in his community to engage in fishing. He helped one poor farmer get a pond for raising fish dug free of cost.Then, he further supported this poor farmer with fingerlings and technology.This is the way he started his community work, and he strongly believes in this course.Together with other clients joining the FGD, he said that, with material and technology supports from outside, he could help poor farmers become actively involved in fish farming.

Box 1: Personal impact

Some participants reported having provided guidance and advice to new farmers. They indicated that most farmers came to their farms and often asked whether raising fish is really a profitable livelihood activity:

"A lot of my neighbors want to raise fish. They came to me asking about possible support, but the project will end soon. So some of them began raising fish by themselves."[Battambang FGD participant]

They emphasized the importance of linking new farmers to markets, and they suggested that once new clients see that local people like to eat domestic aquaculture fish, they will be committed to aquaculture.

Responding to questions about targeting poor clients, participants suggested that the project should support those poor farmers with all necessary inputs. Some farmers suggested that a portion (e.g., fifty percent) of the supports be provided to clients as a loan with no interest, and the other portion could be provided free of charge. In this case,

even a farmer with no money for daily operation can also raise fish. It would be impossible for them to pay back a loan with interest.

Case 2: Promoting local aquaculture fish in Siem Reap Province

Ly Sinh is an entrepreneur for aquaculture. He owns a fish farm in Prey Kroch village, Krabey Riel commune, Siem Reap district.He has long experience in both raising fish and producing fingerlings.With his long experience in his provincial aquaculture fish supply chain, he has a lot of connections with both producers and consumers.He knows about the potential demand for aquaculture fish in Siem Reap town. This entrepreneur has a vision of creating his own aquaculture supply chain where local and clean aquaculture fish are supplied fresh and on time to elite consumers (hotels and restaurants) in the Siem Reap town. He is happy to organize local smallholder fish producers into a group of producers so that the production side can be coordinated in a systematic way.He is one of the Cambodia HARVEST Aquaculture Program clients, he likes the technology recommended to him the Program. (How to raise tilapia better and how to ensure an aquaculture fish is safe for human consumption).He wants to further promote these technologies among smallholder fish producers so that aquaculture gains in popularity among consumers and the producers benefit.

Box 2: Promoting local aquaculture fish in Siem Reap Province

It was suggested that current clients who are successful with fish raising help disseminate aquaculture technologies and provide support to encourage new clients as a "lead farmers". Lead farmers can play a role in sharing their experiences with new clients if they have support from a main trainer who can provide technical support:

> *"… A model client can promote the technology locally."*[Battambang FGD participant]

Lead farmers can be both fish raisers and fingerling producers. It was noted that many ordinary farmers come to a hatchery farm asking for aquaculture information and technology advice.

However, some clients in Siem Reap were not supportive of the idea to use former clients or lead clients to train new clients in the recommended technology. They said that an external trainer is the best person to provide training to new clients because those clients trust an external technical person more than their fellow farmers. This contradicts the ideas offered by clients in the other three provinces:

> *"If a model farmer is teaching them technology, those new clients may not trust. But they trust when HARVEST trainer teaches them."* [Siem Reap FGD participant]

It was suggested further that lead clients (sometimes referred to as model farmers) collaborate as a network to promote aquaculture technologies in their local areas, share technical innovations, and share aquaculture market information.

Case 3: Commitment to aquaculture technology extension

A lead farmer of the Panha Chi village, located in TabaungKrapeur commune, Santuk district, Kompong Thom Province with experience in sustainable rice intensification technology, raising fish, and producing fingerlings revealed that he worked in the past in disseminating aquaculture technologies to local farmers.The condition is that a lead farmer must be a successful person in the area of his/her expertise.If not, it is hard to convince a farmer to trust and accept the lead farmer's ideas and suggestions.

Lead farmers need materials and technical advice from relevant organizations such asthe Fishery Administration, NGOs and/or donor organizations.Technical advice will help update the farmer's knowledge and skills.Their support should also include extension and presentation skills, as well as material inputs that a lead farmer can deliver to a poor farmer.For instance, a lead farmer may manage a community revolving fund.

Box 2: Commitment to aquaculture technology extension

Finally, there were suggestions for future aquaculture interventions and for the extension of the project activities in order to broaden support to new farmers:

> *"Help new clients like what they did when recruiting us, I would like to tell you again that they should keep doing it that way, all the farmers in my village want to have ponds for raising fish, the project should continue its efforts for helping the next generation so that those farmers can raise fish. The project should continue its operation for one or two more years. So, I want HARVEST to provide support to both current and new clients. Now there are a lot of ponds in my village."* [Pursat FGD participant]

5.2 Results of the Household Survey

Results of the household survey are presented below.

Aquaculture clients

For sampling purposes, the population of the household survey included the clients of the Cambodia HARVEST Aquaculture Program. In accordance with the Identification of Poor Households Programme, households in the region are identified by the Ministry of Planning as poor or non-poor, and they are given identification cards from government authorities with their poverty category classification. The Programme is led by the Ministry of Planning in collaboration with the Department of Local Administration of the Ministry of Interior. From the household survey, more non-poor households (86.2%) participated in the household survey than poor households across the four target provinces. Of 436 total

respondents, only 60 respondents identified themselves as poor households. Frequency counts by poor and non-poor households are provided in Table 2.

There are numerous reasons for the low rate of participation of poor households in the Cambodia HARVEST Aquaculture Program, as compared to non-poor households. For example, to be eligible to participate in the aquaculture program, a farmer had to have a pond suitable for raising fish, and he/she had to be able to contribute at least 50 percent of the total cost for buying fish feed. Many poor households lack the land and resources to meet those qualifications.

Table 2.Aquaculture clients

Province	**Poor** ***(n=60)***		**Non-poor** ***(n=376)***		**Total (N)**
	Frequency	Percent	Frequency	Percent	
Pursat	23	15.5%	125	84.5%	148
Battambang	23	16.5%	116	83.5%	139
Siem Reap	8	11.6%	61	88.4%	69
Kampong Thom	6	7.5%	74	92.5%	80
Total	**60**	**13.8%**	**376**	**86.2%**	**436**

Household characteristics

Household characteristics are provided below in Table 3. On average, household size in each of the four target provinces was above five persons per household. The average household size across all of the four provinces was 5.71 persons, which is slightly above the baseline survey result and the national average, which are 5.22 (V. Theng et al., 2013) and 4.7 persons (NIS, 2010), respectively.

Approximately 10.8% of respondents represented female-headed households. Of the four provinces, Pursat had the greatest proportion of households headed by women (21 out of 148 households, or 14.3%).On average, each household had approximately two persons under 14 years old. The average age of the household heads was in the mid-40s.The majority of the headsof householdhad attended school.

Table 3.Household characteristics

Province		Household size	Children <14 years		Female HH head		Average age of HH head (years)	HH head attended school (%)
	Freq.	Average (persons)	Average (persons)	Percent	Freq.	Percent		
Battambang	137	6.11	2.1	79.6%	13	9.6%	48.43	86.8%
Kampong Thom	80	5.91	1.9	80.0%	5	6.3%	46.26	96.3%
Pursat	148	5.48	1.9	65.5%	21	14.3%	46.07	93.9%
Siem Reap	69	5.20	2.1	73.9%	7	10.9%	44.95	87.5%
Total	434	5.71	2.0	74.0%	46	10.8%	46.69	91.1%

The Cambodia HARVEST Program consists of activities in five areas: agribusiness value chains; aquaculture and fisheries; natural resources management, biodiversity and climate change; social inclusion, business development services and capacity development; and policy and enabling environment. Clients may be involved with more than a single activity, and the results of this household survey show that many Cambodia HARVEST Aquaculture Program clients did join more than one activity (see Table 4). In general, these activities are interrelated and complementary to one another. For instance, the focus group discussions conducted as a part of this study indicated that some clients used water from fish ponds for watering their home gardens, and that this can help enhance their household incomes.

Table 4.Households participating in more than one HARVEST activity

HARVEST activity	Poor (*n=60*)	Non-poor (*n=376*)	Total (*N= 436*)
Aquaculture	100.0%	100.0%	100.0%
Horticulture	46.7%	38.0%	39.2%
Rice production	8.3%	18.1%	16.7%

Household assets

Household assets by poverty category are presented below in Table 5. Among those assets owned by both poor and non-poor households, mobile phones were the most common; approximately90 percent of poor households reported owning mobile phones, 97 percent of non-poor households reported owning mobile phones. Bicycles were also common among the two wealth groups, with 80 percent of poor households reported owning on average 1.8 per family, and 86 percent of non-poor households owning 1.2 per family.

Both of the two wealth groups reported owning roughly the same number of motorbikes and televisions.

Table 5.Household assets

Types of assets	Poor *(n = 60)*		Non-poor *(n = 376)*		Total	
	Percent	Average	Percent	Average	Percent	Average
Mobile phone	**90%**	**2.2**	**97%**	**2.7**	**96%**	**2.6**
Radio	**30%**	**1.1**	**41%**	**1.1**	**62%**	**1.1**
Television	**60%**	**1.2**	**84%**	**1.1**	**24%**	**1.1**
Bicycle	**80%**	**1.8**	**86%**	**1.6**	**85%**	**1.7**
Motorbike	**55%**	**1.2**	**89%**	**1.3**	**84%**	**1.3**
Car or truck	**2%**	**1.0**	**11%**	**1.1**	**10%**	**1.1**
Solar panel	**2%**	**1.0**	**14%**	**1.1**	**12%**	**1.1**
Improved cooking stove	**25%**	**1.2**	**27%**	**1.4**	**27%**	**1.4**
Refrigerator	**0%**		**2%**	**1.0**	**2%**	**1.0**
Sofa	**0%**		**1%**	**1.0**	**1%**	**1.0**

Households in each wealth group reported owning livestock in very different numbers (see Table 6).The standard deviation values (SD) indicate a greater spreading of the data compared with large livestock such as cattle, buffalo, and pigs. On average, non-poor households owned more livestock than poor households. The most common livestock among both wealth groups was chickens. The household survey revealed that 82 percent of poor households owned an average of 14.5 chickens. However, the standard deviation values (SD) indicate a greater spreading of the data indicating some clients owned fewer and some owned more chickens. Likewise, 97 percent of non-poor households owned at least 19.8 chickens. The non-poor owned more chickens per household, and the spread of the data is also larger compared with results from the poor households. The second most common livestock owned by both wealth groups is cattle.

About 35 percent of non-poor households owned at least 3.1 cattle, on average, and 53 percent of non-poor households owned at least 4.1 cattle. Fewer households from both wealth groups owned buffalo -- 8 percent of poor households owned an average of 1.2 buffalo, and 8 percent of non-poor households owned three buffalo. About 20 percent of poor households owned an average of 2.2 pigs per household, and non-poor households owned 6.9 pigs per household, on average. Twenty-eight percent of poor households owned an average of 25.8 ducks per household; non-poor households owned 73.8 ducks per household on average. The standard division is high because some clients raised a few ducks just for their own consumption, and others raised more ducks for business purposes.

Table 6.Livestock ownership

Types of livestock	Poor *(n=60)*		Non-poor *(n=376)*		Total *(N=436)*	
	Percent	Mean(SD)	Percent	Mean(SD)	Percent	Mean(SD)
Cattle	35%	3.1(2.0)	53%	4.1(3.4)	51%	4(3.3)
Buffalo	8%	1.2(0.4)	8%	3.0 (1.5)	8%	2.7(1.5)
Pigs	20%	2.2(1.2)	25%	6.9(10.6)	24%	6.3(10.1)
Chickens	82%	14.5(16.2)	87%	19.8(58.3)	86%	19.1(54.7)
Ducks	28%	25.8(48.2)	28%	73.8(267.6)	28%	67.1(249.3)
Other (goose)	0%		4%	4.2(4.2)	3%	4.2(4.2)

Sources of household income

The results of this household survey indicate that both groups of clients (poor and non-poor households) had a range of livelihood activities (see Table 7).The traditional livelihood activity—rice cultivation—involved the majority of both wealth groups and was the primary income source for both poor and non-poor households.

The three primary income sources of poor households were sale of rice from own farm (25 percent), wage labor (23.3 percent) and sale of vegetables from own garden (16.7 percent).For non-poor households, the three primary income sources were sale of rice from own farm (44 percent), small business/self-employment (15.2 percent) and sale of vegetables from own farm (13 percent).Among the three major secondary sources of income, sale of fish is the major secondary source of income of poor households (26.7 percent), followed by wage labor (21.7 percent) and sale of vegetables from own garden(18.3 percent).However, for non-poor households, sale of rice from own farm was the first major secondary income source (19.7 percent), sale of fish was the second (17.6 percent), and sale of vegetables was the third (16 percent).

Even though the statistics on primary and secondary sources of income for both wealth groups vary, it is clear that rice, vegetables and fish were the most important sources of income for rural households.

It is worth noting the relatively high percentages of households reporting wage labor as a primary or secondary source of income. Across both wealth groups, the proportion of households who reported that wage labor was a primary or secondary source of income are greater than that of selling fish and of selling vegetables. This may reflect a greater reliance on income from household members who have migrated to Phnom Penh in

search of wage employment. Migration has implications for the long-term adoption of small-scale aquaculture; in some cases, HARVEST aquaculture program clients reportedly stopped raising fish and migrated to Phnom Penh, Thailand, or Vietnam in pursuit of employment.

Table 7.Sources of income

	Primary source		**Secondary source**	
	Poor *(n=60)*	Non-poor *(n=376)*	Poor *(n=60)*	Non-poor *(n=376)*
Sales of fish	11.7%	6.4%	26.7%	17.6%
Sales of rice from own farm	25.0%	44.4%	5.0%	19.7%
Sales from vegetable gardens	16.7%	13.0%	18.3%	16.0%
Wage labor	23.3%	10.6%	21.7%	11.7%
Small business/self-employment	8.3%	15.2%	8.3%	13.3%
Remittances	8.3%	2.4%	3.3%	3.7%
Retirement funds	3.3%	1.6%	0.0%	.3%
Salary	1.7%	2.7%	0.0%	.5%
Sales of crops other than rice and vegetables	1.7%	2.1%	6.7%	2.7%
Sales of livestock	0.0%	1.1%	6.7%	13.6%
Others	0.0%	0.5%	3.3%	0.8%

Sources of information and extension services

When asked about the extension services received during the previous 12 months, nearly all respondents from all four provinces indicated that they received extension services from the Cambodia HARVEST Aquaculture Program (see Table 8). A secondary but important source of information to respondents across the four provinces is informal advice from neighbors or friends. This point may have implications for the scaling out of small-scale aquaculture and the long-term sustainability of smallholder aquaculture in the region. However, there is a need for further research to examine the social networks of aquaculture farmers to better understand how technologies and practices are disseminated and diffused, and which factors determine the adoption of technologies learned from neighbors and friends.

Other available sources of technological advice to farmers include district agricultural service centers, other development projects, local village commune offices, fish traders,

television and radio messages, and input supply dealers. The percentages of farmers who received advice from these channels vary, but in general they are far below the percentages of the first two categories. Future research could perhaps explore the effectiveness of these multiple channels of information dissemination and diffusion.

Table 8.Sources of extension services

Sources	**Battambang** ***(n=106)***	**Kampong Thom** ***(n=58)***	**Pursat*(n=107)***	**Siem Reap** ***(n=51)***	**Total** ***(N=324)***
HARVEST program	98.1%	96.6%	100.0%	100.0%	98.8%
Neighbors or friends	17.6%	12.1%	18.7%	19.6%	17.1%
District agricultural service center, extension agent	3.8%	8.6%	8.4%	7.8%	6.8%
Other program or project (besides HARVEST program)	3.8%	8.6%	3.7%	13.7%	6.2%
Local village/commune office	8.5%	0.0%	6.5%	3.9%	5.6%
Fish trader	6.6%	3.4%	3.7%	7.8%	5.3%
Other (radio, TV)	5.7%	10.3%	4.7%	0.0%	5.3%
Fertilizer or input supply dealer	2.8%	0.0%	2.8%	2.0%	2.2%

Respondents rated the technical support that they received in fish raising across a variety of sources on a scale of 1 to 5, in terms of the amount learned: 1= nothing at all, 2= a little, 3= some, 4= a fair amount, and 5=a great deal. The results indicate that clients learned most information from the Cambodia HARVEST Aquaculture Program(4.4 out of 5) (see Figure 2).The most effective second sources of information were extension meetings, workshops and courses, and television programs. Other effective sources included information from neighbors and relatives, personal contact with extension agents, extension publications, and leader farmers in the area, radio programs, newspapers and magazines, demonstration fish farming operations (average scores ranging from 1.1 to 1.7). These findings are important for any development project to consider when looking for ways to sustain rural aquaculture technology extension services. Perhaps a project could use these farmers (neighbors/relatives) as local change agents providing technical advice to fellow farmers in a somewhat formal way.

It is worth noting that these results are slightly different from the findings from FGD phase. FGD participants indicated that lead clients or local fingerling producers as the main sources of technology advice, not the Cambodia HARVEST Aquaculture Program trainer. This household survey found the score for leader farmers in the area (lead client or local

fingerling producer) to be 1.4.However, it is worth noting that some clients see these terms as interchangeable.

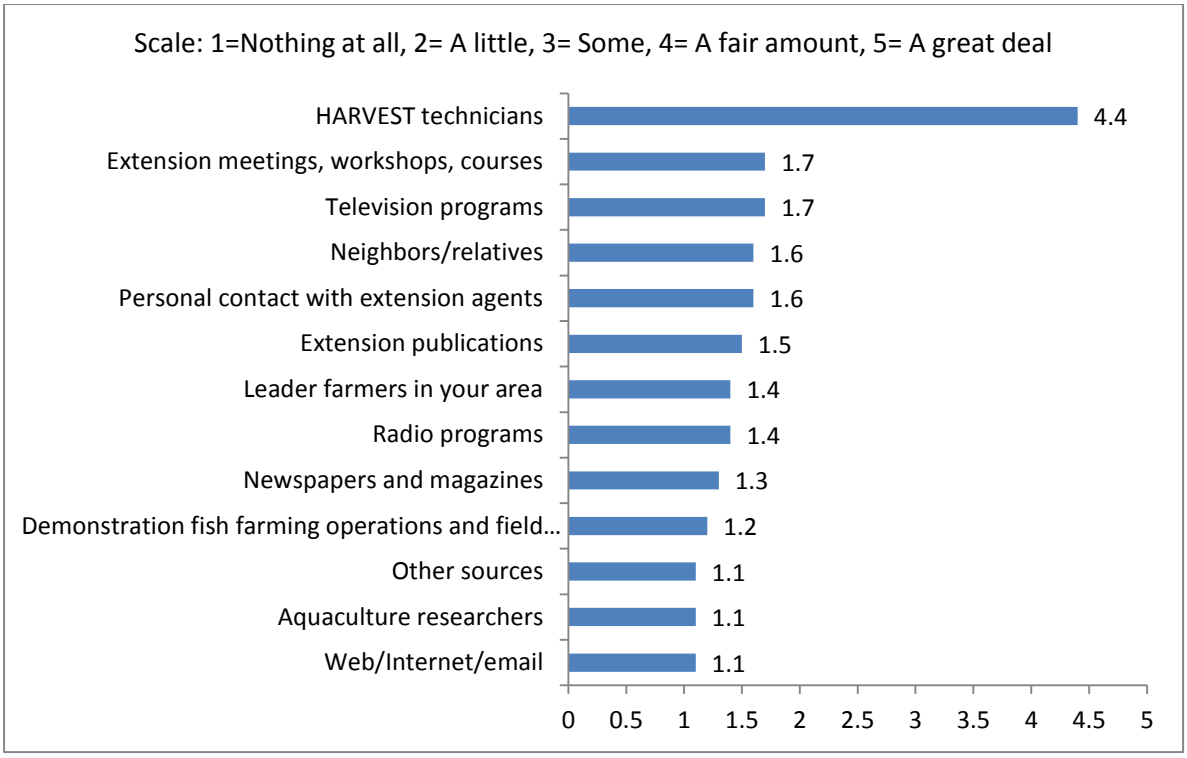

Figure 2. Sources of information (n=324)

Fish production

Table9 below describes the average fish production in the 12 months before the survey by province. The average number of cycles completed was 1.63, and average production in the last 12 months was 537.4 kg. Relatively high SD values for average fish production indicate wide variation in fish produced. Average pond size is 353.5 m^2, and ranges from an average of 238.3 in Kampong Thom to 595.1 m^2 in Siem Reap.

The Cambodia HARVEST Aquaculture Program worked with clients with pond sizes ranging from less than 100m^2 to over 400m^2.Pond sizes are divided into three categories: (i) small (less than 100m^2),(ii) medium (100m^2 to 400m^2), and (iii) large (greater than 400m^2).Figure 3 below illustrates percentages of respondents by pond size and province. In all four provinces, few households owned ponds smaller than 100m^2.Between 16.7 and 32.8 percent of farmers across the four provinces reported having fish ponds in this category. The majority of sample clients owned fish ponds between 100$m^2$and 400m^2, ranging from 45.1 percent to 57.0 percent. Fewer of the sample clients reporting having fish ponds over 400m^2in size. It is interesting to note the regional variation, with nearly one-third of households from Battambang and Siem Reap provinces reported having large ponds, while

nearly as many from Kompong Thom and Pursat reported having small ponds, which is more than double the share that reported having large ponds.

Table 9.Fish production, by province

Province	Farmers currently raising fish		Number of cycles	Fish produced (kg)	Average pond size (m^2)
	Freq.	Percent	Mean (SD)	Mean (SD)	Mean (SD)
Battambang	108	77.7%	1.69(0.68)	581.0(582.4)	382.0 (324.6)
Kampong Thom	58	72.5%	1.55(0.54)	384.3(468.4)	238.3 (270.9)
Pursat	107	72.3%	1.71(0.73)	545.2(499.1)	272.2 (424.3)
Siem Reap	51	73.9%	1.43(0.67)	602.0(693.2)	595.1 (1387.5)
Total	324	74.3%	1.63(0.68)	537.4(559.4)	353.5 (647.3)

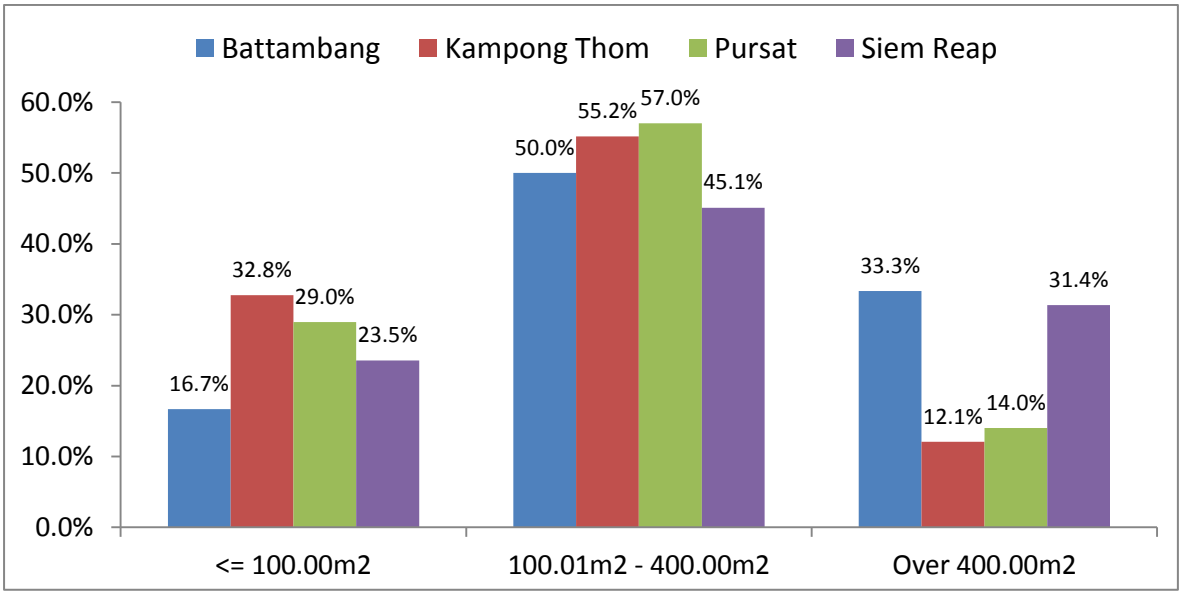

Figure 3.Households, by province and size of fish ponds

Data related to fish production by pond size are provided in Table 10. As expected, the quantity of fish produced increases with pond size. For small ponds (less than $100m^2$), the average production per cycle was 257 kg. For medium-sized ponds(between $100m^2$and $400m^2$), the average production per cycle was 430.4 kg. For large ponds (greater than $400m^2$),average production per cycle was979 kg.

Table 10. Fish produced per cycle in kilograms, by pond size and province

Province	<= 100.00m^2		100.01m^2 - 400.00m^2		Over 400m^2		Total	
	Freq.	Average (kg)	Freq.	Average (kg)	Freq.	Average (kg)	Freq.	Average (kg)
Battambang	18	230.7	51	407.7	35	938.5	104	555.7
Kampong Thom	19	161.4	30	339.2	7	911.4	56	350.4
Pursat	30	373.2	59	502.6	15	979.0	104	534.0
Siem Reap	12	157.7	23	414.3	16	1219.9	51	598.8
Total	79	257.0	163	430.4	73	1006	315	518.7

To better understand the relationship between average production and pond size, correlations analysis was used to calculate correlation coefficients and their significance (see Table 11).With a Pearson correlation of 0.35, there is a low but significant correlation between fish production and average pond size.

Table 11.Pearson's correlation

Correlation -- size of fish pond vs. total fish produced			
Correlations			
		Pond size	Total fish production
Pond size	Pearson correlation	1	.355**
	Sig. (2-tailed)		.000
	N	324	315
Total fish production	Pearson correlation	.355**	1
	Sig. (2-tailed)	.000	
	N	315	315
**. Correlation is significant at the 0.01 level (2-tailed).			

Table 12below provides a summary of fish species raised by respondents by province. The most commonly raised fish species was Pangasiuscatfish, although there was significant regional concentration, particularly in Pursat. Walking catfish were the second most commonly raised fish species, followed by climbing perch. The results of the FGDs revealed no technical or socio economic explanations for clients' preferences for particular species.

Table 12.Fish produced in kilograms, by species and province

Fish species	Battambang	Kampong Thom	Pursat	Siem Reap	Total
Climbing perch	7.4%	31.0%	1.9%	25.5%	12.7%
Walking catfish	25.0%	37.9%	14.0%	41.2%	26.2%
Nile tilapia	8.3%	5.2%	17.8%	3.9%	10.2%
Pangasiuscatfish	35.2%	22.4%	62.6%	5.9%	37.3%
Silver barb	4.6%	5.2%	0.9%		2.8%
Indian carp	0.9%				0.3%
Red tilapia	23.1%	1.7%	7.5%	23.5%	14.2%

Average fish production by species and province is provided below in Table 13. Pangasiuscatfish produced the highest yield per square meter (3.33 kg), followed by Nile tilapia (2.67 kg).

Table 13.Average fish production, by species and province (kg/m^2)

	Mean, in kg/m^2 (SD)				
Fish species	Battambang	Kampong Thom	Pursat	Siem Reap	Total
Climbing perch	2.03 (2.20)	1.30 (0.78)	1.90 (1.71)	1.90 (1.71)	1.69 (1.51)
Walking catfish	1.53 (0.98)	1.56 (1.41)	2.05 (1.15)	2.05 (1.15)	1.66 (1.11)
Nile tilapia	0.76 (0.49)	0.49 (0.22)	3.99 (6.72)	2.20 (0.02)	2.67 (5.24)
Pangasius catfish	2.39 (1.79)	3.66 (1.52)	3.76 (4.63)	3.31 (1.97)	3.33 (3.72)
Silver barb	0.54 (0.29)	0.36 (0.19)			0.58 (0.37)
Red tilapia	1.94 (2.69)	0.61 (0.00)	1.19 (1.48)	1.11 (1.05)	1.57 (2.17)

Fish production by species is provided below in Table 14. A large proportion of all sampled clients in all four provinces reported raising Pangasiuscatfish (36.5 percent of respondents); the average production was 763.6 kg, and 89 percent of households reported having sold some of their fish output. Walking catfish was raised by 27 percent of respondents; the average production was 360.1kg, and 97 percent of households reported having sold.

Looking at what they do with their fish production reveals that the majority of them sold their fish. For instance, out of the average production of 417.1kg of climbing perch, all respondents (n=41) sold355.7kg.Out of the average production of 360.1kg of walking catfish, 82 out of 85 respondents reported selling 292.5kg. Out of the average production of 378.2kg of Nile tilapia, 26 out of 30 respondents reported selling their fish (251.1kg); out of 763.6kg of Pangasiuscatfish, 108 out of 115 respondents reported selling their fish

(707.7kg); out of 181kg of silver barb, seven out of eight respondents sold 148.1kg; and out of 362.1kg of Red tilapia, 42 out of 43 respondents reported selling 296.9 kg. This indicates that aquaculture can be one source of livelihood diversification in rural areas.

Table 14. Production by species

Fish species	Total fish produced (kg)		HH reported to have sold fish		Average amount of fish sold (kg)	Revenue received (USD)
	Freq.	Mean (SD)	Freq.	Percent	Mean (SD)	Mean (SD)
Climbing perch	41	417.1 (403.5)	41	100%	355.7 (372.3)	631.0(680.3)
Walking catfish	85	360.1 (479.0)	82	97%	292.5 (373.1)	446.4(622.4)
Nile tilapia	30	378.2 (541.9)	26	79%	251.1 (455.4)	411.4(678.2)
Pangasiuscatfish	115	763.6 (587.6)	108	89%	707.7 (537.7)	834.0(613.0)
Silver barb	8	181.0 (138.5)	7	78%	148.1 (124.5)	276.9(243.5)
Red tilapia	43	362.1 (415.3)	42	91%	296.9 (383.4)	575.8(733.8)
Total	315	520.3(543.1)	298	92%	451.2(488.8)	631.6(676.5)

Figure 4 below presents the total production of climbing perch in relation to fish pond size. The red bar represents the total fish production corresponding to the blue bar that represents the pond size. In total, 38 clients reported raising climbing perch. The data identify eight data sets as outliers -- the values were too extreme. Therefore, this graph shows only 30 clients with 30 fish pond sizes. The smallest pond size among the sample clients is 25m^2; the largest size is 750m^2.The lowest production of fish in the previous 12 months was 65kg, and the highest production was 1,178kg.

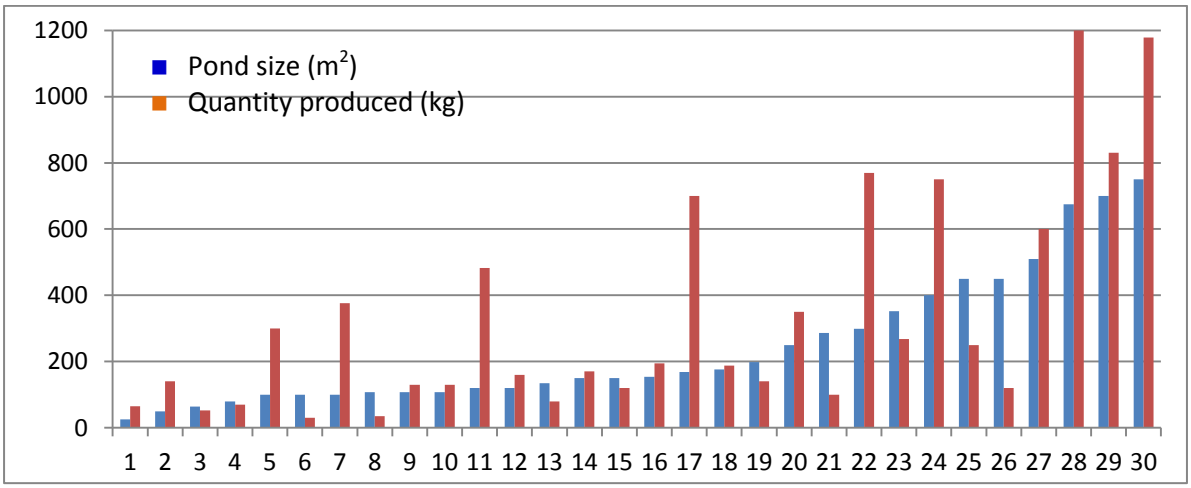

Figure 4.Climbing perch—comparison of pond size and fish production (n=19)

Nineteen of the 30 clients raised climbing perch. The trend of the yield is that the larger the pond size, the higher the fish yield. The total production of the 30 clients was 9,979.60kg.With the total pond size of 7,336m^2, the average production per square meter is 1.36kg.

Eighty-two clients reported raising walking catfish. However, there are 10 cases with extreme data, so this graph represents only 72 cases.

In general, the trend is that the larger the pond size, the higher the fish yield. However, there are a number of cases of large ponds and low yields and vice versa.

For all 72 cases presented in Figure 5 below, the total fish production in the previous 12 months was 17,846kg. The total pond size was 12,382m^2, so the average production per square meter was 1.44kg.

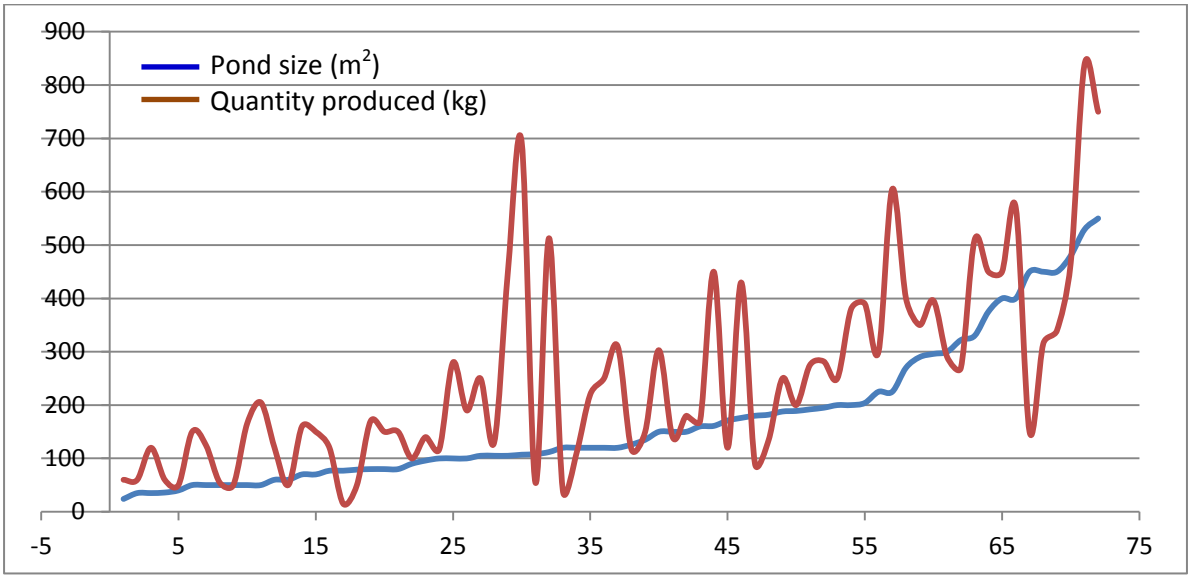

Figure 5.Walking catfish—comparison of pond size and fish production (n=72)

Of 118 respondents who reported raising Pangasuis catfish, 12 cases either did not report the yield or the data was too extreme. Figure 6 below represents106 cases. In general, the trend is that the amount of fish production increased according to pond size. However, a number of cases are exceptional, either because the amount of fish production was high compared with the other data or the fish yield was low compared with the pond size.

With the total production of 80,796kgand the total pond size of 36,150m^2, the average production per square meter was 2.24kg.

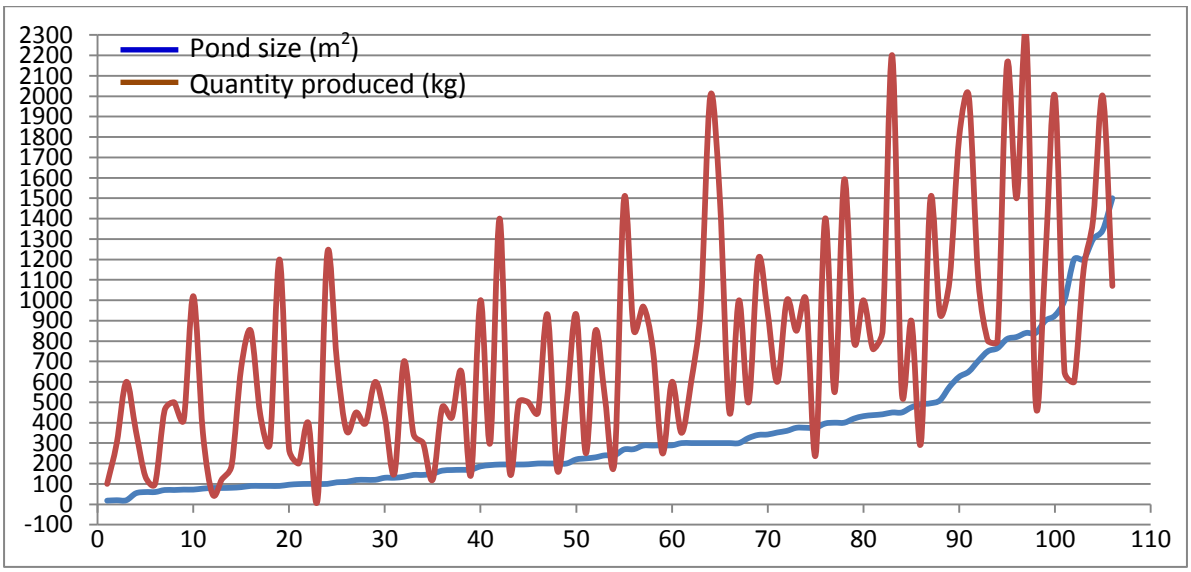

Figure 6.Pangasius catfish—comparison of pond size and fish production (n=106)

Twenty-eight clients reported raising Nile tilapia. Five extreme data sets were treated as outliers, and the analysis is based on 23 cases. The lowest pond size was 28m^2, and the highest was 675m^2.The range of production was between 315kg and 580kg.

The pattern in raising Nile tilapia differs from that of other species. For instance, Figure 7 below indicates that bigger ponds do not necessarily mean higher fish yield. For instance, there are five cases where the pond size is small and the total yield is high. In other cases, pond size is large but production is low. Further investigation is needed to identify the reasons for this variation.

The 23 cases account for 4,820kg in total fish produced in a total pond size of 4,559m^2. Therefore, the average fish production per square meter was 1.06kg.

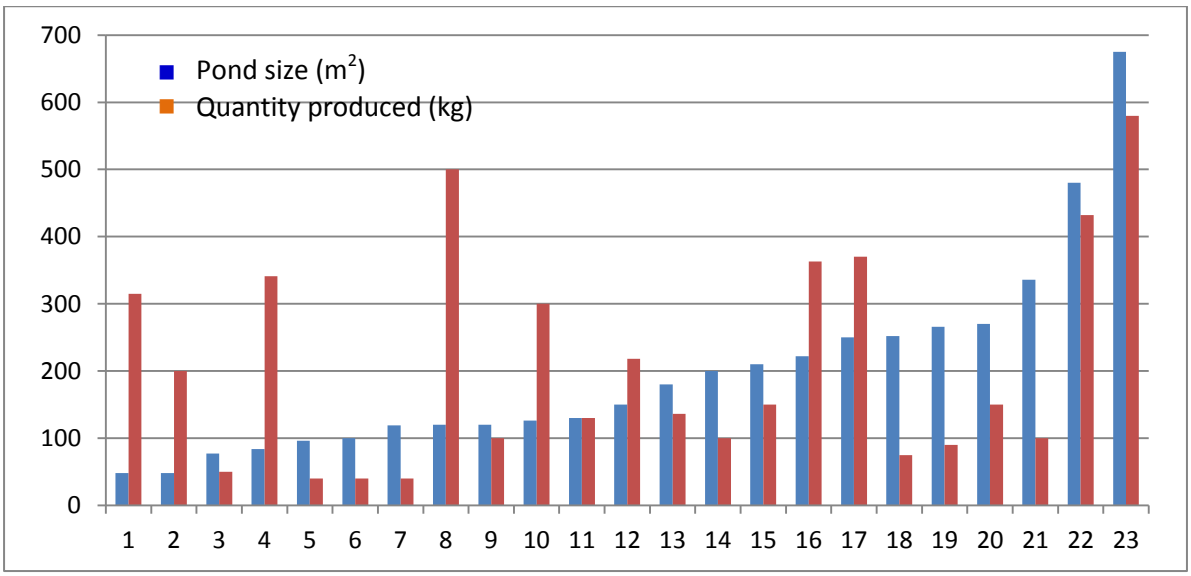

Figure 7.Nile tilapia—comparison of pond size and fish production (n=23)

Figure 8 below is the data set representing the results of comparing pond size with yield of red tilapia. In general, the trend is the same as that in the graph representing Nile tilapia production.

In the 42 cases reporting raising red tilapia, nine cases of extreme data were treated as outliers and excluded from this analysis. In one case, there was no report of the total fish produced. Therefore, the graph below represents 32 cases.

In general, there are five cases where the fish yield was high compared with the pond size. For the rest, the majority trend is that production was low compared with fish pond size. With total fish production of 10,329kg and total pond size of 8,870m^2, the average fish production per square meter was 1.16kg.

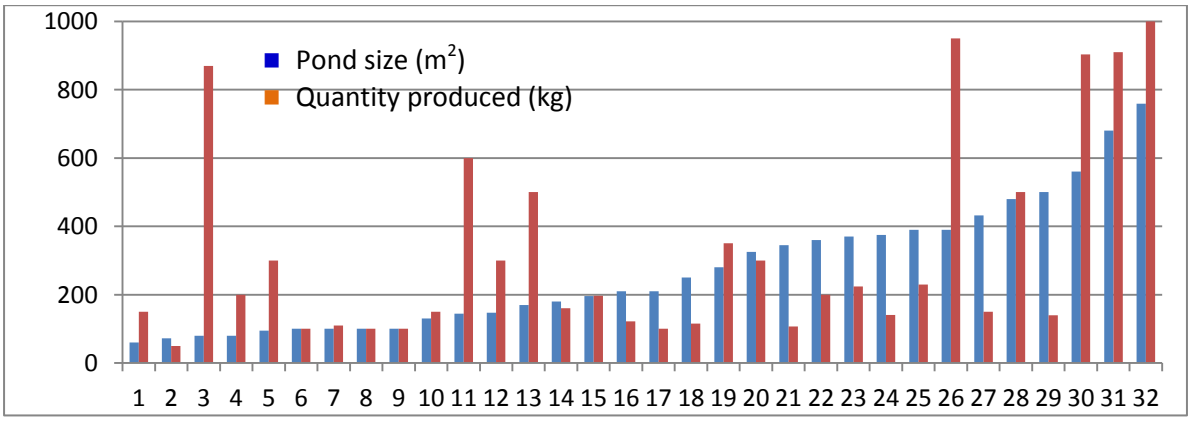

Figure 8.Red tilapia—comparison of pond size and fish production (n=32)

Only seven clients reported raising silver barb (see Figure 9). One case of extreme data was excluded from analysis, so the graph below represents six cases. The trend line is that pond size was big but fish production was low.

With the total fish production of 923kg and the total pond size of 1,758m^2, the average fish production per square meter was 0.53kg.

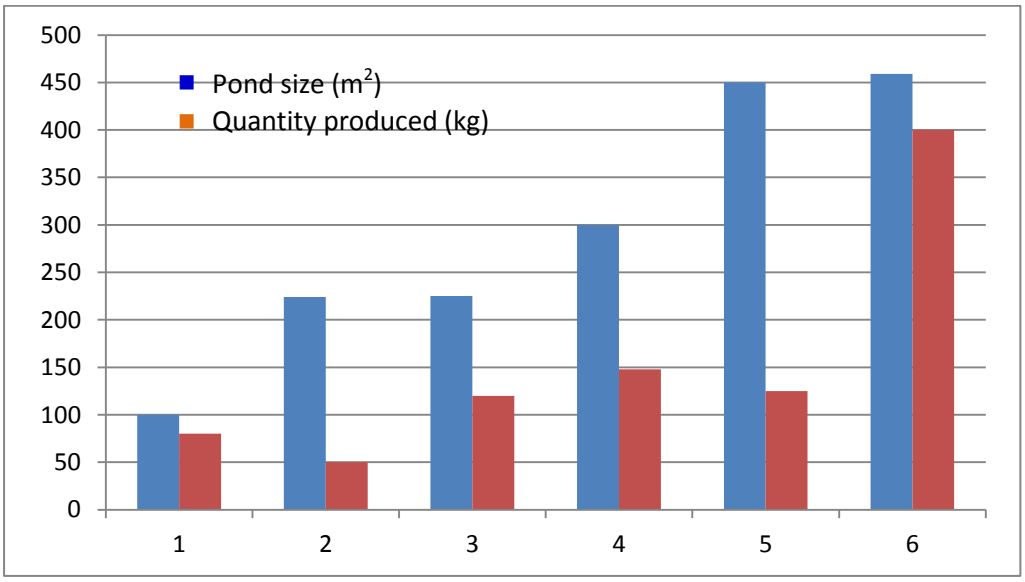

Figure 9.Silver barb—comparison of pond size and fish production (n=6)

Drivers of adoption

Numerous drivers of adoption were identified in the study, including the increasing scarcity of wild fish, increased earnings potential from aquaculture production, advantages of working from home over migration, and increased household food availability. The majority of clients (324) who indicated that they would continue raising fish mentioned continuing to utilize these technologies (see Figure 10).Between 80 percent and 90 percent of farmers mentioned they would continue to buy fingerlings, lime and commercial fish feed, and continue raising fish using ponds. Only 63 percent mentioned purchasing fencing, and this technology is apparently vital to success. The relatively low percentage does not necessarily mean that clients will not use this technology; some clients may use readily available resources for fencing their ponds. Fewer than half of respondents mentioned continuing to use purchased fertilizer and stocking hapa.

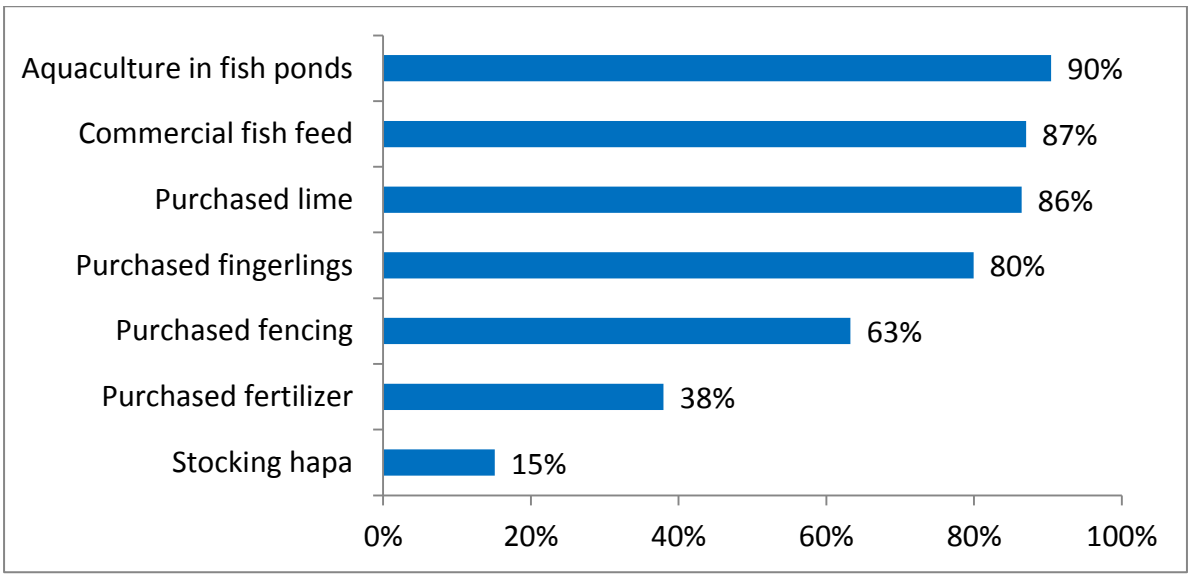

Figure 10.Adoption of fish farming technologies (n=324)

Table 15 below indicates minor differences in percentage of adoption of each technology by wealth group. In some cases, poor households reported a greater likelihood of using some technologies than non-poor households (e.g., purchased fingerlings).

Table 15. Adoption of technologies by wealth group

Fish technologies	Poor *(n=50)*	Non-poor *(n=274)*	Total *(N=324)*
Aquaculture in fish ponds	98%	89%	90%
Purchased fingerlings	88%	79%	80%
Commercial fish feed	88%	87%	87%
Purchased fertilizer	42%	37%	38%
Purchased lime	78%	88%	86%
Purchased fencing	64%	63%	63%
Stocking hapa	16%	15%	15%

Average expenditure on inputs in previous production cycle by wealth group are provided below in Figure 11. Unexpectedly, clients categorized as poor households spent more money than non-poor clients in purchasing most required inputs. For instance, poor households reported having spent approximately $246.30 to buy commercial fish feed; non-poor households spent slightly less, with the average being $238.50.The results demonstrate that commercial fish feed represents greater operational cost per cycle than any other input.

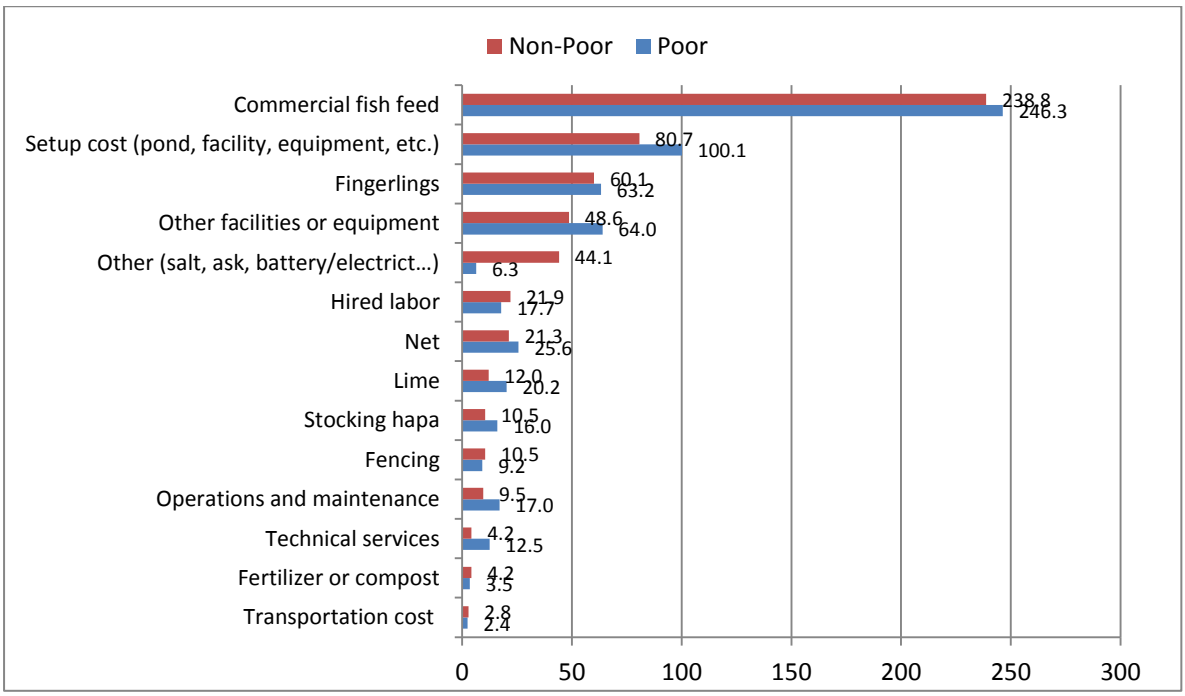

Figure 11. Average expenditure on inputs by wealth group (USD)

Barriers to the adoption of improved farming practices and technologies

The 228 respondents who said they would continue raising fish by applying technologies recommended to them by the Cambodia HARVEST Aquaculture Program responded to questions about factors that hindered them from adopting improved farming practices or technologies. Out of 16 factors (presented in Figure 12 below), lack of water was the most important barrier for 54.8 percent of respondents (the majority of the answers). The second most common response was the market price of local small-scale aquaculture fish (clients complained that the price was fairly below market price), and the third most common response was the price of commercial fish feed. Respondents indicated that the expense of commercial fish feed reduces potential profit.

Therefore, for the long-term sustainability of small-scale aquaculture, secure access to sufficient freshwater for fish production will be an important priority. Addressing the high cost of commercial fish feed may facilitate greater adoption of small-scale aquaculture, particularly among poor households.

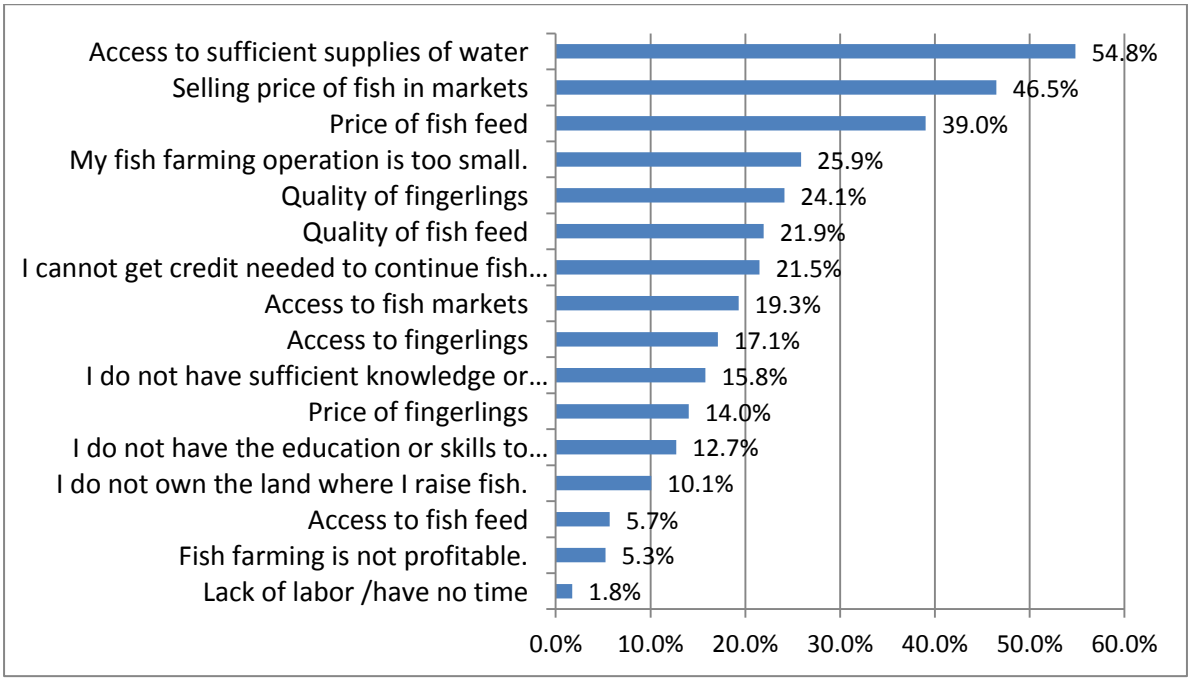

Figure 12.Barriers to adoption of improved farming practices or technologies (n=228)

When asked about important barriers to adoption of improved farming practices or technologies, the largest proportion of clients (124 respondents) reported owning ponds of between 100m^{2}and 400m^2. Only 56 and 48 respondents owned fish ponds smaller than 100m^2 (category 1) or over 400m^2 (category 3), respectively (see Table 16).

Clients with small ponds faced more challenges in adopting improved farming practices or technologies than clients with larger fish ponds. For instance, 30.4 percent of clients with small ponds faced difficulties in accessing fingerlings, compared with 4.2 percent of clients who owned fish ponds in category 3.Also, the price of fingerlings and access to fish feed were of greater concern to respondents with small ponds. In general, clients who owned small fish ponds faced more barriers in adopting improved farming practices or technologies than clients who owned larger fish ponds. In addition, insufficient access to water for fish ponds, access to fish markets, and the price of fish feed are common barriers faced by all clients.

Table 16. Barriers to adoption of improved farming practices or technologies by pond size

	<= 100m^2 *(n=56)*	100.01m^2–400m^2 *(n=124)*	Over 400m^2 *(n=48)*	Total *(N=228)*
Access to fingerlings	30.4%	16.1%	4.2%	17.1%
Price of fingerlings	23.2%	12.9%	6.3%	14.0%
Quality of fingerlings	32.1%	20.2%	25.0%	24.1%
Access to fish feed	12.5%	4.8%	0%	5.7%

Price of fish feed	42.9%	33.1%	50.0%	39.0%
Quality of fish feed	30.4%	20.2%	16.7%	21.9%
Selling price of fish in markets	39.3%	46.8%	54.2%	46.5%
Access to fish markets	21.4%	18.5%	18.8%	19.3%
Access to sufficient supplies of water	64.3%	54.0%	45.8%	54.8%
I do not have sufficient knowledge or information about the technology.	14.3%	18.5%	10.4%	15.8%
I do not have the education or skills to adopt the new technology.	8.9%	14.5%	12.5%	12.7%
Adoption of the new technology is not profitable.	8.9%	5.6%	0%	5.3%
The fish farming technology is not suitable to my operation.	8.9%	8.1%	2.1%	7.0%
I cannot get credit needed to adopt the new technology.	32.1%	17.7%	18.8%	21.5%
I do not own the land where I raise fish.	10.7%	9.7%	10.4%	10.1%
My fish farming operation is too small.	35.7%	27.4%	10.4%	25.9%
Other reasons	0%	1.6%	6.3%	2.2%
High disease and/or high fish dead/lost	3.6%	4.0%	6.3%	4.4%
Have no time	0%	3.2%	0%	1.8%
Heavy rain/flash flood	0%	4.8%	2.1%	3.1%
Thieves	1.8%	4.0%	4.2%	3.5%

Factors related to disadoption

Not all respondents have continued to raise fish. Out of 436, 112 clients had already stopped the activity at the time of the household survey; of those, 10 were poor clients and 102 were non-poor clients (see Table 17).More than half of respondents indicated that they stopped raising fish because of problems related to access to fresh water. Approximately half of respondents indicated that they stopped raising fish because of high prices for commercial fish feed. Concerns about the selling price of fish in markets and the profitability of small-scale fishing operations were also among the major reasons.

Responses to questions about the reasons for stopping fish production are provided below in Figure 13. Access to sufficient supplies of water was identified as the most important reason for disadoption of aquaculture practices. Other common barriers to adoption of continuing to raise fish were the price of fish feed, low selling price of aquaculture fish, and profitability. Other factors were noted, including access to quality fingerlings, as well as access to credit, labor, and fish markets.

Table 17. Reasons for disadoption of aquaculture practices, by wealth group

Variable	Poor *(n=10)*	Non-poor *(n=102)*	Total *(N=112)*
Access to fingerlings	20.0%	24.5%	24.1%
Price of fingerlings	20.0%	20.6%	20.5%
Quality of fingerlings	30.0%	26.5%	26.8%
Access to fish feed	10.0%	15.7%	15.2%
Price of fish feed	50.0%	49.0%	49.1%
Quality of fish feed	20.0%	19.6%	19.6%
Selling price of fish in markets	20.0%	48.0%	45.5%
Access to fish markets	20.0%	23.5%	23.2%
Access to sufficient supplies of water	50.0%	56.9%	56.3%
I do not have sufficient knowledge or information about fish farming.	20.0%	14.7%	15.2%
I do not have the education or skills to continue fish farming.	10.0%	12.7%	12.5%
Fish farming is not profitable.	30.0%	41.2%	40.2%
The fish farming technology is not suitable to my operation.	10.0%	8.8%	8.9%
I cannot get credit needed to continue fish farming	30.0%	26.5%	26.8%
I do not own the land where I raise fish.	20.0%	12.7%	13.4%
My fish farming operation is too small.	20.0%	22.5%	22.3%
Fish did not grow, high disease/dead	0.0%	3.9%	3.6%
Far from home /thieves	20.0%	4.9%	6.3%
Lack of labor /have no time	30.0%	23.5%	24.1%
Other reasons	0.0%	4.9%	4.5%

The survey also asked both clients who disadopted and clients who continued raising fish about their perspectives on small-scale aquaculture as a whole. In general, clients in both groups had similar views (see Figure 14). For instance, 99.4 percent of those who continued raising fish and 94.6 percent of those who disadopted indicated that small-scale aquaculture is environmentally beneficial for the sustainability of the Tonle Sap Lake. They understood that, when more farmers raise fish, there is less pressure on the Tonle Sap capture fishery. When asking about fish feed, most clients from both groups responded with a positive view of aquaculture, and they indicated that availability of fish feed was not a major concern. Furthermore, most clients from both indicated that they considered small-scale aquaculture to be a good livelihood activity, and most indicated that they would encourage their friends and family members to participate in the activity.

In terms of economic factors, there is some divergence in their perspectives. As expected, a greater proportion of clients who committed to continuing to raise fish agreed that small-scale aquaculture is an economically viable and profitable activity, as compared to the group who disadopted. There was also a greater difference between the two groups in

terms of the risks of aquaculture and the quality of fish produced. In both cases, more respondents who had disadopted identified these factors as barriers.

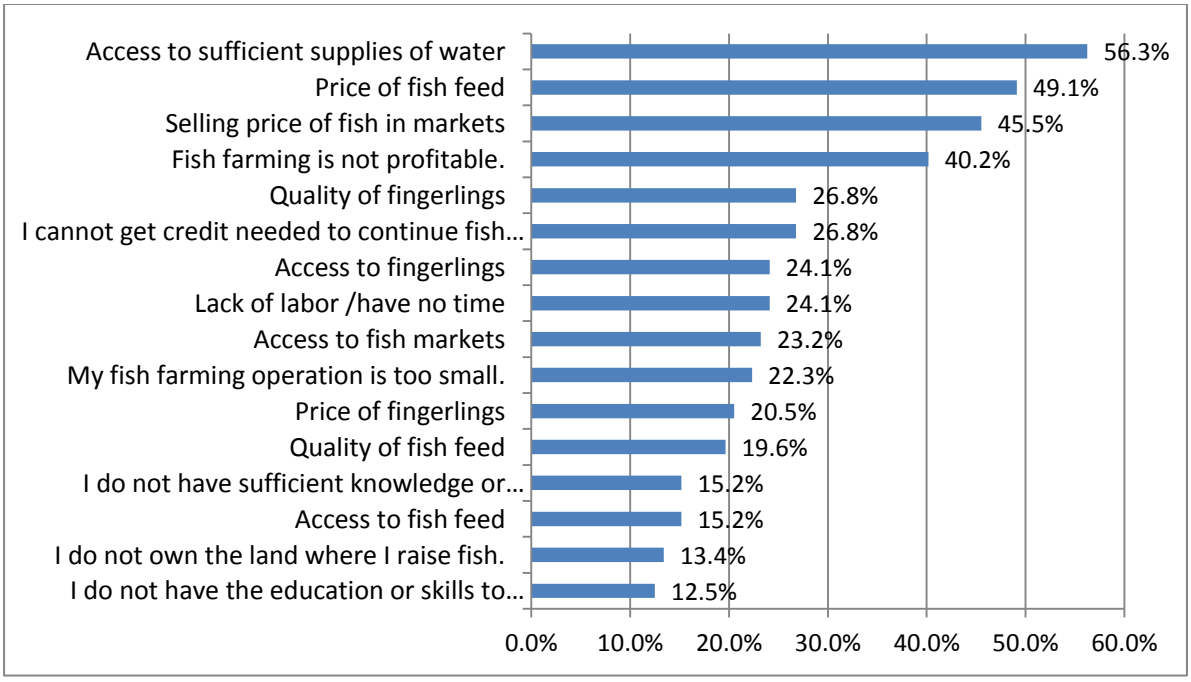

Figure 13.Reasons for disadoption of aquaculture practices (n=112)

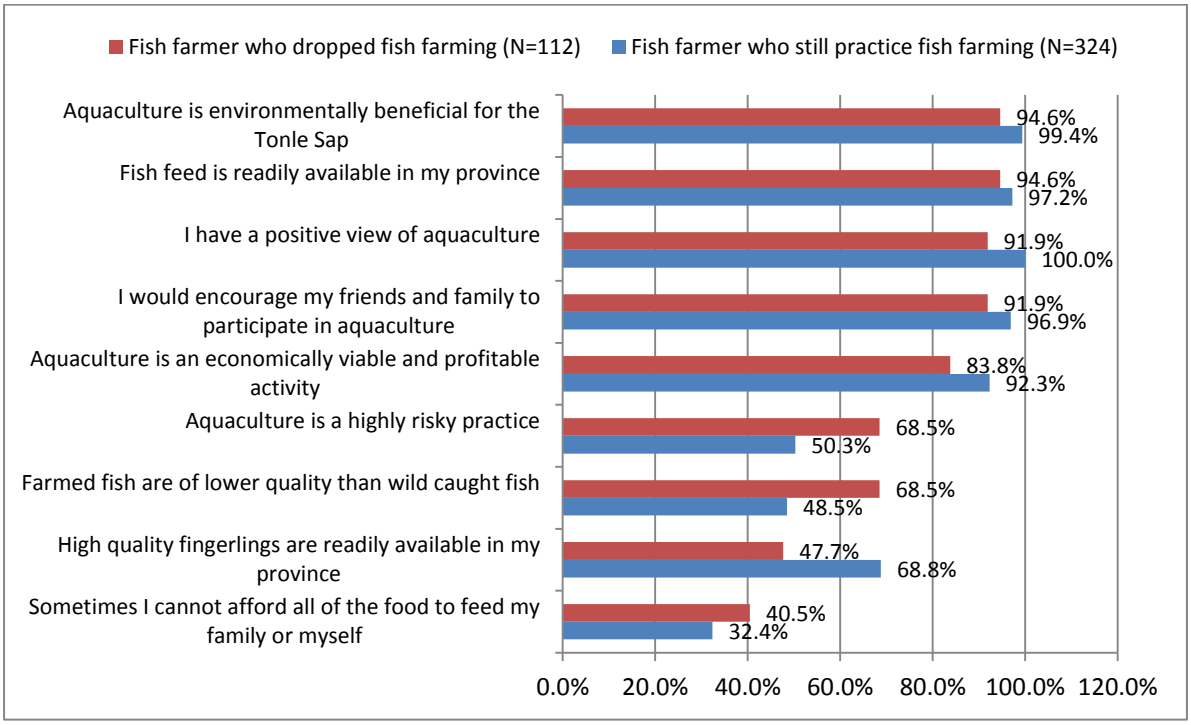

Figure 14.Comparison of clients' perceptions related to raising fish

6. Conclusions and Recommendations

The most effective elements of success of the Cambodia HARVEST Aquaculture Program were client recruitment and training. Most clients were willing to learn and to practice the technologies disseminated through training. Study tours and site visits were noted as effective in providing new clients an opportunity to discuss what they have learned with practicing farmers. Experience sharing helped build the confidence of new clients in putting technologies into practice. Follow-up visits by trainers were also important for success because working with a trainer on a one-on-one basis helped clients gain confidence in practicing the technology correctly.

Recommended technologies such as the formula for the fish-feeding regime were also noted as effective, as they helped farmers learn to calculate the proper amount of fish feed in each stage of the cycle. Learning to avoid overfeeding fish allowed farmers to save money on fish feed.

Fingerling producers played an important role as local change agents because these producers had better knowledge and skills and more experience than other clients. Fingerlings producers always encouraged each client to prepare the pond sufficiently (according to the technology) before they could buy fingerlings. Success also depended on each client's ability to afford inputs, especially fish feed for daily operation.

Numerous drivers of adoption of small-scale aquaculture production were identified in both the FGDs and the household survey, including the increasing scarcity of wild fish, increased earnings potential from aquaculture, advantages of working from home over migration, increased household food availability, and increased household income.

Adoption of small-scale aquaculture systems is limited by several factors, including access to water, prices of commercial fish feed, selling price of fish in markets, and concerns about profitability. Access to fingerlings was identified as a regional barrier. Limited provision of extension services, market access, land access and off-farm employment opportunities present significant barriers to effective development of community fisheries and threaten food security and biodiversity conservation. In this context, small-scale aquaculture has the potential to enhance the sustainability of rural livelihoods in the Tonle Sap region by providing a key source protein to vulnerable rural populations.

The majority of the Cambodia HARVEST Aquaculture Program participants were categorized as non-poor households, which appears to be related to the requirements for availability of land for ponds. Both poor and non-poor households reported having owned cattle, buffalo, pigs, chickens and ducks. But average non-poor households owned larger numbers of livestock than poor households. Both poor and non-poor households had diverse sources of income, but sale of rice from the farm was the major income source for both poor and non-poor households. Wage labor was also important in both groups.

The study reveals that the Cambodia HARVEST Aquaculture Program appears to have effectively transferred small-scale aquaculture technologies to farmers in all of the four provinces. During the program lifecycle, all clients indicated that they received large amounts of technology advice from the program, and that new and improved farming practices or technologies had potential to contribute to food security, nutrition and household income.

Approximately one quarter of respondents reported having stopped fish farming as a livelihood activity altogether. The main reasons behind this are not the quality of technology but issues related to inputs and marketing, such as the availability of water, the price of fish feed, the selling price of fish in the market, concerns about profitability, and the quality of fingerlings.

Aquaculture technology appears to have the potential to contribute to food security, nutrition, and household income, it is important that aquaculture policy address barriers to adoption and scaling out, such as issues related to access to freshwater for ponds, poorly-developed input supply chains, and the availability of markets, especially in rural areas. For example, in addition to the promoted technologies, it is important for the subsector to ensure a quality supply of fingerlings locally throughout the region. It is also important that aquaculture extension services be strengthened. Given the importance of informal advice from neighbors and friends as a source of information, there are significant implications for the scaling out of small-scale aquaculture and the long-term sustainability of smallholder aquaculture in the region. However, there is a need for further research to examine the social networks of aquaculture farmers to better understand how technologies and practices are disseminated and diffused, and which factors determine the adoption of technologies learned from neighbors and friends. Farmer field schools and the use of lead farmers (or model farmers) could be used to promote the adoption of aquaculture technologies to neighboring farmers.

Water remains the most prominent challenge in promoting aquaculture technologies, so aquaculture development should be expanded in areas where there are abundant supplies of water, or where water storage techniques are feasible. It is important to consider the importance of the potential benefits to aquaculture development in adapting to the effects of global climate change, and in promoting benefits to biodiversity conservation, diversifying livelihood strategies, reducing reliance on wild fish stocks, promoting practices to reduce losses during flooding, and demonstrating fish production on a seasonal basis (during the wet season) to mitigate the effects of prolonged drought periods.

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Appendix 1: Focus Group Discussion Guide

Component/Activity

Training and development

There has been some aquaculture training as well as some aquaculture demonstrations in the region. I would like to ask you about both the demonstrations and the training.

1. First, I would like to learn from each of you if you or your group received aquaculture training.

[If YES, then]

a. Please share with me the name, type, and duration of the aquaculture training received?

b. Was the training/ workshop you participated in useful? Why/Why not?

c. Can you give me some examples of what part(s) of the training you found to be useful?

d. Can you give me some examples of parts of the training that were not useful?

e. What are some ways that the aquaculture training might be improved or more useful?

[If NO, then]

f. What, if anything, have you heard about aquaculture training in the area?

g. What, if anything, have you observed about aquaculture training in the area?

Demonstration/Dissemination

2. Now, I would like to learn from each of you about aquaculture demonstrations in the region. Did you attend an aquaculture demonstration?

[If YES, then]

a. Please share with me the technology you saw demonstrated? When? Where?

b. Did you adopt/apply this technology? Why?

c. Do you currently use/practice that technology? If not, why not?

d. Do other fishers nearby practice this technology?

[If NO, then]

e. What, if anything, have you heard about aquaculture demonstrations in the region?

Possible Improvements/Barriers

3. As you think about your own fishery operation and the fish you raise, are there fish farming practices or technologies that you would like to adopt/use that you think would improve your farm's productivity? If so, what are they? Describe them?

4. Can you describe for me some reasons that fishery and/or aquaculture is not more fully developed in your community? Give me some examples of some barriers to improved fishery/aquaculture operations?

Technical Support-HARVEST

5. Have you received technical support from the HARVEST project?

[If YES, then]

a. What kind of technical support did you receive? When?

b. How satisfied or dissatisfied are you with these services? Why?

Aquaculture Technology – Return

6. Did you adopt a new aquaculture technology as a result of HARVEST project?

[If YES, then]

a. What technology did you adopt? Why?

b. Was that aquaculture technology you adopted profitable?

c. On an average, what was your income per unit area using the technology?

d. How did your income with the technology compare to your income before technology?

Aquaculture – Marketing

7. Let us talk about marketing.

a. Where do you buy inputs for your aquaculture operation?

b. Where do you sell your fish products?

c. Do you get fair price of you fish products? Explain

Capacity Building and Sustainability

8. Do you wish to continue your aquaculture activity after the withdrawal of the HARVEST project support?
    a. If YES, why?
    b. If NO, why not?

9. How can the government/others improve its role in helping farmers like you?

Impacts

10. In your own words, how would you describe your experience with the HARVEST program's aquaculture project?
    a. Has your household income changed? How?
    b. Has your household fish consumption changed? How?

11. Can you describe ways that the HARVEST program impacted your aquaculture and/or fish farming?

12. How could the HARVEST project have been improved to enhance aquaculture?

Thank You

Thank you all for your help with today's discussion. I have learned a great deal.

Appendix 2: Aquaculture Household Survey Questionnaire

MODULE A. HOUSEHOLD IDENTIFICATION

A1. HOUSEHOLD IDENTIFICATION

Code	Item	Province	District	Commune	Village	Household
		A101	A102	A103	A104	A105
	Name (Location)					
	Code (location)					
A106	GPS coordinates	(N):		(E):		
A107	Code of enumerator					
A108	Date of visit	_____ dd / _____ mm / _____ yyyy				
A109	Time: Start/End (hours)					
A110	Wealth group:	1. Non-poor ____	2. Poor 1 _____	3. Poor 2 ____		
A111	Name of respondent:					

MODULE B. FISH PRODUCTION, SALES, INPUT USE IN THE LAST COMPLETED PRODUCTION CYCLE

B1. FISH FARMING

B101	Has this household ever raised fish? (current or past)	1=YES (continue below) 2=NO (skip to B104)	
B102	Prior to HARVEST, did this household have an existing barrow pit?	1=YES 2=NO	
B103	Prior to HARVEST, did this household have an existing fish pond?	1=YES 2=NO	
B104	Does this household also participate in HARVEST horticulture (vegetable growing) programs?	1=YES 2=NO	
B105	Does this household also participate in HARVEST rice production programs?	1=YES 2=NO	
B106	Have you sold fish for income?	1= YES (continue below) 2= NO (skip to B108)	
B107	Approximately how much of your total household income is from selling farmed fish?	1=Almost all 2=Most of it 3=Some of it 4=A small amount 5=None	
B108	Have you sold vegetables for income?	1= YES (continue below) 2= NO (skip to B110)	
B109	Approximately how much of your total household income is from selling vegetables?	1=Almost all 2=Most of it 3=Some of it 4=A small amount 5=None	
B110	Have you sold rice for income?	1= YES (continue below) 2= NO (skip to B112)	

B111	Approximately how much of your total household income is from selling rice?	1=Almost all 2=Most of it 3=Some of it 4=A small amount 5=None	
B112	Does this household currently raise fish?	1= YES (continue below) 2= NO (>> Module D)	
B113	Approximately how long have you raised fish?	Years	
B114	How many fish production cycles have you completed with the HARVEST program?	Number (0-4)	
B115	In the past 12 months, approximately how much total fish did this household produce?	Kilograms (kg)	
B116	Approximately how much of your harvest did this household consume as food?	1=Almost all 2=Most of it 3=Some of it 4=A small amount 5=None	

B2. FISH PRODUCTION AND SALES

ENUMERATOR: In the table below, list all the species of fish the household report having raised during the last production cycle. Then, for each species, ask the questions regarding production and sales.

Fish Species and Codes		**Aquaculture Facility**		**Feed**	**How much did you produce?**	***Did you sell any [FISH SPECIES] from the last production cycle?*** **1=YES** **2=NO**(skip to next species)	**Sales of FISH**	
	code	**code**	**Size** (m^2)	**Feed type code**	**Quantity** (kg)		**Quantity** (kg)	***How much did you receive in sales?*** (000s Riels)
FISH SPECIES	**B201**	**B202**	**B203**	**B204**	**B205**	**B206**	**B207**	**B208**

Fish species codes (B201):
1= Climbing Perch
2= Walking Catfish
3= Nile Tilapia
4= Pangasius Catfish
5=Silver Barb
6=Indian Carp
7= Common Carp
8= Silver Carp
9=Other (please specify)

Facility codes (B202):
1=Fish pond
2=Rice/fish intercrop
3=Community fishery
4=Steel cage
5=Wood cage
6=Other (please specify)

Feed type codes (B204):
1=Purchased feed
2=Feed provided
3=Homemade feed
4=Trash fish only

B3. USE OF INPUTS IN FISH PRODUCTION

ENUMERATOR: If the household produced any type of fish (B2), complete the table below. It refers to the use of inputs with respect to fish production during the last production cycle. The spending figures should be related to inputs used in the aggregate for all species of fish.

Input Type and Code		***Did you use* [INPUT TYPE] *in fish production during the last production cycle?*** **1=YES 2=NO (>> next type)**	***What was the source?*** **(Source code list)**	***If purchased, how much did you pay in the total?*** **(Riels)**
	code			
INPUT TYPE		**A**	**B**	**C**
Setup cost (pond, facility, equipment, etc.)	**B301**			
Fingerlings	**B302**			
Commercial fish feed	**B303**			
Fertilizer or compost	**B304**			
Lime	**B305**			
Net	**B306**			
Fencing	**B307**			
Stocking hapa	**B308**			
Transportation cost	**B309**			
Technical services	**B310**			
Operations and maintenance	**B311**			
Other facilities or equipment	**B312**			
Hired labor	**B313**			
Other (specify)	**B314**			
Source codes: 1=Own (self-produced) 2=Provided free by HARVEST program 3=Purchased from dealer 4=Purchased from farmer		5=Provided free by another program (NGO or government) 6-Provided free by friend, neighbour, or family 7= Combination of own and purchased 8=Combination of own and provided free 9=Combination of purchased and provided free 10=others (specify)		

How likely are you to use these fish farming technologies in the future?

Code	Fish technologies	Very likely	Somewhat likely	Neutral	Unlikely	Very unlikely
B315	Aquaculture in fish ponds					
B316	Purchased fingerlings					
B317	Commercial fish feed					
B318	Purchased fertilizer					
B319	Purchased lime					
B320	Purchased fencing					
B321	Stocking hapa					

B4. PERCEPTIONS OF FISH FARMING

B401. *Think about the way you raise your fish. Do you feel you can improve your fish yield by adopting the new technologies (provided to you by HARVEST) and modify your way of normal practice***?**	**1= YES** **2= NO** **3=unsure**	

B402. *Do you believe that there are barriers to fully adopt these aquaculture technologies brought to you by Harvest?* If NO, please skip to question B420.	**1= YES** **2= NO** **3=unsure**	

If YES, let me read some barriers, please indicate how important you feel these barriers are(from 1=Not at all important to 5=Very important):

	Barriers to adoption of new/improved farming practices or technologies	1= Not at all important 2= A little important 3= Neutral 4= Somewhat important 5= Very important
B403	Access to fingerlings	
B404	Price of fingerlings	
B405	Quality of fingerlings	
B406	Access to fish feed	
B407	Price of fish feed	
B408	Quality of fish feed	
B409	Selling price of fish in markets	
B410	Access to fish markets	
B411	Access to sufficient supplies of water	
B412	I do not know the new technology	
B413	I do not understand the new technology	
B414	Adoption of the new technology does not make any differences	
B415	The fish farming technology is not suitable to my operation.	
B416	I cannot get credit needed to adopt the new technology.	
B417	I do not own the land where I raise fish.	
B418	My fish farming operation is too small.	
B419	Other reasons (please specify…)	

In response to the following statements, please respond by saying if you agree, disagree, or neither:

	Statement	**Code** 1 = Agree 2 = Disagree 3 = Neither
B420	I have a good feeling about aquaculture	
B421	Farmed fish are less delicious than wild caught fish	
B422	Fish feed is readily available in my province	
B423	Sometimes I cannot afford all of the food to feed my family or myself	
B424	Aquaculture is a highly risky practice	
B425	I would encourage my friends and family to participate in aquaculture	
B426	High quality fingerlings are readily available in my province	
B427	Aquaculture helps to conserve natural resources in the Tonle Sap	
B428	Aquaculture is an economically viable and profitable activity	

MODULE C. ACCESS TO EXTENSION AND ADVISORY SERVICES

C1. FISH PRODUCTION AND MARKETING

ENUMERATOR: In this section, please collect information on reception of extension and advisory services for fish production and marketing.***I will read a list of extension service providers, please tell me whether you have used services from any of these providers and how often you have used their services in the past 12 months.***

Code	Extension Service Provider	Have you received services from them? 1= YES* 2= NO	*If Yes, number of times contacted in past one year	What type of practice, information, or access did you learn about with this service? (codes)	Did you pay for the service? 1=YES 2=NO	After receiving the advice, did you follow it? 1=YES 2=NO
		A	B	C	D	E
C102	District agricultural service center, extension agent					
C103	Local village/commune office					
C104	Fertilizer or Input supply dealer					
C105	HARVEST program					
C106	Other program or project (besides HARVEST program)					
C107	University or college of agriculture					
C108	Technical or vocational schools					
C109	Cambodian Agricultural Research and Development Institute (CARDI)					
C110	Agricultural research station					
C111	Fish trader					
C112	Neighbors or friends					
C113	Other (Please specify)					
Extension type codes: 1=Fish farming techniques 2=Input usage 3=Pond construction 4=Pond management 5=Drying at post-harvest 6=Storage facilities 7=Advice on output prices 8=Advice on input prices 9=Information on where to sell 10=Credit, micro-finance, or savings 11=Other (please specify)						

C2. SOURCES OF INFORMATION

What is your main source of information about fish farming, I will read the list of possible information source and please indicate how much you use the source for information.

	Type of information	1= Nothing at all 2= A little 3= Some 4= A fair amount 5= A great deal
C201	HARVEST technicians	
C202	Newspapers and magazines	
C203	Extension publications	
C204	Television programs	
C205	Radio programs	
C207	Web/Internet/E-mail	
C208	Extension meetings, workshops, courses	
C209	Aquaculture researchers	

C210	Demonstrations fish farming operations and field days	
C211	Personal contact with extension agents	
C212	Leader farmers in your area	
C213	Neighbors/relatives	
C214	Other sources (Please specify)	

MODULE D. DISADOPTION

ENUMERATOR: This section is only for those households that no longer raise fish (answered **NO** to Question **B112**). For all other households, please skip this module.

D1. Fish production cycles completed

D101	How many fish production cycles did you complete with the HARVEST program?	Number (0-4)	
D102	Did you stop practicing fish farming?	1=YES 2=NO	

How important were the following factors to your decision to stop fish farming?

	Factors related to decision to stop practicing fish farming	1= Not at all important 2= A little important 3= Neutral 4= Somewhat important 5= Very important
D103	Access to fingerlings	
D104	Price of fingerlings	
D105	Quality of fingerlings	
D106	Access to fish feed	
D107	Price of fish feed	
D108	Quality of fish feed	
D109	Selling price of fish in markets	
D110	Access to fish markets	
D111	Access to sufficient supplies of water	
D112	I do not know the new technology	
D113	I do not understand the new technology	
D114	Fish farming is not profitable.	
D115	The fish farming technology is not suitable to my operation.	
D116	I cannot get credit needed to continue fish farming.	
D117	I do not own the land where I raise fish.	
D118	My fish farming operation is too small.	
D119	Other reasons (please specify…)	

In response to the following statements, please respond by saying if you agree, disagree, or neither:

	Statement	**Code** 1 = Agree 2 = Disagree 3 = Neither
D120	I have a positive view of aquaculture	
D121	Farmed fish are of lower quality than wild caught fish	
D122	Fish feed is readily available in my province	
D123	Sometimes I cannot afford all of the food to feed my family or myself	
D124	Aquaculture is a highly risky practice	
D125	I would encourage my friends and family to participate in aquaculture	
D126	High quality fingerlings are readily available in my province	
D127	Aquaculture is environmentally beneficial for the Tonle Sap	
D128	Aquaculture is an economically viable and profitable activity	

MODULE E. DEMOGRAPHICS

E101. Are you the head of this household?	1=YES (skip to E103) 2=NO (continue below)	
E102. What is your relationship to the head of household?	1 = Spouse/partner 2 = Son/daughter 3 = Son-in-law/daughter-in-law 4 = Grandson/granddaughter 5 = Mother/father (or Mother/father-in-law) 6 = Brother/sister (or Brother-/sister-in-law) 7 = Nephew/niece 8 = Cousin 9 = Other relative 10 = Other relationship	

	E103	**E104**	**E105**	**E106**	**E107**
Household Member	Sex 1 = M 2 = F	What is the age in years?	What is the marital status? 1 = married 2 = divorced 3 = widowed 4 = never married	Number of years of schooling	Can this person read and write? 1 = YES 2 = NO
Head of Household					
Respondent					

E108. How many children aged 14 years or less are in this household?	
E109. How many people aged 15-69 years are in this household?	
E110. How many people aged 70 years or above are in this household?	

	Asset	**Number**
E111. *Does this household own a: (If yes, ask how many, if no write 0)*	*a. Mobile phone*	
	b. Radio	
	c. Television	
	d. Bicycle	
	e. Motorbike	
	f. Car or truck	
	g. Solar panel	
	h. Improved cooking stove	
	i. Refrigerator	
	j. Sofa	

E2. LIVESTOCK

Do you raise any of the following livestock?

	Livestock	1=YES* 2=NO	*If YES, how many do you raise? (number)
E201	Cattle		

E202	Buffalo		
E203	Pigs		
E204	Chicken		
E205	Ducks		
E206	Goats		
E207	Others (Please specify……..)		

E3. SOURCES OF HOUSEHOLD INCOME

Sources of income: *(Circle one under both E301. and E302. columns)*	**E301.** *What is the most important source of income for this household?*	**E302.** *What is the second most important source of income for this household?*
Sales of fish	*1*	*1*
Sales of rice from your own fields	*2*	*2*
Sales from vegetable gardens	*3*	*3*
Wage labor	*4*	*4*
Small business/self-employment	*5*	*5*
Remittances	*6*	*6*
Retirement funds	*7*	*7*
Other (specify):	*99*	*99*

Thank you for taking the time to complete this survey.