FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

Feed the Future – Cambodia Impact Evaluation and Strengthening of Local Capacity to Monitor and Evaluate Food Security Programs

EVALUATION CASE STUDY REPORTS

Edited by

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Michigan State University

East Lansing MI, USA

March 2017

USAID FROM THE AMERICAN PEOPLE

MICHIGAN STATE UNIVERSITY

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1. Introduction

Cambodia HARVEST (**H**elping **A**ddress **R**ural **V**ulnerabilities and **E**cosystem **ST**ability) is a five-year integrated food security and climate change program supported by the American people through the United States Feed the Future and Global Climate Change initiatives. The program was aimed at reducing poverty and malnutrition by diversifying and increasing food production and income for up to 100,000 rural Cambodian households. Cambodia HARVEST was designed to develop sound, agricultural-focused solutions to poor productivity, postharvest losses, malnutrition, lack of market access, environmental degradation, and the effects of climate change on vulnerable rural populations. The program was launched in December 2010 and concluded in June 2016 (Fintrac 2015, www.cambodiaharvest.org).

As part of Cambodia HARVEST, a multi-part program evaluation strategy was developed. This strategy included baseline, mid-term, and endline performance evaluations of the program as well as specific program component evaluations. The strategy also included formal efforts to help develop program evaluation capacity of Cambodia professionals in governmental and non-governmental agencies with a series of program evaluation short courses. Participants in these short courses carried out more than 24 case study evaluations of ongoing and recently completed agriculture and rural development programs (many related directly to HARVEST).

The multi-pronged approach to Cambodia HARVEST enabled an impact evaluation of Cambodia HARVEST using a robust, quantitative method based on baseline and endline household surveys, supported five evaluative case studies of HARVEST program areas led by Michigan State University faculty, and a series of evaluative case studies led by Cambodian nationals participating in the evaluation short courses. All together, these evaluation efforts provide a broad overview and detailed understanding of the impact of Cambodia HARVEST as well as specific subfields of the HARVEST project.

As more fully explained in the individual sections of the overall evaluation report, each evaluation component followed generally accepted evaluation methods appropriate for the evaluation task at hand.

This case study report presents the results of five, in-depth case studies led by Michigan State University faculty members in conjuction with local scholars and educators. These five evaluation case studies focused on four focal areas of the Cambodia HARVEST project — Agriculture extension, aquaculture, supplemental feeding, and commercial horticulture. As discussed below, each of these five case studies used an evaluative approach that took advantage of qualitative methods, quantitative methods, and, in some cases, a combination of both qualitative and quantitative methods. The results of these individual, in-depth case study evaluations shed light on how these four elements of Cambodia HARVEST worked, were received by proposed beneficiaries, and impacted proposed beneficiaries, their communities, and other stakeholders.

It is the authors' hope that this compilation of case studies will be instructive and can shed light on international development efforts (and their evaluation) both within Cambodia and in other development contexts globally. While the details of these studies may appeal specifically to Cambodian ministry officials or NGO leaders operating in Cambodia, the principles elaborated herein appear to be relevant to a wide variety of cases and contexts. Development professionals around the world may benefit from learning about our experiences of conducting program evaluations and the lessons learned from these evaluations.

2. Assessment of Agricultural Extension Services in Cambodia: Needs and Constraints: Perceptions of Farmers on Agricultural Extension Services in Cambodia

Murari Suvedi
Men Sarom

Executive Summary

An effective extension service delivery system plays a vital role in increasing farm productivity and improving food security and livelihoods of smallholder farmers. Therefore, determining the quality of agricultural extension services is an important issue in Cambodia. To address the low productivity in agriculture, the government began considering various policies and programs to increase agricultural production through productivity enhancement and increased value addition and marketing. Agricultural extension is expected to address these challenges by expanding and improving locally relevant, cost-effective farming practices through pluralistic agricultural extension systems.

Agricultural extension activities in Cambodia began in 1957 when the Agriculture Ministry set up an extension unit that used television, radio and publications to disseminate agricultural information to farmers. After the civil war, the provision of agricultural extension services to farmers returned in 1986 with an extension office under the Ministry of Agriculture. Then, in 1995, the Department of Agriculture Extension (DAE) was established. Agricultural extension began to promote the use of modern inputs, such as new seed varieties, fertilizers and pesticides by training farmers, organizing method and result demonstrations, and making extensive use of mass media.

Despite considerable efforts from projects, NGOs and government organizations, however, very little improvement in farm productivity has been achieved. There is a need for study about why agricultural extension has largely failed to achieve target results. Additionally, there is a dearth of information regarding the assessment of agricultural extension services in Cambodia. Accordingly, there is little empirical evidence on why some farmers adopt improved technology and increase farm production and income, and others do not. Through this study, we attempt to address this issue by providing a perspective on the constraints on and barriers to agricultural extension services in Cambodia. In doing so, this study makes an empirical contribution to better understanding the realities that farmers face in need for, access to, barriers to and adequacy of agricultural extension services, and their preferences in content, format and delivery.

To represent the agricultural extension conditions across the country, all 24 provinces were included in the sample. First, two agricultural districts were selected randomly from each province, and then two communes were selected randomly from each district. Next, two villages from each commune were selected randomly (192 villages). Finally, using the total household list for each village, 16 farm households were selected randomly using a systematic random sampling. This resulted in a total sample of 3,072 farmers, from whom usable data were obtained for 3,054 households. A survey instrument was designed to gather data directly from the farmers. MSU faculty members working with the Cambodia Feed the Future Impact Evaluation and Strengthening Local Capacity for Monitoring and Evaluation of Food Security Project contributed to designing questions to record farmers' agricultural production. The revised instruments were translated into Khmer before field testing.

Faculty members and senior students of the Royal University of Agriculture (RUA) collected the data, and research professionals at RUA led the in-country data collection and data entry. Team members entered the survey data into SPSS software under the supervision of the team leader, who oversaw all data entry. Finally, data were analyzed at Michigan State University.

Looking at the adoption of improved crop varieties by production season, more than two-thirds of the farmers planted traditional varieties except for dry-season flood recession and dry-season lowland irrigated rice. Farmers used mostly seeds from their own harvest – 81 percent of rice, 69 percent of sweet potato, 59 percent of soybean and 49 percent of mung bean – for wet-season production. In contrast, farmers purchased more than half of maize seeds (59 percent) from the markets. This suggests that seed companies/dealers are interested in selling maize seeds rather than other crop seeds, possibly because of higher profitability of maize versus other seed varieties.

The top three crops for improved variety adoption were maize (69.34 percent), cassava (43.95 percent) and mung bean (42.19 percent); sweet potato (16.67 percent) received the lowest priority. Overall, the adoption of improved rice varieties was far below that of other crops (23.11 percent) except sweet potato. In plot size, cassava, maize and soybean received the highest priority for cultivation.

There exist four prevailing intercropping systems in the wet-season cropping system: maize and cassava; cassava and sweet potato; maize and soybean; and mung bean and cassava. Rice was not included because it is mainly cultivated as a monoculture crop.

Compared with wet-season crop production, adoption of dry-season improved rice varieties has increased except for lowland irrigated rice. This result confirms that, during the wet season, farmers are more likely to adopt improved varieties that are suited to lowland irrigated conditions. However, choosing improved varieties depends on consumers' preferences for specific traits such as high yield, insect/pest resistance, drought/stress tolerance and palatability (eating quality), as well as straw yield and quality.

In the dry season, farmers prefer to plant traditional maize varieties rather than improved varieties. The adoption rate of traditional maize varieties was 74 percent; for improved varieties, only 19 percent. This is possibly because the traditional varieties may contain specific traits such as drought tolerance, resistance to insects/pests or better palatability. Other crops – cassava, sweet potato, soybean and mung bean – had above 50 percent adoption rates for improved varieties during the wet-season cropping pattern. It is worth noting that during wet-season production, dry-season rice varieties and maize had the highest adoption rate for improved varieties, but during dry-season production, these two crops had the lowest adoption rate.

For dry-season production, farmers mostly used seed from their own harvest except for maize and mung bean. However, farmers purchased a great deal of maize (59 percent) and mung bean (55 percent) seed from the markets but only 23 percent of rice. Contribution of private seed companies to supply seed for dry-season production appeared to be nominal. Among intercropping systems, maize and cassava was the dominant pattern for both wet- and dry-season production.

About 66 percent of the households in all the provinces reported that they raised chickens, with 42 percent reporting raising cattle and 14 percent raising buffalo. Over 70 percent of farmers in Preah Vihear engaged in pig production followed by Svay Rieng (60 percent) and Ratanakiri (50 percent). Interestingly, in only three provinces – Preah Sihanouk, Stung Treng and Svay Rieng – did at least 20 percent of farmers report raising all three species of livestock.

Regarding farmers' feedback on extension services, almost 98 percent of farm households from Ratanakiri province were aware of agricultural extension services, but only 23 percent of the households were aware of agricultural extension services in Phnom Penh province. Overall, in six out of 24 provinces, at least 70 percent of households were aware of agricultural extension services. In only five provinces was the awareness rate below 50 percent.

Television and radio farm programs, extension meetings and neighbors/relatives were the most used sources of information. Over 66 percent of farmers reported that they received extension services from NGO-managed projects.

The percentage of farmers receiving services from NGOs was more than 50 percent in 16 provinces. Overall, means ranging from 1.73 to 3.04 represented the number of contacts received from other sources of extension services and NGO-managed projects, respectively, over the course of one year prior to being surveyed. The total number of individuals having contact with extension service providers was the highest for NGO projects (N = 1031) and the lowest for agricultural colleges and universities (N = 48).

Farmers from various provinces expressed their views about the importance of information differently. Neighbor/relative was the most importance source of information for farmers, followed by television and radio farm programs. The least common source of information for farmers was website/Internet/email. Farmers probably do not have access to the Internet or do not know how to use it as a source of agricultural information.

To find out farmers' perception about improved farming practices and their adoption, we asked: Do you feel you can improve your farm's productivity by adopting new/improved farming practices? More than two-thirds of the farmers responded positively. At the same time, when asked: Are there any barriers to fully adopt the improved agricultural practices, about 66 percent of farmers said that there are barriers preventing them from fully adopting such practices.

Assessing the degree of importance of eight selected barriers, the highest ranking barrier was “My farm has no access to irrigation," followed by “I don't have sufficient knowledge about new technology" and "I don't have education and skills to adopt new technology." The least important barrier mentioned by farmers was “I don't own land for farming."

If desired adoption rates and farm productivity are to be achieved, concerned government bodies and related stakeholders will need to overcome the extension barriers by providing irrigation systems and developing high-yielding crop varieties. Moreover, training should be provided for developing new skills to use information and communication technologies (ICTs) in agriculture. Producing quality programs for radio/television and broadcasting them through appropriate channels can be a reasonable way to share information with female farmers. Similarly, linkages between research-extension-education-farmers should be strengthened.

Introduction

Learning about new methods of farming has been a function of every social system. Starting in the 1950s, many countries across the world began establishing more organized systems of nonformal education called agricultural extension services. In most countries, agricultural ministries were reorganized to include an agricultural extension unit. Agricultural extension began to promote the use of modern inputs such as new seed varieties, fertilizers and pesticides by training farmers, organizing method and result demonstrations, and making extensive use of mass media.

Agricultural extension activities in Cambodia began in 1957 when the Agriculture Ministry set up an extension unit that used television, radio and publications to disseminate information to farmers. The civil war in the 1970s devastated the country's economy and destroyed almost all agricultural extension infrastructure. The provision of agricultural extension services to farmers returned in 1986 with an extension office under the Ministry of Agriculture and then, in 1995, the Department of Agriculture Extension (DAE) was established. With Australian assistance, the DAE developed national extension guidelines using a farming systems development approach (Source: http://www.worldwide-extension.org/asia/cambodia.)

At present, the Department of Agricultural Extension has approximately 1,250 professional staff members (including senior management, subject matter specialists and field extension staff members). The staff members collect information at the commune level about major agricultural constraints and opportunities (CAC, 2013). They also offer educational assistance to small- and medium-scale commercial farmers growing rice and other cash crops. The department also has a small communications unit that provides information and communication technology (ICT) support and services in areas of print and mass media, computer-based information technology and Internet services. The ICT unit publishes bulletins and fact sheets, and produces television and radio programs. Most extension services are planned and managed by Provincial Departments of Agriculture (PDA).

Cambodia has hundreds of NGOs providing agricultural extension services to farmers. Almost all NGOs are supported by projects funded by international organizations or projects. More recently, NGOs are working under the new rubric of public/private partnership and/or NGO/private partnership. Further, agricultural extension in Cambodia is organized under many types of projects. Some projects work in collaboration with agribusinesses, such as seed, fertilizer, pesticides and production credit, to focus on technology transfer. Others emphasize training or advisory work.

Despite the fact that many projects and NGOs are involved in the provision of services and training to farmers, there has been little systematic study of the quality of agricultural extension services. Previous studies have primarily focused on the effects of extension services on new practices and technology adoption and, to a lesser extent, on productivity. Even fewer studies have examined the ability of agricultural extension services to disseminate quality content adapted to both female and male farmers. Therefore, there is a need for a better understanding of the different realities that female and male farmers face in need for, access to, barriers to and adequacy of agricultural extension services, and their preferences in content, format and delivery. To fill this research gap, this case study has attempted to address the following research questions:

1) How are new agricultural practices or farming technology adoption patterns and impacts evolving? What is the level of adoption of new agricultural practices such as improved seed varieties for rice and maize, vegetable production including home garden, fruit production and fishery/aquaculture practices by farmers?

2) What are farmers' needs in learning and adopting new technologies and practices?
3) What are the perceived barriers to the provision of high quality extension services and adoption of new technologies and practices by female and male farmers?
4) Who provides agricultural extension services to female and male farmers? How adequate are those services?
5) What is the frequency of advice received by female and male farmers from extension agents?
6) What are the major sources and channels of information used by female and male farmers? Which information sources are considered trustworthy?

Methods and Procedures

Study Population

This study has three populations: farmers, extension workers at the district/ commune level, and commune council chairpersons and/or other key informants. This report discusses only the results of the farmer population survey.

Sampling Procedure

To represent the agricultural extension conditions across the country, all 24 provinces were included in the sample. The sample was selected in the following manner: first, two agricultural districts were selected randomly from each province (48 districts); then, two communes were selected randomly from each district except Ratanakiri, where one commune was selected, (95 communes); after randomly selecting the communes, two villages from each commune were selected randomly except in Malik commune of Ratanakiri, where four villages were selected (192 villages). Finally, using the household list from the 2012 election for each village and with the help of commune council chairs, households not engaged in farming, fishing or other agricultural activities were excluded to create each village sampling frame. From each sample village, 16 farm households were selected randomly using a systematic sampling with a random start. This resulted in a total sample of 3,072 farmers, from whom usable data were obtained for 3,054 households. Table 1 summarizes the sampling plan, and Figure 1 shows the villages selected for this study.

Table 1. Respondents' provinces, districts communes and villages.

Province	District	Commune	Village	
Prey Veng	Ba Phnum	Cheung Phnum	Andoung	Boeng Roka
	Peam Chor	Kaoh Chek	Kaoh Chek	Meanchey
	Sithor Kandal	Preaek Changrkran	Preaek Changkran Leu	Preaek Changkran kraom
		Prey Tueng	Khnar	Boeng Choar
Pursat	Krakor	Boeng Kantuot	Thmey	Boeng
		Kbal Trach	Phsar	Doung
	Phnum Kravanh	Santreae	Srae Popeay	Ksetr Bourei
			Kul Totueng	Santreae
Preah Sihanouk	Prey Nob	Samaki	Boeng Reang	Ta Aong Thom
		Tuek Thla	Preaek Pras	Preaek Toal
	Kampong Seila	Kampong Seila	Veal	Thmei
		Stueng Chhay	Kirivoan	Ou Ta Hoay
Siem Reap	Angkor Thom	Leang Dai	Daun Ov	Samraong
		Svay Chek	Preah Ko Thmei	Svay Chek
	Varin	Lvea Krang	Kouk Kandal	U Tey
		Svay Sa	Ou	Kambaor
Stung Treng	Sesan	Kbal Romeas	Chrab	Krabei Chrum
		Srae Kor	Srae Kor Muoy	Srae Kor Pir
	Siem Pang	Preaek Meas	Thmar Da	Khes Svay
		Sekong	Ban Muong	Siem Pang
Svay Rieng	Chantrea	Samraong	Kaoh Kban Kandal	Kaosh Kban Khang Cheung
		Chantrea	Chantrea	Saenta
	Romeas Haek	Koki	Ta Sek	Prey Kdei
		Troa	Voat	Traorpeang Banteay
Takeo	Angkor Borei	Kouk Tlok	Preaek Ta Pha	Preaek Da
		Prey Pkoam	Prey Pkoam Ka	Prey Pkoam Kha
	Treang	Angkor Khnor	Kor	Ta Pheak
		Srangae	Chrang	PreakChorkran
Pailin	Pailin	Tuol Lvea	Thmei	Ou Pert
		Ou Ta Vau	Ou Preus	Kbal Pralean
	Sala Krau	Sala Krau	Srae Anteak	Veal
		Ou Andoung	Ou Andoung	Koun Phnum
Preah Vihear	Choam Ksant	Pring Thum	Tmat Paeuy	Krala Peas
		Kantuot	Char	Kantuot
	Kuleaen	Kuleaen Khang Tboung	Kouleaen Khang Tboung	Krabau
		Phnum Tbaeng Pir	Baribour	Chhuk
Kandal	Mukh Kampul	Svay Ampear	Kampong Prasat	Preaek Kdei
		Roka Kong Ti Muoy	Peam	Preaek Pdau
	S'ang	Prasat	Chhrouy Russey	Prasat
		Kaoh Khael	Kaoh Khael	Svay Chuor
Kampot	Dang Tong	Domnak Sokram	Angk Ropeak	Khcheay Khang Lech
		Angk Romeas	Bar Knong	Antong Baek
	Tuek Chhou	Preaek Tnoat	Preaek Tnoat	Preaek Kraeng
		Prey Khmum	Prey Tomh	Prey Khmum
Kratie	Chhloung	Chhloung	Kaoh Kandaor	Chhney
		Kampong Damrei	Veal Kansaeng	
	Sambour	Sandan	Thmei	

	Chetr Borei	Bos Leav	Bos Leav Leu	Bos Leav Kraom
		Kaoh Chraeng	Kandal	Kbal Kaoh
Banteay Meanchey	Phnum Srok	Ponley	Ponley	Svay Sa
		Srah Chik	Kandal Khang Lech	Srah Chik
	Thma Puok	Kouk Romiet	Thmei	Kouk Romiet
		Phum Thmei	Thmei Khang Tboung	Thmei Khang Lech
Battambang	Banan	Chaeng Mean Chey	Changhour Svay	Chaeng
		Ta Kream	Thmei	Ou Pong Moan
				Ta Kream
	Sampov Lun	Serei Mean Chey		Sralau Chrum
		Sampov Lun	Thnal Bat	Thnal Bambaek
Kampong Cham	Memot	Rung	Bos	Choam Tuk
		Tonlung	Kdol Phsar	Pong Tuek
	Prey Chhor	Thma Pun	Angdoung Tapech	Lech Voat
		Sour Saen	Angdoung	Trapeaang
Kampong Chhnang	Baribour	Khon Rang	Popel	Daeum Chreae
		Popel	Krang Khmer	Sala Khum
	Tuek Phos	Chieb	Kouk Penh	Chhak Kandaol
		Chaong Maong	Chaong Maong	Khsaet
Kampong Speu	Aoral	Haong Samnam	Prey Totueng	Tang Robang
		Sangkae Satob	Ta Daes	Kantuot
	Thpong	Amleang	Krang Doung	Kouk
		Rung Roeang	Tuek Long Ti Pi	Krang Ta Char
Kampong Thom	Kampong Svay	Domrei Slab	Mongkol Slar	Domrei Slab
		Kdei Doung	Peam Kraeng	Kdei Doung
	Sandan	Mean Rith	Tboung Tuek	Ou Pok Sameakki
		Mean Chey	Choan Leaeng	Roneam
Oddor Meanchey	Chong Kal	Chong Kal	Chong Kal	Chhork
		Krasang	Khnar	Kouk Samreach
	Trapeang Prasat	Trapeang Prasat	Tuol Ta Sek	O Saom
		Ou Svay	Ou Svay	Ou Lhong
Kep	Kaep City	Kaep	Kaev Krasang	Kaenh
		Prey Thum	Damnak Chang' aeur	Kampong Tralach
	Damnak Chang'aeur	Angkaol	Ampeng	Angkaol
		Ou Krasar	Ou Krasar	Damnak Chambak
Mondul Kiri	Pech Chrenaa	Pu Chrey	Mebay	Phutang
		Srae Ampun	Phu Kroch	Phura Den
	Ou Reang	Saen M0nourom	BPu Rang	Pu Hoam
		Dak Dam	Pu Chhab	Pu Traeng
Ratanakiri	Andoung Meas	Malik	Malik	Katae
			Ka Hal	Laom
	Veun Sai	Phnum Kok	Phnum Kok Lav	Phnum Kok Prov
		Veun Sai	Thmei	Veun Sai
Koh Kong	Mondol Seima	Peam Krasaob	Phum Muoy	Phum Pir
		Tuol Kokir	Tuol Kokir Leu	Ta Chat
	Srae Ambel	Chi Kha Kraom	Ta Baen	Preaek Chik
		Srae Ambel	Trapeang Kandaol	Veal Tboung
Phnom Penh	Saensokh	Khmuonh	Khmuonh	Samroang
	Praek Pnov	Ponhea Pon	Prey Pongro	Srae Doun Touch
	Dangkao	Pong Tuek	Pong Tuek	
		Prey Veaeng	Prey Veaeng Khang Lech	Prey Veaeng Khang Kaeut
				Trapeang Chak

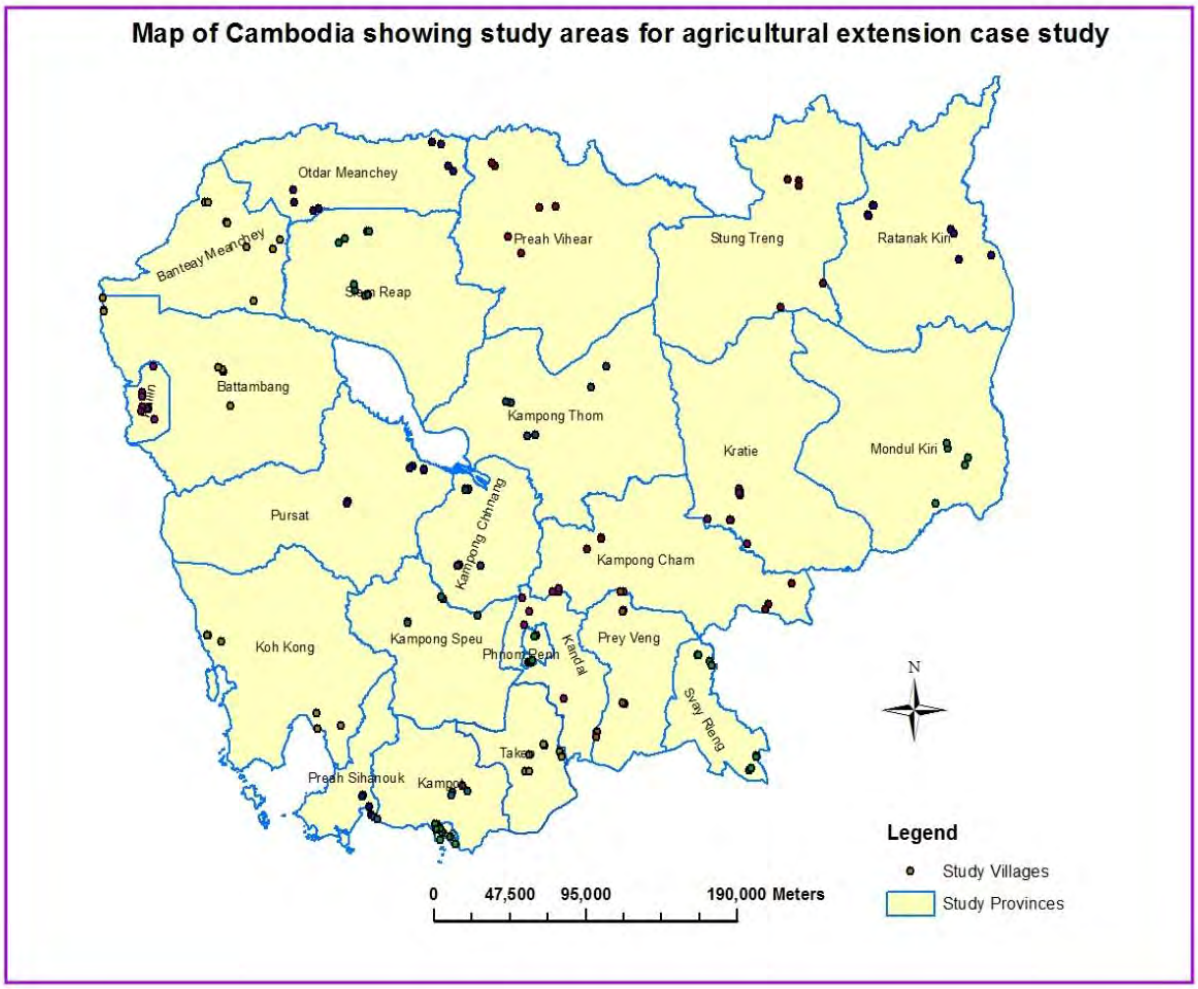

Figure 1. Map of Cambodia showing study areas.

Data Collection Instruments

Two instruments were designed to gather data directly from the farmers and extension workers/commune council chairs. MSU faculty members working with the Cambodia Feed the Future Impact Evaluation and Strengthening Local Capacity for Monitoring and Evaluation of Food Security Project contributed in designing questions to record farmers' agricultural production. The instruments were reviewed by Cambodian agricultural development professionals. The revised instruments were translated into Khmer before field testing.

Data Collection Procedure

Data were collected by faculty members and senior students of the Royal University of Agriculture. Eight RUA faculty/staff members were identified to serve as data collection team leaders. The RUA data collection team leaders then identified and recruited 64 RUA students to serve as field data collectors or enumerators. Special consideration and attention were given to identifying and selecting RUA students so that at least two students were selected from each province. This allowed for local familiarity with districts and communes during data collection. The data collection team members consisted of both male and female students and faculty members. Each data collection team leader worked with eight enumerators during the fieldwork.

There were eight field data collection teams with one team leader in each team. Each team had responsibility to gather data from three provinces. These students received a daylong training on survey data collection and interview protocol. A nine-passenger van was used for travel. One team completed data collection in two villages in a day (i.e., one student interviewed two households in the morning (2 x 8 = 16 households in one village) and moved to the next village in the afternoon and completed interviews with two households in the afternoon.

Before moving to the next village, the team leader checked the completeness of the survey instrument to ensure that there were no missing items. S/he supervised the enumerators and also administered surveys to local extension workers, NGO professionals and commune council chairs. As estimated, it took about four days to complete household surveys for one province. Including travel time, it required a five-day period to complete data collection in one province. Data collection teams made a three-week-long visit -- i.e., one team spent five days in each province to gather survey data. Data collection was completed during May-June 2013.

The RUA data collection team coordinated the field data collection, including communication with relevant stakeholders. The team leaders communicated with respective commune council chairs about the study and the plan for data collection.

The team leader of each team met with provincial and/or district agricultural extension and rural development staff members in each of the sampled district and provided the self-administered survey for extension workers.

Data Entry and Data Analysis

Team members entered the survey data into SPSS software under the supervision of the team leader. Dr. Men Sarom oversaw all data entry. Data were analyzed at Michigan State University. Dr. Mywish Maredia assisted in running some data analysis on agricultural production. Mr. Ramjee Ghimire, a graduate assistant in the Department of Community Sustainability, prepared the preliminary report. Some inconsistencies in data entry were detected during the data cleaning process. To minimize the error, on-site data cleaning was performed during January-February 2014 with the help of Mr. Kimheng An, Cambodia HARVEST staff. Mr. Socheat Keo, Ms. Cynthia Balthazar, Dr. Ramjee Ghimire and Dr. Raju Ghimire at Michigan State University assisted in data analysis and prepared this report.

Findings of the Farmer Survey

Wet-season Crop Production

As presented in Table 2, both deep-water/floating rice and dry-season lowland irrigated rice were grown on plots averaging 1.6 hectares (ha), the greatest areas cultivated for a rice variety, followed by dry-season flood recession with supplementary irrigation, with an average 1.38 cultivated ha. The result shows that more than two-thirds of the farmers planted traditional varieties except FOR dry-season flood recession rice (57.14 percent versus 42.86 percent). Only a few farmers (2 percent) said they did not know the rice varieties they have grown.

For other crops, the result shows that cassava was planted in plots averaging 1.79 ha, maize and soybean in 1.69 ha, and sweet potato in 0.4 ha. In plot size, cassava, maize and soybean received the highest priority for cultivation. The top three crops for improved variety adoption were maize (69.34 percent), cassava (43.95 percent) and mung bean (42.19 percent); sweet potato (16.67 percent) showed the lowest adoption rate of improved varieties among these crops. Overall, the adoption of improved rice varieties was far below that of other crops except

sweet potato. Note that 16 percent, 13 percent, 8 percent and 6 percent of the interviewed farmers said they did not know the varieties of mung bean, cassava, soybean and maize, respectively, they have grown.

Table 2. Wet-season crop production: areas planted to various crops and adoption of improved varieties.

Crop grown	Number of households	Number of plots	Average area cultivated by plot (ha)	Number of varieties planted			
				Number of plots	Improved (%)	Traditional / local (%)	Don't know (%)
Rice (all types)	1987	3170	1.14	3,150	23.11	74.73	2.16
Rice, lowland rain-fed	1811	2,949	1.13	2,933	23.76	74	2.24
Rice, deep-water/floating	34	56	1.6	54	25.93	74.07	0
Rice, upland rain-fed	129	152	1.2	152	7.24	91.45	1.31
Rice, dry-season flood recession with supplementary irrigation	8	8	1.38	7	57.14	42.86	0
Rice, dry-season lowland irrigated	5	5	1.6	4	50	25	25
Maize	282	288	1.69	287	69.34	24.39	6.27
Cassava	504	513	1.79	512	43.95	42.97	13.08
Sweet potato	12	13	0.4	12	16.67	83.33	0
Soybean	73	74	1.69	73	30.14	61.64	8.22
Mung bean	64	65	1.51	64	42.19	42.19	15.62

Table 3 presents various sources of seeds/planting materials for wet- season production. For most of the crops in wet-season production, farmers used seeds from their own harvest – 81 percent of rice, 69 percent of sweet potato, 59 percent of soybean and 49 percent of mung bean. In contrast, farmers purchased more than half of their maize seeds (59 percent) from the markets. This result suggests that seed companies/dealers are more interested in selling maize seeds than other crop seeds, possibly because of higher profitability of maize versus other seed varieties. This corroborates the finding in Table 2 for lower adoption of improved rice varieties.

Table 3. Sources of seed/planting materials for the wet season.

Crops	Rice	Maize	Cassava	Sweet potato	Soybean	Mung bean
Own harvest (%)	81.47	17.71	36.01	69.23	59.46	49.23
Purchased in market (%)	3.92	59.03	26.42	23.08	25.68	29.23
Other farmers (%)	3.38	1.39	11.94	7.69	2.7	9.23
Input dealer (%)	0.45	2.43	2.94	0	1.35	3.08
Seed company (%)	0.57	15.63	6.65	0	1.35	3.08
NGO (%)	2.65	1.04	1.37	0	1.35	1.54
Government (%)	0.29	0	0	0	0	0
Farmer/friend/relative (%)	6.35	1.04	12.33	0	6.76	3.08
Total number of plots	3,136	288	511	13	74	65

Table 4 shows the details about whether the wet-season crop was intercropped. The result reveals that there exist four prevailing intercropping systems in the wet-season cropping system: maize and cassava, cassava and sweet potato, maize and soybean, and mung bean and cassava. Rice was not included because it is mainly cultivated as a monoculture crop. Furthermore, respondents expressed maize and cassava intercropping systems in two ways, listing either one as the first crop with the other as the companion. It is not clear if the intention is to report the same intercropping system.

Table 4. Intercropping in the wet season.

Crops	Number of plots	Was this crop intercropped?	What was the main crop associated with it? (If Yes)
		Yes (%)	
Maize	274	14.96	Cassava
Cassava	491	18.74	Maize
Sweet potato	12	33.33	Cassava
Soybean	69	13.04	Maize
Mung bean	63	19.05	Cassava

Dry-season Crop Production

As shown in Table 5, upland rain-fed rice covered the highest average cultivated area (2.0 ha), followed by dry-season lowland irrigated rice (1.59 ha). Adoption patterns of dry-season improved rice varieties have increased except for the lowland irrigated environment. This result confirms that, during the wet season, farmers are more likely to adopt improved varieties that are suited to lowland irrigated conditions. It is worth mentioning here that 20 percent, 17 percent, 15 percent, 9 percent, 7 percent and 7 percent of respondents growing sweet potato, soybean, mung bean, lowland rain-fed dry-season rice, maize and cassava, respectively, said they did not know the crop varieties they have been growing. It should be noted that choosing improved varieties depends on consumers' preferences for specific traits such as high yield, insect/pest resistance, drought/stress tolerance and palatability, and straw yield and quality.

Table 5. Dry-season crop production: areas planted to various crops and adoption of improved varieties.

Crop grown	Number of households	Number of plots	Average area cultivated by plot (ha)	Varieties planted			
				Number of plots	Improved (%)	Traditional / local (%)	Don't know (%)
Rice (all types)	316	350	1.51	350	28.57	68.86	2.57
Rice, lowland rain-fed	71	77	1.33	77	37.66	53.25	9.09
Rice, deep-water/floating	1	1	1.00	1	100.00	0.00	0
Rice, upland rain-fed	2	2	2.00	2	50.00	50.00	0
Rice, dry-season flood recession with supplementary irrigation	127	139	1.53	139	25.90	73.38	0.72
Rice, dry-season lowland irrigated	118	131	1.59	131	25.19	74.05	0.76
Maize	124	127	2.00	127	18.90	74.02	7.08
Cassava	106	113	2.48	113	58.41	34.51	7.08
Sweet potato	5	5	0.52	5	60.00	20.00	20
Soybean	6	6	1.42	6	66.67	16.67	16.66
Mung bean	20	20	1.52	20	50.00	35.00	15

For maize, it is the opposite case. In the dry season, farmers preferred to plant traditional maize varieties rather than improved ones. The adoption rate of traditional varieties was 74 percent; that of improved varieties, only 19 percent. The reason for this might be that traditional varieties contain specific traits such as drought tolerance, resistance to insects/pests or palatability. Other crops – cassava, sweet potato, soybean, mung bean – had above 50 percent adoption rates for improved varieties during the dry-season cropping pattern.

In area cultivated, cassava and maize in dry-season production placed in first and second place – 2.48 ha and 2.00 ha, respectively. The average plot size for sweet potato was the smallest at 0.52 ha.

It is worth noting that during wet-season crop production, dry-season rice varieties and maize had the highest adoption rate for improved varieties, while during dry-season crop production, these two crops had the lowest adoption. Overall, the adoption rates of improved varieties of rice were 23 percent (wet-season) and 28 percent (dry-season), which, with the exceptions of sweet potato (wet-season, 16.7 percent) and maize (dry-season, 18.9 percent), are lower than those of other crops currently cultivated by farmers in Cambodia.

Table 5 also reveals that dry-season rice is the main crop produced in Cambodia, followed by cassava and maize with mean cultivation areas of 2.5 ha and 2.0 ha, respectively. Overall, plot sizes ranged from 0.4 ha (wet-season sweet potato) to 2.48 ha (dry-season cassava), and all plot sizes apart from sweet potato in both seasons (smaller cultivation areas) and cassava in the dry season (larger cultivation areas) ranged in size from 1.0 ha to 2.0 ha. As observed in Tables 2 and 5, the average plot size for all rice types was 1.14 ha during the wet season and 1.51 ha during the dry season. Adoption rates of improved rice varieties for all types of rice during the wet and dry seasons were observed as 23.11 percent and 28.57 percent, respectively.

Table 6 shows the sources of seeds/planting materials for dry-season crop production. The results show that for most crops (except maize and mung bean), farmers used seed from their

own harvest -- about 48 percent of rice, 67 percent of soybean and 43 percent of cassava were grown from personally harvested seed. However, farmers purchased a great deal of maize (59 percent) and mung bean (55 percent) seed from the markets, compared with only 23 percent of rice. About 16 percent of rice seed came from other farmers and farmer/friend/relative. The contribution of private seed companies to supply seed for dry-season production was nominal— less than 1 percent for rice and 5 percent to 20 percent for other crops. Similarly, input dealers, NGOs and government were very minor players in the Cambodian seed market.

Table 6. Dry-season crop production: sources of seed/planting material.

Crops	Rice	Maize	Cassava	Sweet potato	Soybean	Mung bean
Own harvest (%)	47.85	15.08	43.36	40	66.67	30
Purchased in market (%)	22.92	59.52	14.16	20	0	55
Other farmers (%)	8.31	0.79	17.7	0	0	0
Input dealer %)	2.58	3.97	4.42	0	0	5
Seed company (%)	0.86	16.67	7.96	20	16.67	5
NGO (%)	3.72	0	0	20	0	0
Government (%)	0.57	0	0	0	0	0
Farmer/friend/relative (%)	8.02	1.59	4.42	0	16.67	0
Total number of plots	349	126	113	5	6	20

Table 7 depicts the intercropping pattern during dry-season production. As shown, two prevailing intercropping systems – maize and cassava (or cassava and maize) and mung bean and cassava – are dominant in the dry season. It is again unclear whether maize-cassava and cassava-maize systems are reported as the same system.

Table 7. Intercropping in the dry season.

Crops	Number of plots	Was this crop intercropped?	What was the main crop associated with it? (If yes)
		Yes (%)	
Maize	119	7.56	Cassava
Cassava	103	9.71	Maize
Mung bean	18	11.11	Cassava

Table 8 shows the combined (wet- and dry-season) crop production data and adoption status. Among the six crop types presented in Table 8, rice is the main crop, planted in more than 3,500 plots with an average plot size of 1.18 ha. The adoption rate of traditional rice varieties was much higher (70 percent) than that of improved varieties (28 percent). Note that 15 percent, 12 percent, 9 percent, 7 percent, 6 percent and 2 percent of respondents growing mung bean, cassava, soybean, maize, sweet potato and lowland rain-fed rice, respectively, said they did not know the crop varieties they have been growing. Furthermore, the plot size for maize was the highest (1.79 ha) among six crop types, followed by soybean and mung bean – 1.67 ha and 1.52 ha, respectively. Sweet potato appears to be the least prioritized crop in area planted, with an average of 0.43 ha and adoption rate of 17.65 percent. Maize had the highest adoption rate for improved varieties (70.77 percent), suggesting that farmers are aware of improved maize varieties and the crop's cultivation practices, and satisfied with its profitability.

Table 8. Crop production: dry and wet seasons combined.

Name of crop	Number of plots growing the crop (N)	Number of households growing the crop	Average area cultivated by plot (ha)	Varieties planted			
				Number of plots	Traditional / local (%)	Improved (%)	Don't know (%)
Rice (all types)	3,520	2,111	1.18	3,500	70.11	27.69	2.2
Rice, lowland rain-fed	3,026	1,828	1.13	3,010	73.09	24.52	2.39
Rice, deep-water/floating	57	35	1.59	55	74.55	25.45	0
Rice, upland rain-fed	154	131	1.21	154	90.91	7.79	1.3
Rice, dry-season flood recession with supplementary irrigation	147	134	1.52	146	26.71	72.6	0.69
Rice, dry-season lowland irrigated	136	122	1.59	135	25.19	73.33	1.48
Maize	415	326	1.79	414	22.71	70.77	6.52
Cassava	626	569	2	625	45.76	42.24	12
Sweet potato	18	17	0.43	17	76.47	17.65	5.88
Soybean	80	78	1.67	79	62.03	29.11	8.86
Mung bean	85	81	1.51	84	44.05	40.48	15.47

Livestock Production

Table 9 reports the number of households raising livestock and their percentage by province. According to the data, 66 percent of the households in all of the provinces reported that they raised chickens, with at least 75 percent of farmers in 10 provinces raising chickens. Approximately 42 percent and 14 percent of farmers, respectively, responded that they raised cattle and buffalo. Over 70 percent of farmers in Preah Vihear engaged in pig production, followed by Svay Rieng (60 percent) and Ratanakiri (50 percent). Interestingly, in only three provinces – Preah Sihanouk, Stung Treng and Svay Rieng – did at least 20 percent of farmers report raising all three types of livestock.

Table 9. Livestock production: percentages of households raising livestock.

Province	Households surveyed (N)	Percentage of "Yes" responses				
		Cattle	Buffalo	Pig	Chicken	Duck
Prey Veng	128	73.44	1.56	26.56	83.59	14.84
Pursat	128	46.09	35.16	25.00	75.00	14.06
Preah Sihanouk	126	43.65	41.27	36.51	93.65	30.95
Siem Reap	128	57.81	7.81	46.09	79.69	11.72
Stung Treng	128	29.69	42.19	46.88	44.53	20.31
Svay Rieng	128	39.84	50.78	60.16	73.44	21.88
Takeo	128	49.22	5.47	38.28	67.97	23.44
Pailin	128	12.50	0.00	10.94	55.47	14.06
Preah Vihear	128	46.09	8.59	71.09	78.13	15.63
Kandal	127	34.65	0.79	18.11	48.03	9.45
Kampot	128	64.06	6.25	43.75	78.13	29.69
Kratie	128	57.81	3.91	9.38	73.44	9.38
Banteay Meanchey	127	14.96	0.79	22.05	73.23	26.77
Battambang	123	19.51	0.81	4.88	65.85	21.95
Kampong Cham	128	29.69	3.13	9.38	37.50	8.59
Kampong Chhnang	128	57.81	39.84	45.31	75.78	5.47
Kampong Speu	128	69.53	1.56	37.50	75.00	11.72
Kampong Thom	128	46.88	24.22	35.16	64.84	15.63
Oddar Meanchey	125	34.40	0.00	24.00	58.40	16.00
Kep	128	71.09	2.34	39.06	76.56	17.97
Mondul Kiri	128	15.63	4.69	25.00	28.91	4.69
Ratanakiri	128	29.69	44.53	50.78	57.03	12.50
Koh Kong	122	20.49	9.84	36.07	74.59	24.59
Phnom Penh	128	50.00	0.00	0.78	46.09	16.41
Total	3,054	42.37	14.01	31.83	66.01	16.54

Table 10 summarizes the herd size data for all provinces in the study area. The data show that cattle, pigs, chicken and ducks are raised in all provinces. Buffalo are raised in all provinces except four: Pailin, Kandal, Oddar Meanchey and Phnom Penh. The overall mean herd size for cattle, pigs and buffalo was just over three animals, with standard deviation close to 3 for cattle and buffalo and 5 for pigs. In Preah Vihear, the mean cattle herd size appeared to be 5.80, with a SD of 5.89. This indicates that some farmers in this province raise cattle for commercial purposes. Looking at poultry, the mean flock sizes for chickens and ducks were 13.28 (SD = 17.95) and 11.68 (SD = 50.74), respectively. Standard deviations larger than means suggest that, particularly in pigs, chickens and ducks, there are some farmers who probably are running commercial livestock and poultry farms in these provinces.

Table 10. Livestock production: herd sizes.

Province	Cattle			Buffalo			Pig			Chicken			Duck		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Prey Veng	94	3.01	1.76	2	2.50	0.71	34	3.94	5.93	107	10.74	9.11	19	3.37	2.14
Pursat	59	3.29	2.95	45	3.02	1.98	32	3.41	3.59	96	9.80	14.84	18	6.22	5.31
Preah Sihanouk	55	3.24	2.82	52	3.67	2.94	46	5.35	8.07	118	15.05	17.84	39	7.36	6.79
Siem Reap	74	2.47	1.20	10	2.40	1.17	58	3.24	3.84	102	10.36	8.24	15	5.73	5.26
Stung Treng	38	5.26	4.51	54	5.11	3.73	60	2.80	2.36	57	17.70	21.01	25	6.60	4.46
Svay Rieng	51	2.82	1.88	65	3.12	2.68	77	3.03	3.52	93	11.52	13.35	27	7.48	9.31
Takeo	63	2.60	2.41	7	2.71	0.95	49	4.41	8.49	87	11.24	8.19	30	40.20	177.74
Pailin	16	4.31	2.85	0			14	4.07	2.95	71	16.27	19.55	18	11.94	16.98
Preah Vihear	59	5.80	5.89	11	5.18	2.93	90	2.48	1.92	100	9.16	10.21	20	4.95	3.68
Kandal	41	4.46	3.54	0			23	8.87	15.23	61	23.21	54.19	11	13.36	12.32
Kampot	82	2.82	1.56	8	2.75	2.38	56	3.00	3.44	100	21.21	21.91	38	7.82	5.54
Kratie	74	3.34	2.23	5	3.20	1.79	11	1.82	0.98	94	9.97	11.18	12	4.92	6.29
Banteay Meanchey	19	3.00	2.38	1	3.00	0.00	28	2.25	1.29	89	6.57	6.75	34	5.41	4.02
Battambang	24	2.83	2.01	1	1.00	0.00	6	5.50	5.09	81	13.95	13.81	27	12.07	10.72
Kampong Cham	38	2.58	1.37	4	2.75	0.96	12	9.00	7.73	48	18.27	25.43	11	13.64	16.65
Kampong Chhnang	74	2.99	2.34	51	3.04	1.66	58	2.81	2.45	97	12.16	12.18	7	4.29	6.95
Kampong Speu	89	3.94	2.72	2	2.00	1.41	48	2.73	3.45	96	9.17	10.27	15	5.00	3.48
Kampong Thom	59	4.24	2.67	31	3.06	2.00	44	2.39	1.99	83	14.16	16.77	19	8.68	8.01
Oddar Meanchey	31	2.87	2.09	0			23	2.70	2.60	55	15.82	15.61	16	13.13	14.38
Kep	90	2.93	1.60	3	2.33	0.58	50	3.44	7.62	98	12.36	11.32	23	9.04	7.39
Mondul Kiri	20	2.70	1.45	6	3.17	2.56	32	2.63	2.09	35	8.77	6.86	5	8.80	4.44
Ratanakiri	38	3.39	2.53	57	2.86	1.66	65	2.40	1.82	73	7.86	6.53	16	5.94	5.51
Koh Kong	21	3.33	3.06	7	1.86	1.57	37	5.86	7.18	79	28.22	26.97	26	42.27	102.27
Phnom Penh	64	3.64	2.67	0			1	8.00	0.00	59	12.34	14.18	21	10.52	9.04
Total	1273	3.38	2.76	427	3.36	2.54	954	3.43	5.15	1979	13.28	17.95	492	11.68	50.74

Farmer Feedback on Extension Services

Table 11 indicates the percentage of farm households that were aware of agricultural extension services in their villages. Almost 98 percent of farm households from Ratanakiri province indicated that they were aware of agricultural extension services, while only 23 percent of the households in Phnom Penh province were aware of agricultural extension services. Overall, in only six out of 24 provinces were at least 70 percent of households aware of agricultural extension services, but in only five provinces was the awareness rate below 50 percent.

Table 11. Percentages of farmers indicating awareness about agricultural extension services.

Provinces	Number of HHs (N)	Farmers indicating awareness (%)	Provinces	Number of HHs (N)	Farmers indicating awareness (%)
Prey Veng	128	58.59	Banteay Meanchey	127	53.54
Pursat	128	59.38	Battambang	123	38.21
Preah Sihanouk	126	55.56	Kampong Cham	128	37.50
Siem Reap	128	65.63	Kampong Chhnang	128	63.28
Stung Treng	128	75.00	Kampong Speu	128	62.50
Svay Rieng	128	51.56	Kampong Thom	128	78.13
Takeo	128	69.53	Oddar Meanchey	125	64.80
Pailin	128	58.59	Kep	128	39.84
Preah Vihear	128	71.09	Mondul Kiri	128	65.63
Kandal	127	70.08	Ratanakiri	128	97.66
Kampot	128	48.44	Koh Kong	122	77.87
Kratie	128	57.81	Phnom Penh	128	23.44

Table 12. Information sources.

Sources of information	Nothing at all	A little	Some	A fair amount	A great deal	Total		
	%					N	Mean*	SD
General newspapers	93.00	3.80	2.15	0.96	0.10	3,028	1.11	0.46
Farm magazines	88.99	5.75	3.67	1.32	0.26	3,024	1.18	0.58
Extension publications	80.54	7.93	7.47	3.70	0.36	3,026	1.35	0.80
TV farm programs	55.97	13.39	16.36	12.56	1.72	3,025	1.91	1.17
Radio farm programs	48.71	15.70	17.51	15.40	2.68	3,026	2.08	1.23
Local demonstration farms	83.44	6.68	6.51	2.88	0.50	3,025	1.30	0.76
Web/Internet/e-mail	97.68	1.03	0.76	0.43	0.10	3,023	1.04	0.31
Extension meetings, workshops, courses	55.58	14.14	19.23	9.91	1.12	3,026	1.87	1.11
Agricultural research stations	93.69	3.24	2.15	0.83	0.10	3,027	1.10	0.44
Demonstration plots at local farmers' field, field days and tours	88.69	5.52	4.26	1.32	0.20	3,025	1.19	0.58
Personal contact with extension agents	83.90	7.74	5.72	2.28	0.36	3,025	1.27	0.70
Leader farmers in your area	80.36	8.03	6.51	4.10	0.99	3,025	1.37	0.85
Neighbors/relatives	45.43	17.25	14.83	19.23	3.26	2,974	2.18	1.28
Others	86.29	2.82	4.41	5.75	0.73	817	1.32	0.86

** Means were calculated based on: 1 = Nothing at all, 2 = A little, 3 = Some, 4 = A fair amount, 5 = A great deal.*

Tables 12 and 13 summarize sources of information and the receipt of extension services along with the number of contacts that households had with extension service providers. Tables 14, 15 and 16 provide further details on these topics. The data suggest a pluralistic agricultural extension service in Cambodia with farmers receiving services from a variety of sources. When asked about possible sources of agricultural information (from a predetermined list of 14 sources), the great majority of households reported that they received no information at all from 10 of the 14 listed sources. The most used sources were TV farm programs, radio farm programs, extension meetings and neighbors/relatives. Even so, the means for these four sources and their importance as sources of agricultural information were 1.87 (SD = 1.11) to 2.18 (SD = 1.28), where 1 means they received "nothing at all" from the source and 5 indicates that they received "a great deal" of information from the source. This implies the limited effectiveness of these sources as means of delivering agricultural information in Cambodia in general. Further details of these data are reflected in Table 16, where the mean values for the usefulness of the sources of agricultural information are presented by province. With very few exceptions, provincial means of importance were less than 3, and most have values between 1 and 2 (mean values range from 1.0 (web/Internet/email), SD = 0.5, to 2.18 (neighbors/relatives), SD = 1.28) confirming the information in Table 12. Table 13 shows that over 66 percent of farmers reported that they received extension services from NGO-managed projects, with the highest frequency per household (mean = 3.04, SD = 5.31). Local village and commune offices were the second most frequent service providers, with approximately 54 percent reporting receiving services.

Table 13. Receipt of services from extension service providers.

Extension service provider	% receiving service (N):	If yes, number of contacts in the past year		
		N	Mean	SD
Local agricultural service center	24.35 (1,684)	390	2.77	3.43
Local village/commune office	54.13 (1,672)	878	2.22	2.57
Agriculture colleges/universities, Cambodia	4.00 (1,575)	48	2.54	3.09
Technical or vocational school	5.40 (1,574)	79	2.52	3.61
Extension agents from the Ministry of Agriculture, Forestry and Fisheries	26.14 (1,618)	406	1.96	2.27
Cambodian Agricultural Research and Development Institute (CARDI)	6.48 (1,573)	88	2.60	5.25
NGO-managed projects	66.26 (1,657)	1,031	3.04	5.31
Local demonstration farms	22.33 (1,585)	327	1.87	2.06
Local agricultural research stations	4.97 (1,570)	70	2.06	2.48
Local fertilizer/input supply dealer	17.41 (1,608)	271	2.11	2.00
Other service providers	8.35 (1,305)	105	1.73	1.58

Table 14 presents the number of households that received services from various agricultural extension organizations. The data from three provinces appeared too ambiguous, so we omitted those data from the analysis. In 16 out of 21 provinces, more than 50 percent of the farmers had received agricultural extension services from NGO programs. On the other hand, in 15 provinces, less than 5 percent had received services from agricultural colleges and universities in Cambodia, and in 14 provinces, less than 5 percent had received services from local agricultural research stations. Finally, in 13 provinces, less than 5 percent had received services from technical and vocational schools.

Table 15 summarizes the number of respondents having contact with extension service providers and the average number of contacts in the previous year. The overall means range from 1.73 (SD = 1.58) to 3.04 (SD = 5.31) for the contacts received from other sources of extension services and NGO-managed projects, respectively. In some cases, particularly in Kompot province, large variances are observed, with the means ranging from 3.24 to 12.67 and SD from 7.25 to 18.03. The total number of individuals having contact with extension service providers was the highest for NGO projects (N = 1031); the lowest number was for agricultural colleges and universities (N = 48). These numbers correspond with the information provided in Table 13.

Table 16 presents the degree of importance of information available from various sources. Farmers from different provinces expressed their views about the importance of information differently. For instance, television and radio farm programs were the most important sources of information for farmers in Phnom Penh (2.8 mean score, 1.3 SD) and Stung Treng province (2.8 mean score, 1.4 SD), respectively. Information from neighbors/relatives received the highest score (3.11 mean score, 1.17 SD) in Pailin province. In several provinces, farmers gave relatively high scores to "other sources of information": Pailin, 3.76 (0.58); Kampong Cham, 3.33 (1.15); Battambang, 3.07 (1.00); and Oddar Meanchey, 3.00 (0.01). If we generalize the overall importance of the sources of information, neighbors/relatives received the highest score indicating the greatest importance (2.18 mean score, 1.28 SD), followed by radio farm programs (2.1 mean score, 1.2 SD). The least important source of information for farmers was website/Internet/email, with the lowest mean score of 1.00 (0.3 SD). This result suggests that, along with neighbors/relatives, farm radio and television programs for disseminating agricultural technology remained crucial for the success of farming systems in rural Cambodia.

Table 14. Percentages of respondents who received services from various agricultural extension organizations.

Extension services providers	Local agricultural service center		Local village/commune office		Agriculture colleges/universities, Cambodia		Technical or vocational school		Extension agents from the Ministry of Agriculture, Forestry and Fisheries	
Provinces	N	Yes (%)	N	Yes (%)	N	Yes (%)	N	Yes (%)	N	Yes (%)
Battambang	47	21.28	47	38.30	47	14.89	47	8.51	47	25.53
Banteay Meanchey	65	13.85	67	34.33	67	2.99	67	4.48	67	20.90
Kandal	89	11.24	89	46.07	89	2.25	89	1.12	89	35.96
Kep	51	0.00	51	29.41	51	1.96	51	1.96	51	27.45
Koh Kong	95	58.95	95	76.84	94	5.32	93	9.68	95	45.26
Kampong Chhnang	75	5.33	75	46.67	75	1.33	75	2.67	75	5.33
Kampong Speu	79	34.18	44	27.27	44	2.27	44	11.36	44	11.36
Kampong Thom	97	10.31	100	65.00	100	2.00	98	4.08	99	34.34
Kratie	74	4.05	74	27.03	74	1.35	74	6.76	74	16.22
Mondul Kiri	84	25.00	84	46.43	84	2.38	84	7.14	84	25.00
Oddar Meanchey	81	62.96	81	72.84	81	0.00	81	3.70	81	24.69
Phnom Penh	30	23.33	30	73.33	30	16.67	30	3.33	30	26.67
Preah Vihear	88	51.14	72	29.17	74	10.81	74	13.51	74	22.97
Prey Veng	75	6.67	75	54.67	75	0.00	72	2.78	75	16.00
Pursat	74	41.89	57	29.82	56	14.29	56	8.93	57	14.04
Ratanakiri	125	7.20	125	40.80	125	0.80	125	0.00	125	17.60
Siem Reap	84	29.76	84	73.81	84	3.57	84	8.33	84	21.43
Preah Sihanouk	70	2.86	70	41.43	70	0.00	70	2.86	70	32.86
Stung Treng	95	9.47	95	60.00	95	2.11	94	3.19	95	20.00
Svay Rieng	66	16.67	66	72.73	66	0.00	66	1.52	66	21.21
Takeo	89	15.73	89	61.80	89	7.87	89	0.00	89	26.97

Note: Data for this table from three provinces – Pailin, Kompot and Kompong Cham – appeared to be ambiguous, so are not included.

Table 14. Percentages of respondents who received services from various agricultural extension organizations (cont'd.).

Extension services providers	NGO-managed projects		Local demonstration farms		Local agricultural research stations		Local fertilizer/input supply dealer		Others	
Provinces	N	Yes (%)	N	Yes (%)	N	Yes (%)	N	Yes (%)	N	Yes (%)
Battambang	46	43.48	47	17.02	47	8.51	47	40.43	47	19.15
Banteay Meanchey	67	62.69	67	20.90	67	2.99	67	14.93	67	2.99
Kandal	89	47.19	89	11.24	89	3.37	89	32.58	89	3.37
Kep	51	86.27	51	7.84	51	0.00	51	0.00	51	0.00
Koh Kong	95	74.74	94	18.09	95	15.79	95	9.47	0	
Kampong Chhnang	75	53.33	75	37.33	75	1.33	75	17.33	75	36.00
Kampong Speu	44	79.55	45	35.56	45	2.22	45	0.00	46	4.35
Kampong Thom	100	67.00	100	18.00	98	12.24	99	32.32	66	10.61
Kratie	74	51.35	74	21.62	74	8.11	74	33.78	74	37.84
Mondul Kiri	84	82.14	84	14.29	84	3.57	84	7.14	84	3.57
Oddar Meanchey	81	61.73	81	23.46	81	3.70	81	30.86	0	
Phnom Penh	30	20.00	30	6.67	30	6.67	30	10.00	30	3.33
Preah Vihear	74	52.70	74	37.84	72	11.11	71	11.27	43	11.63
Prey Veng	73	72.60	75	24.00	75	2.67	75	6.67	75	1.33
Pursat	56	55.36	57	29.82	57	3.51	58	6.90	27	0.00
Ratanakiri	125	97.60	125	13.60	125	0.80	125	2.40	125	0.00
Siem Reap	84	60.71	84	23.81	84	4.76	84	15.48	84	3.57
Preah Sihanouk	70	74.29	70	1.43	70	0.00	70	1.43	70	0.00
Stung Treng	95	73.68	94	26.60	95	6.32	94	3.19	92	2.17
Svay Rieng	66	48.48	66	33.33	66	1.52	66	18.18	66	7.58
Takeo	89	39.33	89	31.46	89	1.12	89	23.60	89	6.74

Note: Data for this table from three provinces – Pailin, Kompot and Kompong Cham – appeared to be ambiguous, so are not included

Table 15. Number of respondents having contact with extension service providers and the frequency of contacts in the past year.

Extension services providers	Local agricultural service center			Local village/commune office			Agriculture colleges/universities, Cambodia			Technical or vocational school			Extension agents from the Ministry of Agriculture, Forestry and Fisheries			Cambodian Agricultural Research and Development Institute (CARDI)		
Provinces	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Banteay Meanchey	8	4.13	4.88	22	1.82	1.01	2	3.5	2.12	2	7	4.24	13	2.31	2.66	4	1.75	1.5
Battambang	10	7.30	8.88	18	3.39	3.66	7	2.43	1.4	4	4.25	3.95	11	1.55	0.52	7	3	3.16
Kampong Cham	8	3.13	3.68	27	4.04	4.82				3	1.67	1.15	6	4.17	4.12	1	7	
Kampong Chhnang	5	1.80	1.10	35	2.14	1.31	1	1		3	1	0	4	3	1.41	1	5	
Kampong Speu	24	3.88	4.48	11	2.36	1.43	0			4	2	0	4	1.75	0.96	3	3	2.65
Kampong Thom	7	2.43	0.98	61	1.67	1.03	1	1		2	1.5	2.12	29	1.34	0.9	2	1.5	0.71
Kampot	14	1.93	1.21	41	3.24	7.25	2	1.5	0.71	3	12.67	15.04	19	3.26	4.17	6	11.33	18.03
Kandal	10	1.00	0.47	39	1.31	1.15	1	2		1	1		29	1.48	0.69	2	1	0
Kep	0			15	1.07	0.26	1	1		1	1		14	1.5	0.52	3	1	0
Koh Kong	56	2.84	4.08	73	2.58	3.75	5	2.4	1.14	9	2.11	1.69	43	1.77	1.77	8	1.63	0.74
Kratie	3	1.33	0.58	16	2.38	0.96	0			4	1.5	1	10	1.5	0.85	8	1.63	0.92
Mondul Kiri	21	3.86	4.69	39	3.28	1.73	2	4.5	3.54	6	2.5	0.84	21	2.86	4.15	5	2.4	1.52
Oddar Meanchey	50	1.54	0.68	59	2.12	1.87	0			3	1.33	0.58	20	1.1	0.31	2	1	0
Pailin	29	2.41	2.24	34	2.65	2.24	3	1.67	0.58	5	1.6	0.89	22	2.05	2.01	2	1	0
Phnom Penh	7	4.57	6.83	22	2.23	1.60	5	5	8.4	1	2		8	3.88	6.58	1	1	
Preah Vihear	38	3.79	3.29	15	3.07	2.22	4	4.25	3.95	9	2.44	1.24	17	1.59	0.87	9	2.11	1.05
Prey Veng	5	3.40	1.52	40	1.70	0.88	0			2	3	2.83	11	1.91	0.94	1	5	
Pursat	28	3.32	2.68	15	3.27	2.87	3	2	0	4	3.25	1.89	7	3.71	3.25	6	1.5	0.84
Ratanakiri	9	1.44	0.73	51	1.69	0.86	1	1		0			22	1.32	0.57	2	1	0
Siem Reap	24	1.88	0.99	62	2.18	1.24	2	1.5	0.71	7	1.43	0.79	17	2.12	2.26	3	1	0
Preah Sihanouk	2	1.00	0.00	29	1.55	1.43	0			2	0.5	0.71	23	1.96	2.93	0		
Stung Treng	7	1.14	0.90	51	1.59	0.85	2	0.5	0.71	3	0.67	0.58	18	1.5	1.04	6	0.67	1.03
Svay Rieng	11	1.82	1.25	48	2.15	1.74	0			1	1		14	2.29	1.54	0		
Takeo	14	2.00	2.91	55	1.91	1.55	6	1.83	0.98	0			24	1.96	1.9	6	3.17	3.71
Total	**390**	**2.77**	**3.43**	**878**	**2.22**	**2.57**	**48**	**2.54**	**3.09**	**79**	**2.52**	**3.61**	**406**	**1.96**	**2.27**	**88**	**2.6**	**5.25**

Table 15. Number of respondents having contact with extension service providers and the frequency of contacts in the past year (cont'd…)

Extension services providers	NGO-managed projects			Local demonstration farms			Local agricultural research stations			Local fertilizer/input supply dealer			Others		
Provinces	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Banteay Meanchey	35	3.46	4.78	12	1.42	0.90	2	10.5	13.44	10	2.20	1.75	2	2.5	0.71
Battambang	18	2.50	2.23	7	1.57	0.98	4	1.25	0.5	18	2.78	2.18	9	1.89	1.62
Kampong Cham	31	6.10	7.35	2	1.00	0.00				5	1.80	0.84			
Kampong Chhnang	40	1.90	1.01	28	1.75	1.27	1	3		13	1.62	0.65	27	1.33	0.88
Kampong Speu	24	4.42	3.87	9	1.00	0.00	0			0			2	1.5	0.71
Kampong Thom	63	1.87	1.68	13	0.77	0.73	7	1.86	0.9	30	1.63	1.16	5	1.2	0.45
Kampot	28	3.07	2.71	4	3.25	1.26				8	2.75	3.24	1	1	
Kandal	38	1.42	1.20	9	0.89	0.78	3	1.67	0.58	28	2.04	1.67	2	1	0
Kep	44	1.20	0.41	4	1.00	0.00	0			0			0		
Koh Kong	71	2.42	1.73	17	1.47	0.51	14	1.64	0.84	8	1.75	1.16			
Kratie	34	2.47	2.15	14	3.29	5.25	5	1.6	0.89	22	1.41	0.85	29	1.45	0.95
Mondul Kiri	69	4.62	3.39	12	3.00	3.41	3	1.67	0.58	6	1.67	1.21	3	2.67	1.15
Oddar Meanchey	50	2.60	3.12	19	1.37	0.60	3	1	0	24	1.38	0.49			
Pailin	30	4.30	9.25	8	3.63	3.70	1	1		26	3.04	2.18	3	2	1
Phnom Penh	6	2.83	0.75	2	3.00	0.00	2	4	1.41	3	7.33	10.12	1	10	
Preah Vihear	26	4.69	4.11	23	2.00	1.21	7	1.71	1.11	7	3.14	3.24	5	1.8	1.1
Prey Veng	52	6.06	10.21	18	4.50	3.57	2	5	0	5	5.20	4.32	1	2	
Pursat	20	4.85	5.44	14	1.64	0.84	2	1	0	4	2.75	1.71	0		
Ratanakiri	122	1.89	0.83	17	1.35	0.61	1	1		3	1.67	1.15	0		
Siem Reap	51	2.39	2.18	20	2.10	2.02	4	2.75	1.71	12	1.58	1.08	3	5.33	4.51
Preah Sihanouk	49	5.57	14.73	1	2.00		0			1	3.00		0		
Stung Treng	63	2.16	6.00	24	1.21	0.93	7	1	0.82	4	1.75	0.50	1	0	
Svay Rieng	32	1.81	1.03	22	1.32	0.89	1	5		13	1.31	0.48	5	2.2	1.79
Takeo	35	2.43	2.10	28	1.68	1.61	1	1		21	2.05	1.07	6	1.33	0.82
Total	**1,031**	**3.04**	**5.31**	**327**	**1.87**	**2.06**	**70**	**2.06**	**2.48**	**271**	**2.11**	**2.00**	**105**	**1.73**	**1.58**

Table 16. Importance of the sources of agricultural information.

Information sources / Provinces	General newspapers			Farm magazines			Extension publications			TV farm programs			Radio farm programs			Local demonstration farms			Web/Internet/ e-mail		
	N	M	SD	N	M	SD	N	M	SD	N	M	SD	N	M	SD	N	M	SD	N	M	SD
Battambang	105	1.1	0.4	105	1.2	0.6	104	1.3	0.8	106	2.7	1.3	105	1.7	1.2	105	1.2	0.6	105	1.0	0.1
Banteay Meanchey	126	1.1	0.5	125	1.2	0.5	126	1.3	0.7	126	2.0	1.2	126	2.2	1.2	126	1.3	0.8	125	1.0	0.0
Kandal	127	1.1	0.5	127	1.2	0.6	127	1.5	0.8	127	2.3	1.1	127	2.3	1.2	127	1.1	0.5	127	1.0	0.3
Kep	128	1.0	0.2	128	1.1	0.4	128	1.1	0.3	127	1.7	0.9	128	1.8	1.0	128	1.1	0.4	128	1.0	0.0
Kampong Cham	128	1.1	0.3	128	1.1	0.4	128	1.2	0.7	128	1.9	1.2	128	1.9	1.2	128	1.1	0.4	128	1.0	0.3
Kampong Chhnang	125	1.0	0.2	125	1.1	0.3	125	1.3	0.8	125	1.7	1.1	125	1.7	1.1	124	1.4	0.8	125	1.0	0.1
Kampong Speu	127	1.0	0.0	127	1.0	0.3	127	1.1	0.5	126	1.5	0.9	127	1.7	1.1	127	1.3	0.9	125	1.1	0.5
Kampong Thom	128	1.1	0.3	128	1.2	0.5	128	1.3	0.7	127	2.1	1.2	128	2.2	1.2	126	1.2	0.7	128	1.0	0.2
Kampot	128	1.1	0.6	128	1.2	0.6	128	1.3	0.8	128	2.0	1.3	128	2.2	1.3	128	1.3	0.7	128	1.0	0.3
Koh Kong	122	1.1	0.5	122	1.2	0.6	122	1.6	1.0	122	1.7	1.1	122	2.0	1.2	122	1.3	0.8	122	1.0	0.0
Kratie	126	1.1	0.5	126	1.2	0.7	127	1.5	1.0	128	1.7	1.1	128	2.1	1.3	127	1.5	1.0	127	1.1	0.6
Mondul Kiri	128	1.2	0.5	128	1.4	0.8	128	1.6	1.0	128	1.6	1.1	128	2.0	1.3	128	1.2	0.7	128	1.0	0.0
Oddar Meanchey	125	1.2	0.6	125	1.2	0.6	125	1.5	1.0	125	2.0	1.3	125	2.1	1.2	125	1.4	0.8	125	1.0	0.0
Pailin	128	1.1	0.4	128	1.1	0.5	128	1.5	0.9	128	2.1	1.3	128	2.3	1.4	128	1.3	0.8	128	1.1	0.5
Phnom Penh	128	1.2	0.5	128	1.2	0.5	128	1.2	0.7	128	2.8	1.3	128	2.1	1.3	128	1.1	0.4	128	1.1	0.4
Preah Vihear	128	1.1	0.3	128	1.1	0.5	128	1.3	0.7	128	1.2	0.6	126	1.9	1.1	127	1.6	1.1	127	1.0	0.3
Prey Veng	128	1.1	0.5	128	1.2	0.6	126	1.4	0.9	127	2.2	1.2	128	2.6	1.2	128	1.3	0.7	128	1.0	0.1
Pursat	128	1.1	0.5	125	12	0.7	128	1.4	0.8	125	1.6	1.0	127	1.7	1.1	127	1.4	1.0	125	1.2	0.6
Ratanakiri	128	1.1	0.4	128	1.2	0.6	128	1.3	0.7	128	1.7	0.9	128	2.0	1.1	128	1.2	0.6	128	1.0	0.2
Siem Reap	128	1.1	0.4	128	1.2	0.5	128	1.2	0.6	128	1.6	1.0	128	2.0	1.2	128	1.4	0.8	128	1.0	0.1
Preah Sihanuk	126	1.2	0.7	126	1.4	0.8	126	1.4	0.8	126	1.9	1.1	126	2.4	1.2	126	1.0	0.3	126	1.0	0.0
Stung Treng	127	1.1	0.6	127	1.1	0.4	127	1.2	0.7	128	1.9	1.2	126	2.8	1.4	128	1.5	0.9	128	1.1	0.3
Svay Rieng	128	1.1	0.5	128	1.3	0.7	128	1.4	0.9	128	1.9	1.2	128	2.0	1.2	128	1.3	0.8	128	1.0	0.1
Takeo	128	1.1	0.5	128	1.3	0.7	128	1.4	0.9	128	2.1	1.2	128	2.0	1.2	128	1.7	0.9	128	1.1	0.4
Total	**3028**	**1.1**	**0.5**	**3024**	**1.2**	**0.6**	**3026**	**1.4**	**0.8**	**3025**	**1.9**	**1.2**	**3026**	**2.1**	**1.2**	**3025**	**1.3**	**0.8**	**3023**	**1.0**	**0.3**

Note: Mean was computed based on scale: 1= Nothing at all, 2= A little, 3=Some, 4=A fair amount, 5= A great deal.

Table 16. Importance of sources of agricultural information (cont'd…).

Information sources / Provinces	Extension meetings, workshops, courses			Agricultural research stations			Demo plots at local farmers' field, field days and tours			Personal contact with extension agents			Leader farmers in your area			Neighbors/ relatives			Others		
	N	M	SD	N	M	SD	N	M	SD	N	M	SD	N	M	SD	N	M	SD	N	M	SD
Banteay Meanchey	126	1.72	1.06	126	1.11	0.48	126	1.11	0.48	126	1.16	0.60	126	1.49	0.94	126	2.29	1.31	23	1.70	1.29
Battambang	106	1.81	1.12	105	1.09	0.40	105	1.09	0.40	105	1.21	0.72	105	1.37	0.85	106	2.61	1.33	14	3.07	1.00
Kampong Cham	128	1.91	1.30	128	1.05	0.25	128	1.05	0.25	128	1.14	0.56	128	1.34	0.79	128	2.78	1.31	3	3.33	1.15
Kampong Chhnang	125	1.93	1.10	124	1.27	0.66	124	1.27	0.66	124	1.27	0.65	124	1.28	0.70	124	2.27	1.11	3	2.00	1.00
Kampong Speu	125	1.79	1.02	127	1.13	0.54	127	1.13	0.54	126	1.13	0.48	127	1.43	0.92	123	1.89	1.30	20	1.25	0.79
Kampong Thom	128	1.96	1.07	127	1.20	0.59	127	1.20	0.59	128	1.19	0.57	128	1.61	1.12	126	2.23	1.22	59	1.58	1.04
Kampot	128	1.99	1.22	128	1.17	0.53	128	1.17	0.53	128	1.26	0.75	128	1.34	0.79	128	2.66	1.27			
Kandal	127	1.61	0.93	127	1.06	0.35	127	1.06	0.35	127	1.24	0.60	127	1.37	0.86	127	1.83	1.19	26	1.54	1.07
Kep	128	1.12	0.46	128	1.00	0.00	128	1.00	0.00	128	1.03	0.22	128	1.05	0.30	128	1.38	0.73			
Koh Kong	121	2.37	1.21	122	1.20	0.68	122	1.20	0.68	122	1.48	0.84	122	1.46	1.01	122	2.16	1.16			
Kratie	128	1.91	1.19	127	1.39	0.93	127	1.39	0.93	127	1.44	0.96	126	1.29	0.80	125	2.07	1.23	9	2.22	0.97
Mondul Kiri	128	2.27	1.19	128	1.12	0.45	128	1.12	0.45	128	1.37	0.83	128	1.61	0.97	128	2.41	1.51			
Oddar Meanchey	125	2.05	1.16	125	1.25	0.56	125	1.25	0.56	125	1.40	0.80	125	1.45	0.88	125	2.06	1.16	4	3.00	0.00
Pailin	128	2.02	1.21	128	1.27	0.71	128	1.27	0.71	128	1.38	0.81	128	1.34	0.77	128	3.11	1.17	3	3.67	0.58
Phnom Penh	128	1.30	0.73	128	1.06	0.33	128	1.06	0.33	128	1.13	0.45	128	1.23	0.71	128	2.08	1.39			
Preah Vihear	126	1.83	1.05	126	1.33	0.82	126	1.33	0.82	126	1.25	0.71	127	1.62	1.14	116	1.64	1.13	26	1.31	0.79
Prey Veng	128	2.08	1.21	128	1.08	0.32	128	1.08	0.32	128	1.17	0.60	128	1.23	0.62	128	2.02	1.23	43	1.91	1.54
Pursat	127	1.76	1.18	127	1.23	0.66	127	1.23	0.66	127	1.20	0.63	126	1.46	1.04	93	1.69	1.26	23	1.70	1.02
Ratanakiri	128	1.65	0.91	128	1.09	0.36	128	1.09	0.36	128	1.16	0.51	128	1.11	0.51	128	1.97	0.98	127	1.09	0.53
Siem Reap	128	2.02	1.03	128	1.30	0.67	128	1.30	0.67	128	1.51	0.71	128	1.27	0.60	128	2.41	1.25	128	1.05	0.38
Preah Sihanouk	126	1.98	1.11	126	1.02	0.27	126	1.02	0.27	126	1.12	0.48	126	1.42	0.86	126	2.05	1.24	6	2.50	1.64
Stung Treng	128	1.83	0.97	128	1.22	0.57	128	1.22	0.57	128	1.27	0.70	128	1.35	0.77	127	1.75	1.06	44	1.30	0.79
Svay Rieng	128	1.76	1.03	128	1.31	0.72	128	1.31	0.72	128	1.55	0.98	128	1.38	0.92	128	2.50	1.30	128	1.12	0.54
Takeo	128	2.19	1.10	128	1.55	0.86	128	1.55	0.86	128	1.55	0.89	128	1.46	0.93	128	2.24	1.33	128	1.05	0.30
Total	**3,026**	**1.87**	**1.11**	**3,025**	**1.19**	**0.58**	**3,025**	**1.19**	**0.58**	**3,025**	**1.27**	**0.70**	**3,025**	**1.37**	**0.85**	**2,974**	**2.18**	**1.28**	**817**	**1.32**	**0.80**

Notes: Mean was computed based on scale: 1 = Nothing at all, 2 = A little, 3 = Some, 4 = A fair amount, 5 = A great deal.

Table 17 reports the farmers' perceptions and feedback about awareness, frequency of contact and source of information from agricultural extension services by gender. For the sources of information, the responses are scaled from 1 to 5, with 1 indicating that the source provided nothing at all, while 5 indicating that it provided a great deal, so a low average value reflects unfavorable perceptions, and a value closer to 5 reflects favorable perceptions. In general, farmers had little to do with most sources of information, as indicated by the majority of responses by female and male farmers having an average below 3.

Table 17. Feedback on extension services by female and male farmers.

Statements	Female farmers			Male farmers			*t*-value	*p*-value
	N	Mean	SD	N	Mean	SD		
Awareness about agricultural extension services	2299	1.37	0.482	1551	1.34	0.474	-1.527	0.127
Receipt of agricultural extension services from government organizations	843	1.78	0.413	938	1.74	0.437	-1.912	0.056
Frequency of contact with extension service providers	176	2.12	2.597	232	1.83	1.985	-1.267	0.206
Service received from NGO-managed projects	852	1.39	0.488	852	1.39	0.491	0.169	0.866
Frequency of contact with NGO extension workers	474	3.41	6.858	572	2.70	3.438	-2.140	0.033
Source of agricultural information--extension publications	1341	1.28	0.716	1700	1.41	0.856	4.481	0.000
Source of agricultural information--TV farm programs	1338	1.78	1.105	1702	2.02	1.217	5.551	0.000
Source of agricultural information--radio farm programs	1340	1.96	1.174	1701	2.17	1.270	4.668	0.000
Source of agricultural information--extension meetings, workshops, courses	1340	1.84	1.097	1702	1.90	1.126	1.507	0.132
Source of agricultural information--demonstration plots at local farmers' field, field days and tours	1339	1.18	0.570	1701	1.20	.598	0.772	0.440
Source of agricultural information--personal contact with extension agents	1339	1.24	0.651	1701	1.30	0.745	2.427	0.015
Source of agricultural information--neighbors/relatives	1315	2.13	1.301	1677	2.22	1.262	1.843	0.065

In the case of frequency of contact with NGO-based extension workers, there was significant difference between female and male farmers for receiving extension services (at 5 percent level of significance). Results show that female farmers visited with extension workers more frequently than the male farmers did. This suggests that NGO-based projects focused their services more on female farmers than males. Similarly, television and radio farm programs as sources of information appeared to be significantly different between the two groups (female and male), with a high mean value among male farmers (at 1 percent level of significance). This indicates that television and radio farm programs were popular among male farmers, and they used these media as an information source for farming. Additionally, extension publications and personal contacts as sources of information appeared to be significantly different (at 1 percent and 5 percent levels of significance, respectively), with higher means for males. This implies that male farmers are more educated and have access to and search for reading materials about farming.

Perceptions about Improved Farming Practices and their Adoption

Changing low-productivity subsistence agriculture to high-productivity sustainable farming, and thus reducing poverty and hunger, primarily depends on the adoption of improved agricultural technology. However, farmers in rural Cambodia have not been able to adopt yield-increasing improved farming practices for decades. We asked farmers: Do you feel you can improve your farm's productivity by adopting new/improved farming practices? In response, more than two-thirds of the farmers responded confidently that they could improve agricultural productivity with the adoption of improved agricultural practices (Figure 2). At the same time, when we asked if there are any barriers to fully adopting the improved agricultural practices, results shown in Figure 3 indicated that about 66 percent of farmers felt that there are barriers preventing them from fully adopting such practices.

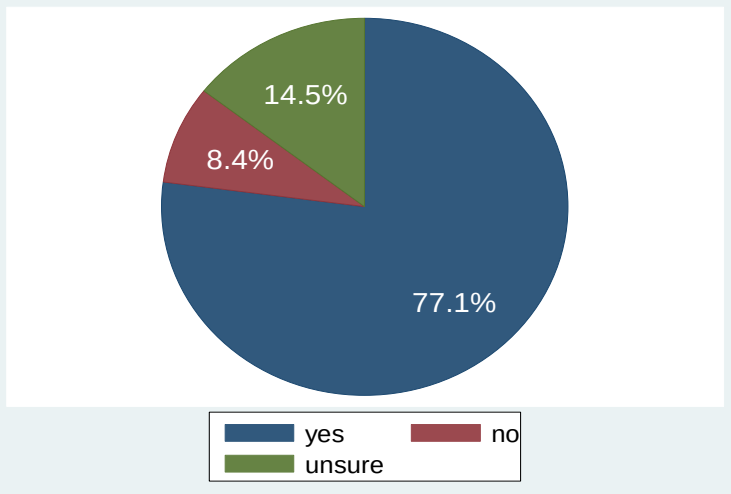

Figure 2. Farmers' responses about whether they can improve farm productivity after adopting improved farming practices (N = 3,049).

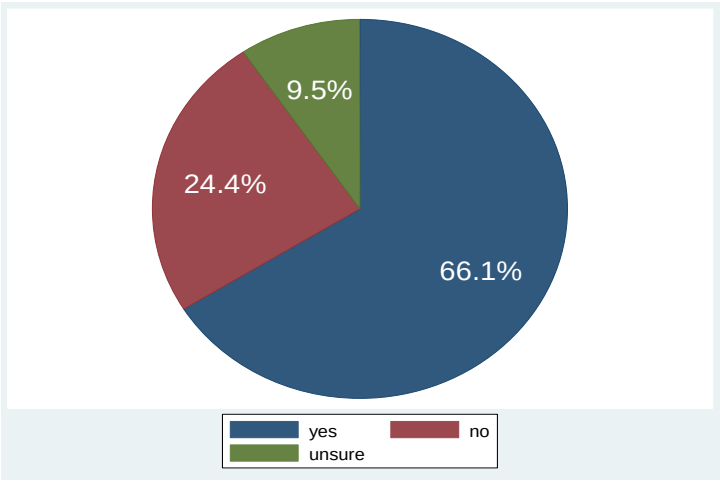

Figure 3. Farmers' responses about whether there are any barriers to fully adopt the improved agricultural practices (N = 3,049).

Table 18 shows the perceptions of farmers toward adoption of improved agricultural practices. The majority of farmers from all the provinces indicated that their farms' productivity could be improved by adopting improved farming practices. With respect to barriers, in all provinces except Koh Kong, farmers responded that they encountered barriers to adopt new farming practices. In contrast, almost two-thirds (63 percent) of the farmers in Koh Kong province did

not notice any barriers to adopting new farming practices. We explore these barriers more detail in Table 19.

Table 18. Perceptions about improved farming practices and their adoption.

Provinces	Do you feel you can improve your farm's productivity by adopting new and improved farming practices?				Are there any barriers to fully adopting these improved agricultural technologies?			
	N	Yes	No	Unsure	N	Yes	No	Unsure
		%				%		
Prey Veng	128	94.53	0.78	4.69	128	67.19	32.03	0.78
Pursat	128	53.13	13.28	33.59	128	48.44	47.66	3.91
Preah Sihanouk	126	96.03	0.00	3.97	126	69.84	28.57	1.59
Siem Reap	128	66.41	33.59	0.00	128	66.41	33.59	0
Stung Treng	128	65.63	8.59	25.78	128	78.13	5.47	16.41
Svay Rieng	128	66.41	33.59	0.00	128	82.81	17.19	0
Takeo	128	80.47	19.53	0.00	128	85.16	14.84	0
Pailin	128	92.97	0.00	7.03	128	78.13	17.19	4.69
Preah Vihear	128	60.94	11.72	27.34	128	54.69	34.38	10.94
Kandal	127	76.38	10.24	13.39	127	79.53	12.6	7.87
Kampot	128	86.72	3.91	9.38	128	70.31	25.78	3.91
Kratie	123	74.80	5.69	19.51	123	65.85	17.07	17.07
Banteay Meanchey	127	89.76	3.94	6.30	127	74.02	23.62	2.36
Battambang	123	61.79	3.25	34.96	123	56.1	9.76	34.15
Kampong Cham	128	82.03	3.91	14.06	128	67.19	25.78	7.03
Kampong Chhnang	128	72.66	3.91	23.44	128	71.88	7.81	20.31
Kampong Speu	128	49.22	19.53	31.25	128	53.91	39.84	6.25
Kampong Thom	128	73.44	7.81	18.75	128	82.03	8.59	9.38
Oddar Meanchey	125	85.60	5.60	8.80	125	40.8	47.2	12
Kep	128	96.09	0.00	3.91	128	89.06	10.16	0.78
Mondul Kiri	128	67.19	0.78	32.03	128	46.09	20.31	33.59
Ratanakiri	128	94.53	1.56	3.91	128	79.69	15.63	4.69
Koh Kong	122	85.25	4.10	10.66	122	27.87	63.11	9.02
Phnom Penh	128	78.91	5.47	15.63	128	49.22	28.91	21.88

The farmers who responded affirmatively to the question on barriers to adopting new technologies were then asked to assess the degree of importance of eight selected barriers on a scale from 1, not at all important, to 5, meaning very important, along with a ninth option to rank other barriers not listed. The results (Table 19) show that the most important barrier with the highest rank was: “My farm has no access to irrigation," with a mean score of 3.86 and standard deviation 1.16. For this barrier, 11 of the 24 provinces reported a mean value of greater than 4, suggesting that access to irrigation is an important barrier to address. Kimsun *et al.* (2011) also stated this problem in Cambodia in their study.

The second most important barrier was: “I don't have sufficient knowledge about new technology," with the mean score 3.60 and SD 1.02. Similarly, the third most important barrier was: “I don't have education and skills to adopt new technology," with the mean score of 3.48 and SD 1.05. Finally, the least important barrier mentioned by farmers was from the “others” category, in which barriers were not listed. The least important listed barrier was: “I don't own land for farming," with mean score of 2.57 and standard deviation 1.37.

These results indicate that farmers do have barriers to adopt new farming practices, particularly lack of irrigation, and lack of education, knowledge and skills to adopt improved technology. If desired adoption rates and improved farm productivity are to be achieved, concerned government bodies and related stakeholders must overcome these barriers by providing means of irrigation, training to develop new skills for adopting improved practices and adult/informal educational programs in rural Cambodia.

Table 19. Farmers' responses about the degree of importance of selected barriers.

Barriers / Provinces	I do not have sufficient knowledge or details about the new technology			I do not have the education or skills to adopt the new technology			The agricultural technology is not suitable to my farm			I cannot get credit needed to adopt the new technology			I do not own the land which I farm		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Prey Veng	86	3.10	1.05	86	2.77	1.14	85	2.29	1.15	84	2.52	1.31	86	1.86	1.13
Pursat	61	2.93	1.22	60	2.88	1.17	61	2.62	1.1	60	3.10	1.34	61	2.26	1.05
Preah Sihanouk	88	3.06	1.15	88	2.85	1.10	88	2.31	1.14	88	2.00	1.10	88	1.73	0.98
Siem Reap	85	3.35	1.21	85	3.12	1.24	85	2.58	1	84	3.31	1.23	85	2.21	1.44
Stung Treng	100	3.77	0.74	100	3.82	0.74	99	2.97	1.03	99	3.00	1.38	100	2.55	1.44
Svay Rieng	106	3.62	1.07	106	3.51	1.09	106	2.92	1.06	106	3.41	1.40	105	1.90	1.19
Takeo	109	3.51	1.14	109	3.35	1.13	109	2.9	1.05	109	3.35	1.27	109	2.00	1.13
Pailin	100	3.81	0.97	100	3.81	0.97	100	2.97	1.18	100	3.54	1.07	100	2.72	1.46
Preah Vihear	69	3.45	1.05	70	3.24	1.13	70	3.06	1.18	67	3.36	1.21	68	2.54	1.41
Kandal	101	3.80	0.84	101	3.92	0.87	101	3.03	1	101	3.46	1.14	101	3.30	1.34
Kampot	90	4.02	0.52	90	3.92	0.52	90	3.13	1.03	90	3.52	0.78	90	2.81	1.30
Kratie	80	3.79	0.76	80	3.51	0.95	80	3.36	1.03	79	3.65	1.23	80	3.30	1.42
Banteay Meanchey	94	3.29	1.26	94	3.01	1.20	94	2.3	1.12	94	2.87	1.33	93	1.59	1.01
Battambang	69	3.71	1.09	68	3.54	1.10	69	3.03	1.16	69	3.62	1.43	66	2.98	1.58
Kampong Cham	86	3.83	0.64	86	3.74	0.74	86	3.13	0.93	86	3.69	0.86	86	2.94	1.37
Kampong Chhnang	85	3.52	0.95	83	3.51	0.86	85	3.45	0.84	83	2.94	1.51	83	3.23	1.32
Kampong Speu	69	3.30	1.00	68	3.04	1.11	67	2.99	1.15	68	3.21	1.20	68	2.09	0.91
Kampong Thom	105	3.75	0.76	105	3.97	0.66	104	3.15	0.92	105	3.14	1.31	105	2.76	1.28
Oddar Meanchey	51	3.90	1.04	51	3.55	1.21	51	3.57	1.04	51	3.88	0.86	51	3.25	1.49
Kep	114	3.73	1.18	114	3.54	1.15	114	2.9	1.02	114	3.34	1.30	114	2.51	0.90
Mondul Kiri	59	3.81	1.01	59	3.64	0.96	59	2.68	1.09	59	3.90	1.23	59	3.20	1.44
Ratanakiri	102	3.83	0.92	102	3.51	0.90	102	2.76	0.95	102	3.78	1.10	102	2.70	1.28
Koh Kong	34	3.56	1.02	34	3.65	0.95	34	3.12	1.07	34	3.76	0.99	34	3.62	1.02
Phnom Penh	63	3.76	0.73	63	3.76	0.56	63	3.11	0.95	63	3.57	1.23	63	3.03	1.36
Total	**2,006**	**3.60**	**1.02**	**2,002**	**3.48**	**1.05**	**2,002**	**2.91**	**1.09**	**1,995**	**3.30**	**1.29**	**1,997**	**2.57**	**1.37**

Notes: Mean was computed based on scale: 1 = Not at all important, 2 = A little important, 3 = Neutral, 4 = Somewhat important, 5= Very important.

Table 19. Importance of specific barriers. (Cont'd…)

Barriers / Provinces	My farm is too small			My farm has no access to irrigation			I do not have access to a market for my product			Other reason		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Banteay Meanchey	94	2.60	1.37	94	3.78	1.34	94	3.34	1.3	19	3.16	1.92
Battambang	67	3.10	1.43	68	4.41	0.88	68	4.04	1.2	10	4.60	0.52
Kampong Cham	86	3.08	1.16	86	3.99	0.93	86	3.79	1.03			
Kampong Chhnang	84	3.42	1.06	84	4.31	0.79	83	3.9	0.76	4	4.50	0.58
Kampong Speu	68	2.41	1.04	68	3.84	0.92	66	2.92	1.28	10	3.80	1.03
Kampong Thom	105	3.07	1.18	104	4.16	0.75	104	3.47	1.05	25	2.16	1.46
Kampot	90	2.72	1.07	90	4.28	0.64	90		0.63			
Kandal	101	3.24	1.15	101	3.62	1.21	101	3.65	1.21	12	3.67	0.98
Kep	114	2.73	1.00	114	4.09	0.94	114	3.09	1.01	4	4.25	0.96
Koh Kong	34	3.32	1.07	34	3.71	1.19	34	3.35	1.18	2	5.00	0.00
Kratie	79	3.29	1.43	79	3.87	1.26	77	4.05	0.81	1	4.00	
Mondul Kiri	59	3.22	1.16	59	4.27	0.91	59	3.98	1.42	1	5.00	
Oddar Meanchey	51	3.39	1.18	51	4.02	1.10	51	3.57	1.4			
Pailin	100	2.65	1.25	100	3.90	1.14	100	4.2	0.93	1	4.00	
Phnom Penh	63	3.19	1.13	63	4.13	1.04	63	3.51	1.15	1	5.00	
Preah Vihear	67	2.75	1.30	69	4.01	1.04	66	2.77	1.43	9	3.33	1.80
Prey Veng	86	2.31	1.21	86	3.14	1.32	86	3.08	1.28	20	3.95	0.89
Pursat	61	2.52	1.21	61	3.79	1.02	58	2.64	1.27	17	3.29	1.36
Ratanakiri	102	2.54	1.03	102	3.84	1.22	102	3.02	1.01			
Siem Reap	85	2.73	1.42	84	4.05	1.02	84	3.29	1.25	85	1.64	1.42
Preah Sihanouk	88	2.31	1.14	87	3.26	1.38	87	2.15	1.11	10	3.10	1.52
Stung Treng	100	2.82	1.31	100	3.95	1.02	99	2.95	1.34	13	2.15	1.46
Svay Rieng	106	2.29	1.33	106	4.13	1.09	106	3.29	1.34	106	1.62	1.38
Takeo	109	2.54	1.24	109	2.61	1.36	109	3.19	1.24	109	1.70	1.49
Total	**1,999**	**2.81**	**1.25**	**1,999**	**3.86**	**1.16**	**1,987**	**3.37**	**1.25**	**459**	**2.23**	**1.66**

Notes: Mean was computed based on scale: 1 = Not at all important, 2 = A little important, 3 = Neutral, 4 = Somewhat important, 5 = Very important.

Table 20 presents farmers' perceptions about the adoption of improved agricultural technologies and barriers to adopt such technologies by gender. No significant gender differences appeared in farmers' perceptions toward increasing farm productivity after adopting improved farm practices. Similarly, there is no significant difference between male and female farmers about experiencing barriers to adopt improved farming practices. However, barriers regarding market access were significantly different at a 10 percent level, suggesting that male farmers have comparatively more access to markets than their female counterparts. This suggests that, at the policy level, market access should be improved among female farmers to increase income from farming.

Table 20. Perceptions of female and male farmers on adoption of improved farming practices and their barriers.

Statements	Female farmers			Male farmers			*t*-value	*p*-value
	N	Mean	SD	N	Mean	SD		
Farmers' perceptions on improving farm's productivity by adopting new and improved farming practices	1340	1.38	0.723	1703	1.35	0.712	-1.291	0.197
There are barriers to fully adopt improved agricultural technologies.	1336	1.41	0.626	1699	1.43	0.663	0.795	0.427
Importance is: I do not have the education or skills to adopt the new technology.	966	3.46	1.055	1280	3.50	1.050	0.889	0.374
Importance of barrier: I cannot get credit needed to adopt the new technology.	962	3.31	1.320	1277	3.29	1.277	-0.358	0.721
Importance of barrier: My farm has no access to irrigation.	963	3.88	1.159	1280	3.86	1.171	-0.526	0.599
Importance of barrier: I do not have access to a market for my product.	959	3.32	1.242	1270	3.42	1.264	1.782	0.075

Demographics of the Respondent Farmers

To understand the demographics of the respondents, we analyzed the data presented in Table 21. Out of 3,024 respondents, 56 percent were female, which is a little higher than the national population average of 51.34 percent (GPCC, 2008). The average age was 44.5 years, and the average household size was 5.32. Similarly, the average number of years of schooling was 4.21 years, and 70.15 percent of the respondents could read and write. These figures stand in contrast to the national figures, where average years of education is 3.2, the literacy rate is 77.6 percent, and the household size is 4.6 (GPCC, 2008; NIS, DGH and ICF, 2015). In other words, years of schooling are higher in the sample population and the literacy rate is lower, the proportion of females is higher, and household sizes are higher. These indicators, however, show that the respondents are close to representing the national averages of the Cambodian population.

Table 21. Demographics of respondents.

Demographics / Provinces	Gender			Age (years)			HH size			Number of years of schooling			Can read and write	
	N	Female (%)	Male (%)	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Yes (%)
Prey Veng	127	33.86	66.14	127	45.16	12.43	127	5.3	1.79	127	4.46	2.95	127	76.38
Pursat	127	47.24	52.76	127	41.87	13.69	127	5	1.59	127	4.09	3.5	127	68.5
Preah Sihanouk	126	37.30	62.70	126	45.53	13.77	126	5.41	1.87	125	4.14	3.13	126	76.19
Siem Reap	128	53.13	46.88	128	44.33	11.96	128	5.37	1.89	128	1.85	2.34	128	44.53
Stung Treng	127	58.27	41.73	127	43.64	14.59	127	5.83	1.87	121	3.22	3.21	127	61.42
Svay Rieng	128	50.00	50.00	128	46.03	12.73	128	5.11	1.72	128	4.34	4.07	128	69.53
Takeo	128	60.16	39.84	128	45.76	13.17	128	5.18	1.75	128	4.27	3.18	128	76.56
Pailin	128	78.13	21.88	128	44.2	13.46	128	5.14	1.96	128	4.71	3.61	128	76.56
Preah Vihear	127	45.67	54.33	127	41.67	13.64	127	5.09	1.84	112	2.92	2.97	127	53.54
Kandal	127	63.78	36.22	127	48.54	14.16	127	5.61	2.2	127	5.51	3.65	127	80.31
Kampot	128	71.09	28.91	128	42.5	12.95	128	5.15	2.22	128	3.99	3.64	128	70.31
Kratie	127	70.08	29.92	127	49.91	12.62	127	5.45	2.3	119	5.29	2.79	127	90.55
Banteay Meanchey	126	37.30	62.70	126	44.51	13.57	126	4.73	1.64	126	3.78	3.29	126	64.29
Battambang	106	74.53	25.47	106	47.83	13.01	106	5.29	1.9	84	5.6	3.06	106	89.62
Kampong Cham	128	77.34	22.66	128	43.34	12.63	128	5.32	2.07	128	4.4	3.62	128	73.44
Kampong Chhnang	125	67.20	32.80	125	47.34	13.42	125	4.7	1.71	123	4.68	3.36	125	80
Kampong Speu	128	44.53	55.47	128	41.55	13.63	128	5.18	1.89	128	3.59	3.12	128	68.75
Kampong Thom	125	52.00	48.00	126	45.44	13.3	126	5.02	1.74	124	4.15	3.85	126	66.67
Oddar Meanchey	125	72.00	28.00	125	43.78	12.95	125	5.26	1.8	124	3.9	3.53	125	69.6
Kep	128	33.59	66.41	128	46.4	12.3	128	5.26	1.88	88	5.02	2.88	128	66.41
Mondul Kiri	127	48.82	51.18	127	37.17	12.49	127	5.43	2.51	127	3.63	3.52	127	62.2
Ratanakiri	128	60.16	39.84	128	40.55	11.96	128	6.4	3.03	81	4.81	3.11	128	50
Koh Kong	122	63.11	36.89	122	43.93	11.5	122	5.34	2.12	122	3.53	3.46	122	67.21
Phnom Penh	128	50.78	49.22	128	48.23	13.18	128	6.02	2.83	128	5.94	3.99	128	84.38
Total	3,024	56.12	43.88	3,025	44.53	13.31	3,025	5.32	2.06	2,881	4.21	3.47	3,025	70.15

Conclusions and Recommendations

Cambodia has a predominantly rural population, with almost 85 percent of people engaging in agriculture as their main occupation. Despite government promotion of the use of modern inputs such as new and improved seed varieties, fertilizers and pesticides, farm productivity remains fairly low. Farmers are facing various constraints and barriers to adopting improved agricultural technologies. In this milieu, an effective extension service delivery system is expected to play a vital role in increasing farm productivity and food security, and improving livelihoods of smallholder farmers in rural Cambodia.

A survey was carried out across the country, with all 24 provinces included in the study. A sample of 3,072 farmers was randomly selected from 192 villages using a systematic random sampling procedure. This study was conducted to examine the adoption level of improved agricultural practices by farmers as well as to assess farmers' needs and perceived barriers to adopt new farming practices. In addition, this study determined the level of adequacy of extension services and examined the major sources and channels of information used by farmers. With this study, we attempt to address the gap in the existing knowledge by providing a close look at the constraints faced by agricultural extension services and barriers to the adoption of improved farming practices by rural farm households in Cambodia.

The study reveals that more than two-thirds of the farmers planted traditional rather than improved varieties except for dry-season flood recession and dry-season lowland irrigated rice. In wet-season production, farmers used seeds from their own harvest except for maize seeds. Farmers purchased maize seeds from the market, suggesting that most seed companies/dealers primarily concentrated on maize seeds rather than other crop seeds. This is possibly because the maize seed business is more profitable than others are.

During the wet season, farmers are more likely to adopt improved varieties that are suited to lowland irrigated conditions. However, choosing improved varieties depends on consumers' preferences for specific traits such as high yield, insect/pest resistance, drought/stress tolerance and palatability (eating quality), as well as straw yield and quality. For maize, the case is the opposite. In the dry season, farmers preferred to plant traditional maize varieties rather than improved ones. The reason for this could be that traditional varieties may contain many of traits mentioned above.

Contribution of private seed companies to supply seed for dry-season production was nominal –less than 1 percent for rice and 5 percent to 20 percent for other crops. So, seed systems for crops -- more importantly, of improved dry rice varieties -- need to be restructured.

The awareness rate for extension programs was below 50 percent in many provinces, so programs about new seeds and other inputs through mass media are suggested. Additionally, the role of agricultural colleges and universities as a source of information is limited. A pluralistic agricultural extension service in Cambodia needs to be established. Television and radio farm programs, extension meetings, and neighbors/relatives were the most relevant sources of information among farmers.

Although two-thirds of the farmers felt that they could improve their farm's productivity by adopting improved farming practices, about the same proportion of farmers felt that there were barriers preventing them from fully adopting such practices, such as lack of irrigation and lack of education, knowledge and skills to adopt improved technology.

To sum up, some policy interventions are needed to improve the overall quality of agricultural extension services and overcome the constraints/barriers to the adoption of improved farming practices by farming households in rural Cambodia. Trainings are needed for educating farmers

and developing skills and knowledge of improved practices on their farms along with methods/results demonstrations.

Improved crop varieties suited to wetland or lowland irrigated conditions need to be developed and distributed to promote the adoption of improved rice varieties. For dry-season production, drought/stress-tolerant varieties with good yield and quality should be promoted.

Expanding irrigation systems is an important issue to address because most farmers reported that irrigation was the most important barrier to adopting improved technologies. Producing good quality radio and television farm programs and broadcasting those programs through appropriate channels is a key success point to empower farmers. Why female farmers did not use these sources as male farmers did needs to be studied. Similarly, access to Internet/email and ICTs should be increased, but further research is necessary to determine if this is an infrastructural (access) issue or a technical skills or networking (utilization) issue. An effective market mechanism and information sharing forum should also be designed.

To address the nominal contribution of private seed companies/dealers to supply seed, an effective seed distribution mechanism/network may be established in coordination with NGOs and government organizations. Because limited information was available from agricultural colleges and universities, linkages between research, education, extension and farmers should be strengthened.

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3. Perceptions of Agricultural Extension Workers and Relevant Stakeholders about Agricultural Extension Services in Cambodia

Ramjee Ghimire
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Executive Summary

As key human resources and facilitators of agricultural value chain development, agricultural extension professionals and other agriculture-related key informants can play catalytic roles to educate and inform farmers of new agricultural technologies and practices and help boost agricultural productivity. Therefore, this study, commissioned jointly by Michigan State University and Cambodia's Royal University of Agriculture, sought to examine agricultural extension professionals and associated key informants' perspectives of extension services. Specifically, this study aimed to examine the perceived importance of irrigation, credit, marketing and extension services on agricultural development; to assess the status of irrigation, fertilizer use, agricultural credit, agricultural marketing and agricultural extension services; and determine problems associated with agricultural extension services to farmers and solicit suggestions to improve those services. This study, conducted in May-June 2013 alongside a study of farmers, sampled 148 extension professionals and key informants. The findings of this study have been reviewed, adapted, and promulgated via Cambodia's Agricultural Extension Policy 2015.

In summary, all four factors – agricultural extension services, marketing, irrigation and credit – were perceived as important to enhancing both agricultural production and productivity and ensuring food security. Water scarcity and difficulty finding funding dominated as the problems hindering irrigation. Most farmers used fertilizers but lack education and information about fertilizer use. Farmers' lack of collateral and cumbersome credit application processes limit farmers' access to credit. Hog, chicken, fish and cattle are the most traded commodities, followed by seasonal vegetables and fruits. Farmers do not use telephones or email/Internet to receive information. Extension workers rarely visit farmers. Dry-season rice production has potential, but getting quality seed on time and for a lower price at the local level are problems hindering production.

The authors recommend Ministry of Agriculture, Forestry and Fisheries (MAFF) and concerned Cambodian authorities provide training to both MAFF and NGO extension staff members on extension process skills, and strengthen inter-organizational coordination; scale up farmer's training programs; review and/or design water use policy giving due attention to small irrigation systems; educate farmers about fertilizers: their use, sources, benefits, detriments, markets; review and revisit agricultural credit policy; promote use of smartphones, short messaging services, social media in extension; train and mobilize more female extension workers; and work to increase NGOs, Cambodian Agricultural Research and Development Institute (CARDI) and agricultural college/university collaboration focusing on farmer-centered research.

Introduction

Cambodia has been striving to intensify its agricultural production and productivity, commercialize its agriculture, and increase its milled rice export to 1 million tons from 0.4 million tons in 2013. As of 2015, that goal is yet to be attained (FAO, 2014; IFC, 2015). Persistent food insecurity and high rural poverty show that Cambodia has more work to do to strengthening agricultural value chains and enhancing agricultural production and productivity. However, agricultural systems are complex, comprising natural resources, social and/or human activity (e.g., farmers, extension workers, other stakeholders, extension services), and economic (production, sale/marketing, credit) subsystems. These systems should complement each other to attain and sustain agricultural growth. Agricultural extension services (AES), in particular, are in need of restructuring because only 1 percent of Cambodian farmers have the opportunity to meet with extension workers (Feed the Future-Cambodia, 2011). The Cambodia Regional Agricultural Trade Environment (RATE) Assessment attributes the weak implementation of agricultural policy and programs to the lack of resources and awareness of best practices among institutions charged with governance and accountability (USAID, 2013). A recent study commissioned by MSU and RUA has revealed that agricultural development professionals in Cambodia do not feel as competent as they should in extension skills to effectively serve their clients (Suvedi, Tynna and Ghimire, 2016). Additionally, women play pivotal roles in agricultural production and constitute 60 percent of the farm work force, but, the 2010 Cambodia Gender Assessment (Feed the Future-Cambodia, 2011) reports that they have limited access to agricultural credit, training and extension services.

The above background information underscores the need for a study to find out where Cambodia stands in delivering extension services and why extension services are not more effective. As key human resources in the agricultural value chain, extension professionals and AES associated key informants can greatly promote technological adoption among farmers and thus agricultural growth. Therefore, this study, commissioned jointly by Michigan State University and Cambodia's Royal University of Agriculture, sought to examine agricultural extension professionals' and associated key informants' perceptions of extension services. Specifically, this study aimed to:

- Examine the perceived importance of irrigation, credit, marketing and extension services on agricultural development.
- Assess the status of irrigation, including unirrigated land, areas that can be irrigated and barriers to irrigation development, and solicit suggestions to improve irrigation facilities.
- Assess status of fertilizer use by farmers, such as types, sources and factors affecting fertilizer use, and solicit suggestions to improve fertilizer use.
- Assess the status of use of agricultural credit by farmers, including availability, sources, purposes and the perceived importance of select factors in getting credit, and solicit suggestions to improve farmers' access to credit.
- Assess the status of marketing of agricultural products, and solicit suggestions to improve marketing of those products.
- Assess the status of agricultural extension services, including providers of extension services, activities conducted by extension technicians, frequency of visits of technicians to farmers and extension technicians' perceived satisfaction with extension services.
- Determine common problems associated with the delivery of agricultural extension services to farmers, and solicit suggestions to improve agricultural extension services.

This study is based on the premise that extension professionals are the key human resources in extension services, and they are and/or should be cognizant of the farming systems they are involved in. More importantly, their delivery of extension and advisory services greatly influences their clientele's performance. Therefore, extension professionals' opinions are invaluable to determine problems pertaining to field extension services and to augment agricultural development. A final point to be noted is that extension services need to be supported with agricultural inputs (e.g., credit, fertilizers, irrigation) and marketing, which are integral parts of agricultural development.

Evaluation Methods

Population and Sample

Extension workers and key informants (e.g., commune council chairpersons [CCCs] and members, police, village chiefs and vice chiefs, NGO/INGO staff members) made up the study population. Employing convenience sampling, 148 individuals were selected and surveyed. Agricultural extension workers and NGO or project staff members serving within the communes where a farmers' survey was conducted were invited to participate in the self-administered survey. Provincial Ministry of Agriculture Forestry and Fisheries (MAFF) and Ministry of Rural Development staff members as well as current and recent CCCs in sample communes were also invited to complete the survey.

Data Collection

Data collection survey instruments consisted of 25 questions related to agricultural credit, irrigation, marketing, extension services and fertilizers. Data were collected by faculty members and senior students of the Royal University of Agriculture. Dr. Men Sarom, vice rector for research at RUA, led the in-country data collection, data entry and data analysis. This was one of two studies conducted simultaneously, the first being a baseline study of farmers representing 24 provinces. More details about data collection can be found in the farmers' perceptions in Part I of this report. Data were collected during May-June 2013.

Data Entry and Data Analysis

Data were analyzed using SPSS software. Prior to analysis, data were checked for errors and cleaned as needed. Descriptive statistics were calculated for quantitative data. Responses to open-ended questions were coded and themes were drawn.

Evaluation Results

Demographics

As shown in Table 1, male participants (n = 98) outnumbered females (n = 41). They were on average 47.6 (SD = 12.79) years old, with males (49 years) being slightly older than females (44 years). On average, they had been serving in their current positions for over 11 years. Males had been serving in their current positions for a longer average period (12.35 years) than their female counterparts (9 years). Slightly fewer than half (43.9 percent) were commune council chairs/members, followed by village chiefs/vice chiefs (22.3 percent) and MAFF extension workers/professionals (12.9 percent). MAFF provincial extension workers and NGO/INGO staff members each made up 7.2 percent. Finally, 6.5 percent were police and people from local associations.

Table 1. Demographics of respondents.

Demographic characteristics	Female	Male	Total
Age (years)	n = 41	n = 98	N = 139
Mean (SD)	43.56 (13.72)	49.31 (12.05)	47.61 (12.79)
Years working in current position	n = 39	n = 96	N = 135
Mean (SD)	9.00 (7.37)	12.35 (10.36)	11.39 (9.74)
Current position	Female (n = 41)	Male (n = 98)	Total (N = 139)
MAFF extension worker/professional	19.5%	10.2%	12.9%
MAFF provincial extension worker/professional	7.3%	7.1%	7.2%
Commune council chair/member	56.1%	38.8%	43.9%
NGO/INGO staff member	4.9%	8.2%	7.2%
Village chief /vice chief	2.4%	30.6%	22.3%
Other (police, local association)	9.8%	5.1%	6.5%

Agricultural Extension Service Providers

When asked which among the given nine organizations provide agricultural extension services in their area, 87.6 percent of respondents indicated MAFF; and 49.7 percent NGOs. Other providers of extension services included the Ministry of Rural Development, the Ministry of Water Resources and Meteorology, the Ministry of Women's Affairs and Veterans, the Cambodian Agricultural Research and Development Institute (CARDI), donor-funded projects such as USAID, HARVEST, JICA, GIZ, etc., agricultural colleges and universities, and others. The findings indicate the adoption of a pluralistic approach to extension services in Cambodia.

Table 2. Major AES providers (N = 145).

Major AES providers	Percent
Ministry of Agriculture, Forestry and Fisheries	87.6%
Ministry of Rural Development	40.0%
Ministry of Water Resources and Meteorology	33.8%
Ministry of Women's Affairs and Veterans	42.8%
Cambodian Agricultural Research and Development Institute (CARDI)	20.7%
Donor-funded project such as USAID, HARVEST, JICA, GIZ, etc.	22.8%
NGOs in the area*	49.7%
Agricultural colleges/universities	11.0%
Other institutions**	7.6%

*Note: * CEDAC, DPA, MVI, Caritas, PADEE, JICA, DANIDA, My Village (Mvi), CARE Cambodia, AMK, Jay, MJP, Lum Ang, PVD, LCK, CDT; ** TV/Radio, Police, MoEYS, MoL.*

Factors Essential for Agricultural Development

Table 3 shows the respondents' ratings of the importance of irrigation, credit, fertilizers, marketing of agricultural products and access to extension services for agricultural development. They perceived provision of agricultural extension services to be extremely important (4.50), and provision of agricultural marketing services (4.21), irrigation provision in the local area (4.07) and farmers' access to agricultural credit (3.94) as important. There was more disagreement on the importance of timely availability of fertilizers (3.47) to farmers. The findings confirm the earlier statement that agricultural extension services are invaluable to agricultural development.

Table 3. Perceptions on the importance of services to improve food security in their area.

Services to improve food security	N	Mean (SD)
Irrigation provision in this area	140	4.07 (0.96)
Farmers access to agricultural credit	143	3.94 (1.02)
Timely availability of fertilizers	140	3.47 (1.29)
Provision of agricultural marketing services	140	4.21 (0.98)
Provision of agricultural extension services	144	4.50 (0.65)

Scale: 1= Not at all important, 2 = Not important, 3 = Undecided, 4 = Important, 5 = Extremely important.

Agricultural Irrigation

As shown in Table 4, a large percentage of respondents (74.5 percent) indicated "scarce water sources" and "lack of funding" as the biggest barriers for developing irrigation, while 47.6 percent, 46.2 percent, 20 percent and 2.1 percent of respondents perceived "lack of irrigation policies," "maintenance of irrigation facility is costly," "intercommunity conflict about the water source" and "far from water source," respectively, as barriers to irrigation development. This study did not explore further sources of water for irrigation or causes of scarcity. These findings prompt us to ask what are the legal, socioeconomic or other barriers to accessing water?

Table 4. Respondents reporting barriers to the development of irrigation system (N= 145).

Barriers to developing irrigation system	Percent
Scarce water sources	74.50%
Lack of funding	74.50%
Lack of irrigation policies	47.60%
Maintenance of irrigation facilities is costly	46.20%
Intercommunity conflict about the water source	20.00%
Water source is very far	2.10%

Table 5 presents suggestions to improve irrigation systems. Leading the list is "Build/renovate/expand the irrigation system," which 58 percent of the respondents suggested. Other suggestions include "Set up committee or water user group for maintenance," "Support well, pond," "Set up/create water use policy" and "Support pumping machine." Contrary to the opinion of scarce water sources being the most pressing barrier, as reported in Table 4, suggestions were directed more toward constructing irrigation canals or irrigation systems, and not toward finding new water sources.

Table 5. Suggestions to improve irrigation system.

Comments /suggestion to improve irrigation system	Female (n = 36)	Male (n = 85)	Total (N = 121)
Build /renovate /expand the irrigation system	61.10%	56.50%	57.90%
Set up committee or water user group for maintenance	5.60%	16.50%	13.20%
Support well, pond	13.90%	10.60%	11.60%
Set up /create policy for water use	8.30%	10.60%	9.90%
Support pumping machine	5.60%	9.40%	8.30%
Don't know/No idea	5.60%	7.10%	6.60%
Participation from relevant ministries	11.10%	3.50%	5.80%
Support funding and equipment	2.80%	3.50%	3.30%
Other	2.80%	1.20%	1.70%

Note that past research has shown that investment in large irrigation infrastructure is unlikely to significantly and efficiently increase rice productivity; it is improved rice varieties and use of fertilizers that help improve wet-season rice productivity (Wokker et al., 2011; IRRI, 2012, as reported in Johnston, Try and de Silva, 2013). Since every community and country situation is different, a detailed inquiry to determine whether to embark on big irrigation projects would be worthwhile.

Fertilizers

Out of 145 respondents who reported whether farmers in their locality used fertilizers, 85 percent said that farmers used some fertilizers on their farms. Urea topped the list, which 79.8 percent of the respondents reported, followed closely by N-P-K. (75.8 percent). Three other fertilizers (Buffalo head brand, DAP and other (natural, organic, Chinese fertilizers) were used by a few farmers (Figure 1).

Figure 1. Fertilizers used reported
(N = 124)

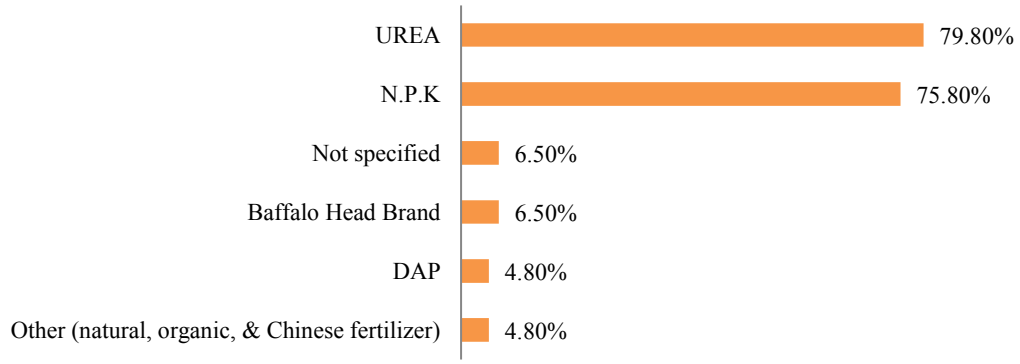
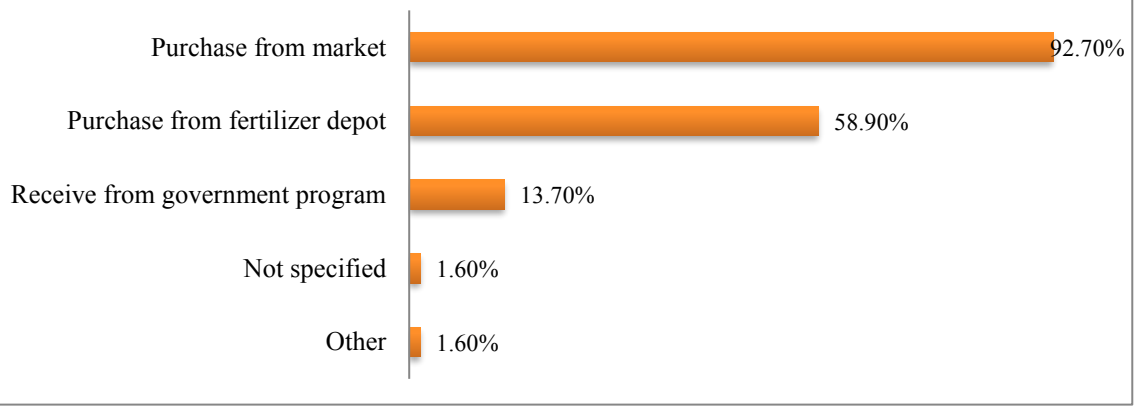


Figure 2 shows that the majority of respondents (92.7 percent) said farmers purchased fertilizers from the market, 58.9 percent said farmers purchased from fertilizer depots, 13.7 percent said farmers received fertilizers from government programs, and a few respondents (1.6 percent) reported other sources.

Figure 2. Sources of fertilizers (N = 124)



Respondents perceived all four factors – timely supply, quality of fertilizers, price of fertilizers and local accessibility – to be influential in the use of fertilizers by farmers in their area. However, descriptive statistics in Table 6 show that quality of fertilizer is perceived to be most important among the four factors, followed by price, timely supply and local accessibility. Furthermore, males perceived all four factors to be more important to fertilizer use than females

did. Being a study based on convenience sampling, it was not that important to examine whether ratings for importance of these factors differed by gender, but it is an issue requiring further inquiry through systematic research.

Table 6. Perceived importance of factors in the use of fertilizers.

	Female		Male		Total	
Factors	n	Mean (SD)	n	Mean (SD)	N	Mean (SD)
Timely supply	31	3.87 (1.06)	92	4.00 (0.96)	123	3.97 (0.98)
Quality of the fertilizer	31	3.90 (1.14)	90	4.21 (0.77)	121	4.13 (0.89)
Price of the fertilizer	29	4.03 (0.87)	84	4.11 (0.81)	113	4.09 (0.82)
Local accessibility	29	3.34 (1.32)	84	3.64 (1.00)	113	3.57 (1.10)

Scale: 1 = not at all important, 2 = not important, 3 = undecided, 4 = important, 5 = extremely important.

Suggestions to improve fertilizer use: Eighty-nine respondents reported suggestions to improve fertilizer use by farmers in their locality. Some of the suggestions are listed below.

"Advertisement about good fertilizer and new technique."
"Advertisement about quality and advantage."
"Decrease price of fertilizer."
"Disseminate the chemical fertilizer widely to the farmers."
"Do not increase [in] using [use of] chemical fertilizer[s]."
"Do not use chemical fertilizer[s]."
"Explain them before giving fertilizer to use appropriately and on time to plant."
"Explain farmers the quality of fertilizer."
"Extension about the problem of using the fertilizer, availability."
"Give formula of using fertilizer and give/communicate about sources of fertilizer."
"Have the local demonstration farm for farmer."
"Market for selling fertilizer in the community."
"Reduce price of fertilizer; advertisement; [and] provide credit."
"Provide information in local Khmer language."
"Training, practice with farmer, demonstrate the outcome."

These suggestions indicate that education and information about fertilizers – use, quality, time to use, advantages and disadvantages of using fertilizers – are pressing issues among farmers. A few respondents even suggested not to use chemical fertilizers but rather use natural and/or organic and/or compost fertilizer. Providing fertilizers at lower prices, improving access to credit to buy fertilizers, and providing training and information about fertilizers in local Khmer dialects were other practical suggestions that participants made.

Agricultural Credit

Credit is one of the important inputs for farmers. It is even more important for small, female and marginalized farmers, most of whom do not have the necessary collateral to acquire credit. A study by Jessop et al. (2012) in Cambodia, Mali, Senegal, Tanzania, Thailand and Tunisia shows that financial institutions frequently hesitate to provide credit for agriculture. This same study reveals that, despite contributing over one-third of the national GDP, the agricultural sector in Cambodia receives a mere 7 percent of total credit. Conversely, with increased commercialization of agriculture and renewed stakeholder interest in agricultural value chains, farmers and other stakeholders increasingly demand agricultural credit. The following section addresses several underlying issues with Cambodia's agricultural credit management.

Table 7. Perceptions on the availability of credit to farmers.

Perceptions	Female (n = 40)		Male (n = 96)		Total (N = 136)	
	f	%	*f*	%	*f*	%
It is readily available	18	45.0%	46	47.9%	64	47.1%
It is not readily available	9	22.5%	31	32.3%	40	29.4%
Cannot say	10	25.0%	15	15.6%	25	18.4%
Do not know	3	7.5%	4	4.2%	7	5.1%

Table 7 shows that approximately half (47 percent) of respondents believed credit to be readily available in their locality. About one-third replied, "It is not readily available," while about one-fifth responded, "Cannot say." Only 5 percent of respondents replied, "Do not know." These findings indicate that a large percentage of farmers in sample areas may not have access to credit or may be struggling to get credit for agriculture. Reporting differences exist between genders; the proportion of males reporting readily available and not readily available credit was slightly higher than that of females.

To the question of sources of credit, a large percentage (87.2 percent) indicated formal lenders (financial institutions/banks), followed by microcredit/groups/cooperatives (48.6 percent), friends and relatives (37.2 percent), NGOs (29.7 percent) and other sources (2.7 percent) (Table 8).

Table 8. Sources of credit for farmers reported by respondents (N = 148).

Sources of credit	Percent
Formal lenders (financial institutions/banks)	87.2%
Non-governmental organizations	29.7%
Friends and relatives	37.2%
Microcredit/groups/cooperatives	48.6%
Other	2.7%

To the question of uses of agricultural credit, as shown in Table 9, the majority (72.5 percent) of the respondents indicated that farmers used it to buy fertilizers, 70 percent to buy seeds, 49.3 percent to buy or rent new plots of land, 47.8 percent to pay off old debts, and 45.7 percent to get fruit and vegetable seedling. The findings imply that seed and fertilizers are very important inputs for Cambodian farmers in which they are willing to invest. Farmers would greatly benefit from locally available, high-quality inputs supplied in a timely manner at affordable prices. Buying or renting livestock, getting fruit and vegetable seedlings, paying off debts and acquiring household goods were other areas that agricultural credit is used for.

Table 9. Perceptions of respondents on the use of credit by farmers.

Use of credit	Female (n = 41)	Male (n = 97)	Total (N = 138)
To buy seeds	68.3%	71.1%	70.3%
To buy fertilizers	68.3%	74.2%	72.5%
To get fruit and vegetable seedlings	36.6%	49.5%	45.7%
To market the farm products	14.6%	24.7%	21.7%
To buy or rent new plots of land	58.5%	45.4%	49.3%
To buy or rent livestock	43.9%	32.0%	35.5%
To buy or rent fish pond	17.1%	15.5%	15.9%
To acquire household goods	29.3%	47.4%	42.0%
To pay off old debts	39.0%	51.5%	47.8%
Other (equipment, pesticides, ceremonies, renovated house)	2.4%	11.3%	8.7%
To pay for labor/renting machine/oil	14.6%	2.1%	5.8%
To create/expand small business	4.9%	5.2%	5.1%

Ensuring farmers' access to agricultural credit is long overdue, especially in developing countries, and Cambodia is no exception. Examination of the ratings of problems shown in Table 10 reveal that respondents perceived "Lenders want collateral and getting collateral is the problem" to be the most severe issue that farmers have been facing. Not getting credit in time, high interest rates and cumbersome credit applications were other problems that respondents rated lower but perceived to be important to receiving agricultural credit.

Table 10. Perceptions of respondents on problems of farmers to receive agricultural credit.

Problems to receive agricultural credit	Female		Male		Total	
	f	Mean (SD)	*f*	Mean (SD)	*f*	Mean (SD)
Lenders want collateral and getting collateral is the problem	41	4.20 (0.87)	95	4.20 (0.79)	136	4.20 (0.81)
Interest rate is high	41	3.80 (1.31)	93	3.72 (1.13)	134	3.75 (1.18)
Lending process is cumbersome	39	3.03 (1.16)	92	3.05 (1.19)	131	3.05 (1.18)
There are no or a few financial institutions in this area	40	3.45 (1.24)	91	3.33 (1.21)	131	3.37 (1.22)
Payoff period is short	40	3.40 (1.28)	91	3.32 (1.21)	131	3.34 (1.23)
Getting credit in time is the difficult part	40	3.33 (1.44)	93	4.15 (6.08)	133	3.90 (5.15)
Lenders do not provide adequate credit as needed	40	3.58 (1.20)	92	3.45 (1.30)	132	3.48 (1.26)
Cumbersome paperwork which most farmers are not able doing on their own	41	3.88 (1.08)	93	3.40 (1.27)	134	3.54 (1.23)
There is not much information available about credit limit, procedures and interest rates	40	3.35 (1.19)	92	3.33 (1.30)	132	3.33 (1.26)

Scale: 1 = not at all important, 2 = not important, 3 = undecided, 4 = important, 5 = extremely important.

Table 11 presents measures to improve farmers' access to credit. One-third of the 109 respondents (34 percent) suggested providing credit at lower interest rates, while 22.9 percent suggested that microfinance institutions educate borrowers about the lending process and the risks associated with credit. Regarding differences on opinions between genders, more males (30%) recommended "MFI to make sure borrowers completely understand the process, risks"

than females (11%); and opposite was the finding for "Extend the period of loan and delay the payment," which 18% females and 3% males reported.

Table 11. Recommendations to improve access to credit.

Recommendations to improve access to credit	Female (n = 38)	Male (n = 71)	Total (N = 109)
Low interest rate	31.6%	35.2%	33.9%
Extend the period of loan, and delay the payment	18.4%	2.8%	8.3%
Create community loan/village saving group	7.9%	7.0%	7.3%
MFI to make sure borrowers completely understand the process, risks	10.5%	29.6%	22.9%
Simplify paperwork, reduce collateral	10.5%	12.7%	11.9%
Borrowers to pay back on time	0.0%	5.6%	3.7%
Borrowers should have clear goals before borrowing	10.5%	9.9%	10.1%
Don't know/No idea	21.1%	12.7%	15.6%
Other	7.9%	2.8%	4.6%

Agricultural Marketing

Table 12 presents responses to the following questions: whether farmers in your area produce the listed ten products, whether they sell them and to whom these products are sold. Wet-season rice topped the list of products that farmers produce (85.4 percent), followed by hogs, chickens, cattle, seasonal vegetables, seasonal fruits, fish and buffalo. Most farmers sold hogs, chicken, cattle, buffalo, seasonal fruits, seasonal vegetables and fish, but few sold non-timber forest products (NTFP). Farmers sold these products primarily to traders and only a few products (e.g., fish and NTFP) directly to users.

Table 12. Marketing of major agricultural products.

Agricultural products	Is this a major product of this community?		Do farmers market this product?		Whom do farmers sell this product to?				
	N	Yes (%)	N	Yes (%)	N	Direct to consumers	To traders	To wholesalers	Other
Dry-season rice	126	51.6%	86	75.6%	52	9.6	90.4	0.0	0.0
Wet-season rice	137	85.4%	121	79.3%	69	7.2	87.0	0.0	5.8
Fish	128	53.9%	97	80.4%	50	40.0	58.0	0.0	2.0
Cattle	132	69.7%	114	91.2%	86	1.2	97.7	0.0	1.2
Buffalo	127	52.8%	94	85.1%	69	1.4	97.1	0.0	1.4
Hogs	130	76.2%	115	97.4%	95	2.1	95.8	1.1	1.1
Chickens	131	74.0%	112	95.5%	72	11.1	87.5	0.0	1.4
Seasonal fruits	124	54.0%	98	84.7%	52	25.0	61.5	7.7	5.8
Seasonal vegetables	122	59.8%	98	84.7%	50	28.0	60.0	8.0	4.0
Non-timber forest products	99	28.3%	53	69.8%	16	43.8	50.0	6.3	0.0

Table 13 presents respondents' suggestions to improve the marketing of agricultural products. The five most common suggestions are: farmers need to have enough and quality production, invite more traders/buyers and search/find markets, ensure price security for their products, provide market information to growers, and provide extension and training to farmers about marketing.

Table 13. Suggestions to improve marketing of agricultural products (no of suggestions = 109).

Suggestions	Percent
Farmers need to have enough and quality production	16.51
Invite more traders/buyers and search/find the markets	15.60
Price security: farmers should get reasonable price for the produce	11.93
Provide market information to the growers	11.01
Provide extension and training to farmers about marketing	10.09
Increase access to the market	9.17
Farmers use quality seeds, varieties	8.26
Plan before production and do timely production: grow before festive seasons	4.59
Build infrastructures: road, market places	3.67
Advertise about the products	3.67
Government has to buy the products	2.75
Communities have to play role in marketing agricultural products	2.75

Agricultural Extension Services

A large percentage of respondents (94 percent) said there is an agricultural extension technician assigned to help farmers in their area, which is a positive indicator of extension services. As shown in Figure 3, the Ministry of Agriculture, Forestry and Fisheries (MAFF) extension workers are the most common providers of extension services, with 85.8 percent of respondents reporting their presence, followed by NGO/INGO workers (64.2 percent). USAID/HARVEST, JAICA, GIZ, etc., staff members ranked third (30.6 percent) and others, with only 2.2 percent reported. The findings are consistent with data from many other agrarian countries in Asia and Africa where the public sector dominates extension services. Interestingly, Cambodia has a large NGO/INGO presence in development agencies, including extension services (Siphana et al., 2011). It is a positive indicator given the current effort to streamline and strengthen extension services toward demand-driven and pluralistic forms.

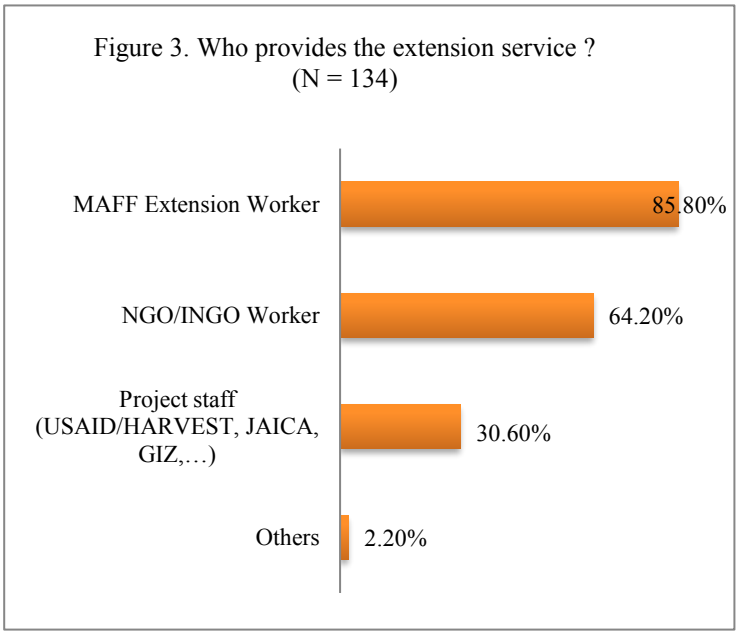


Table 14 presents extension activities conducted in communities and shows a large percentage of respondents (90.7 percent) reporting training, followed by group meetings (66.7 percent). Other activities conducted in the community mentioned by respondents include farm

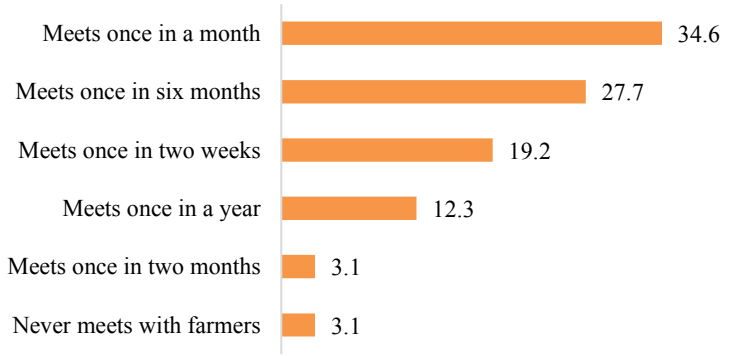
exhibitions (59.7 percent), demonstrations (54.3 percent), farmers' field days (55 percent) and observation tours (36.4 percent). Visits to a farm/home were reported by only two respondents. None reported telephone or email/Internet as extension activities currently used. Surprisingly, extension workers rarely visited farmers' farms/homes.

Table 14. Types of extension activities conducted reported by respondents (N = 131)

Action activities	Female	Male N (%)	Total
Training	35 (89.7)	82 (91.1)	117 (90.7)
Demonstration	14 (35.9)	56 (62.2)	70 (54.3)
Observation tour	12 (30.8)	35 (38.9)	47 (36.4)
Farm exhibition	20 (51.3)	57 (63.3)	77 (59.7)
Group meeting	20 (51.3)	66 (73.3)	86 (66.7)
Farmers' field days	25 (64.1)	46 (51.1)	71 (55.0)
Telephone	-	-	-
Email/Internet	-	-	-
Visit to farm/home	1 (2.6)	1 (1.1)	2 (1.6)
Others	0	1 (1.1)	1 (0.8)

As shown in Figure 4, more than one-third of respondents said they meet farmers once in a month, about one-third said once in six months, and about 20 said once in two weeks.

Figure 4. Frequency of visit to farmers (in %) (N = 130)



When asked to rate on a 1-5 scale how satisfied they were with the agricultural extension services provided to farmers in their area, respondents indicated that they were satisfied with the services. Females (n = 39) rated services slightly lower (4.05) than males did (4.15) (Table 15). Note that 13 percent of the female respondents were found to be either unsatisfied or not at all satisfied with the services, compared with only 10 percent of males. Whether and how these findings reflect the opinions of farmers could not be determined.

Table 15. Respondents' satisfaction with agricultural extension services for farmers in their area.

Satisfaction level	Female (n = 39)	Male (n = 86) N (%)	Total (N = 125)
Extremely satisfied	17 (43.6)	27 (31.4)	44 (35.2)
Satisfied	16 (41.0)	50 (58.1)	66 (52.8)
Not at all satisfied	4 (10.3)	2 (2.3)	6 (4.8)
Not satisfied	1 (2.6)	7 (8.1)	8 (6.4)
Undecided	1 (2.6)	0 (0)	1 (0.8)

Scale: 1 = not at all satisfied, 2 = not satisfied, 3 = undecided, 4 = satisfied, 5 = extremely satisfied.

Table 16 presents responses to problems associated with new agricultural services and provisions for farmers. The study's findings support anecdotal evidence that producing rice in the dry season, even though feasible, is still challenging, with all five factors – timeliness of supply, local accessibility, quality, price of dry-season rice and training on use of inputs – reported to being critical to dry-season rice production. Local accessibility and training on use of inputs for improved varieties were indicated as the two most pressing problems that farmers have been facing for wet-season rice production.

Training on use of inputs related to improved fruit saplings/cuttings/seedlings was reported as a problem that farmers face by 44 percent of the respondents. They also said that local accessibility of vegetable seeds/seedlings and training on use of inputs are important factors to be considered to boost vegetable production.

Local accessibility and training on use of inputs are two important factors for fish production, also. Similarly, local accessibility, price and training on use of inputs for improved breeds are indicated to be the important factors for cattle production. The findings resonate with those of Serey et al. (2014), who reported that farmers holding local cattle breeds and having limited access to and knowledge of breeding programs were their major constraints.

Buffaloes are popular for milk, meat, manure and draft purposes in Cambodia, but their population is declining. The price of improved buffalo breeds and training on use of inputs were the two issues that respondents felt were important for buffalo production in Cambodia. Regarding pigs, local accessibility of improved hogs, their prices and training on use of inputs emerged as critical factors requiring urgent attention. For poultry, about 40 percent of the extension professionals and other key informants indicated that local accessibility, price and training on use of inputs were critical factors for production. For livestock feed, accessibility at the local level, the price of feed and training on use of inputs for feed production remained important for farmers.

Table 16. Respondents' perceptions on problems associated with agricultural services.

Problem associated with:	Female	Male	Total
Improved varieties of rice seed for dry season	n = 31	n = 53	N = 84
Timeliness of supply	58.1%	50.9%	53.6%
Locally accessible	48.4%	50.9%	50.0%
Quality	48.4%	37.7%	41.7%
Price	61.3%	47.2%	52.4%
Training on use of inputs	41.9%	58.5%	52.4%
Improved varieties of rice seed for wet season	n = 31	n = 58	N = 89
Timeliness of supply	38.7%	32.8%	34.8%
Locally accessible	38.7%	51.7%	47.2%
Quality	25.8%	22.4%	23.6%
Price	51.6%	32.8%	39.3%
Training on use of inputs	35.5%	53.4%	47.2%
Improved fruit saplings/cuttings/seedlings	n = 24	n = 54	N = 78
Timeliness of supply	20.8%	29.6%	26.9%
Locally accessible	16.7%	48.1%	38.5%
Quality	37.5%	24.1%	28.2%
Price	54.2%	29.6%	37.2%
Training on use of inputs	25.0%	51.9%	43.6%
Improved vegetable seeds/seedlings	n = 22	n = 52	N = 74
Timeliness of supply	18.2%	26.9%	24.3%

Locally accessible	22.7%	48.1%	40.5%
Quality	22.7%	23.1%	23.0%
Price	45.5%	28.8%	33.8%
Training on use of inputs	18.2%	55.8%	44.6%
Improved fingerlings	n = 22	n = 52	N = 74
Timeliness of supply	36.4%	26.9%	29.7%
Locally accessible	31.8%	48.1%	43.2%
Quality	18.2%	21.2%	20.3%
Price	45.5%	30.8%	35.1%
Training on use of inputs	27.3%	51.9%	44.6%
Improved cattle breeds	n = 21	n = 50	N = 71
Timeliness of supply	33.3%	28.0%	29.6%
Locally accessible	23.8%	54.0%	45.1%
Quality	14.3%	20.0%	18.3%
Price	66.7%	32.0%	42.3%
Training on use of inputs	23.8%	54.0%	45.1%
Improved buffalo breeds	n = 20	n = 45	N = 65
Timeliness of supply	35.0%	24.4%	27.7%
Locally accessible	20.0%	46.7%	38.5%
Quality	10.0%	13.3%	12.3%
Price	70.0%	26.7%	40.0%
Training on use of inputs	25.0%	53.3%	44.6%
Improved hogs	n = 22	n = 54	N = 76
Timeliness of supply	40.9%	25.9%	30.3%
Locally accessible	27.3%	50.0%	43.4%
Quality	18.2%	24.1%	22.4%
Price	59.1%	38.9%	44.7%
Training on use of inputs	22.7%	50.0%	42.1%
Improved poultry (ducks and chickens)	n = 23	n = 48	N = 71
Timeliness of supply	39.1%	29.2%	32.4%
Locally accessible	34.8%	56.3%	49.3%
Quality	26.1%	18.8%	21.1%
Price	60.9%	31.3%	40.8%
Training on use of inputs	34.8%	54.2%	47.9%
Livestock feed	n =22	n = 52	N = 74
Timeliness of supply	27.3%	26.9%	27.0%
Locally accessible	36.4%	51.9%	47.3%
Quality	27.3%	17.3%	20.3%
Price	63.6%	42.3%	48.6%
Training on use of inputs	31.8%	48.1%	43.2%

Suggestions to Improve Extension Services

Table 17 shows comments and suggestions to improve extension services. About 39 percent of informants suggested providing training to farmers, followed by more frequent extension services by slightly fewer respondents. Other key suggestions reported are: promote participation of stakeholders in extension programs by supporting transportation (15.9 percent), increase number of extension workers (10.3 percent), provide support funding for

projects/programs/NGO interventions (8.7 percent) and strengthen capacity of extension workers (7.9 percent). These suggestions support the earlier findings that provision of training for farmers and extension workers, and trustworthy and reliable extension services are critical to agricultural development in Cambodia, and two areas that the Royal Government of Cambodia has to urgently address.

Table 17. Comments/suggestions made by respondents to improve extension services.

Comments/Suggestions	Female (n = 37)	Male (n = 89)	Total (N = 126)
Provide training to farmers	21.60%	46.10%	38.90%
Provide extension activities more frequently	27.00%	40.40%	36.50%
Promote participation by supporting transportation, provide snacks	16.20%	15.70%	15.90%
Increase numbers of extension workers	18.90%	6.70%	10.30%
Support funding for projects/programs/NGO interventions	10.80%	7.90%	8.70%
Strengthen capacity of extension workers	5.40%	9.00%	7.90%
Support agriculture inputs (i.e., improved seed, pesticide, fertilizer, ...)	5.40%	5.60%	5.60%
Support marketing of agriculture products	10.80%	0.00%	3.20%
Don't know/No idea	2.70%	3.40%	3.20%
Publish agriculture magazine, book	5.40%	1.10%	2.40%
Other	2.70%	5.60%	4.80%

Conclusions and Recommendations

The results and analysis point to the following conclusions:

- MAFF dominated as the extension service providing organization, but NGOs also have a significant share in service delivery, illustrating the existence of pluralistic extension services.
- Scarce water sources and difficulty in finding funding are the primary factors hindering irrigation.
- Four factors -- agricultural extension services, marketing, irrigation and credit -- are perceived as important in ensuring food security.
- Most farmers use fertilizer, but they lack education and information about fertilizer use, quality, detriments and benefits of using fertilizers.
- Many farmers are unable to provide collateral for loans, and credit application processes are cumbersome, which bars them from credit.
- Hogs, chicken, fish and cattle are the most commonly traded commodities, followed by seasonal vegetables and fruits. It is important that marketing and value chains be strengthened for these agricultural products.
- Telephone and email/Internet, which are the cheapest, quickest and most popular extension tools today, are not in use in Cambodia.
- There is a need for training for farmers and extension workers. Trustworthy, reliable and timely extension services are necessary to improve agricultural development.
- Visits of extension workers to farmers are very limited.
- Dry-season rice production has potential, but there are challenges: price, quality, local accessibility, training on inputs and timeliness of supply. For wet-season rice production, locally accessible seeds, training and information to use seeds seem to be the problems.

Recommendations:

- Provide training for farmers and extension workers. Trustworthy extension services are necessary to improve agricultural development.
- Review and/or design water use policy (for irrigation purposes). Promote small irrigation systems, and empower local farming communities to manage them.
- Train extension workers (and through them, farmers) about fertilizers: their use, sources, benefits, detriments, markets, etc.
- Review agricultural credit policy.
- Train both MAFF and NGO extension staff members in extension process skills, and strengthen inter-organizational coordination.
- Train technicians to encourage the use of digital tools (smartphones, short messaging services, social media, etc.) to deliver extension messages to their clients.
- Train and mobilize more female extension workers.
- Improve the quality of training/extension programs. Trainings should be hands-on and use applied technologies to address current problems in the field.
- Organize periodic in-service trainings for extension workers.
- Encourage collaboration between NGOs, CARDI and agricultural colleges/universities to develop farmer-centered research and education.

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4. Cambodia HARVEST Aquaculture Program Evaluation

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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, 2010-2). However, concern is growing that declining natural fish catches will have immediate consequences for rural food security and aquatic ecosystems in Cambodia.

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 community fisheries and small-scale aquaculture (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, which are commonly fed a commercially produced feed product or homemade feed made of ground grains or 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' perspectives of aquaculture and household food security, as part of the evaluation of the HARVEST aquaculture interventions. The study will seek to understand the way in which household aquaculture has affected multiple aspects of household food security. 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.

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 7000 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 central aim of the Cambodia HARVEST Aquaculture Program is 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 community fisheries and small-scale aquaculture.

Evaluation Objectives and Framework

This evaluation focuses only on small-scale aquaculture, 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).

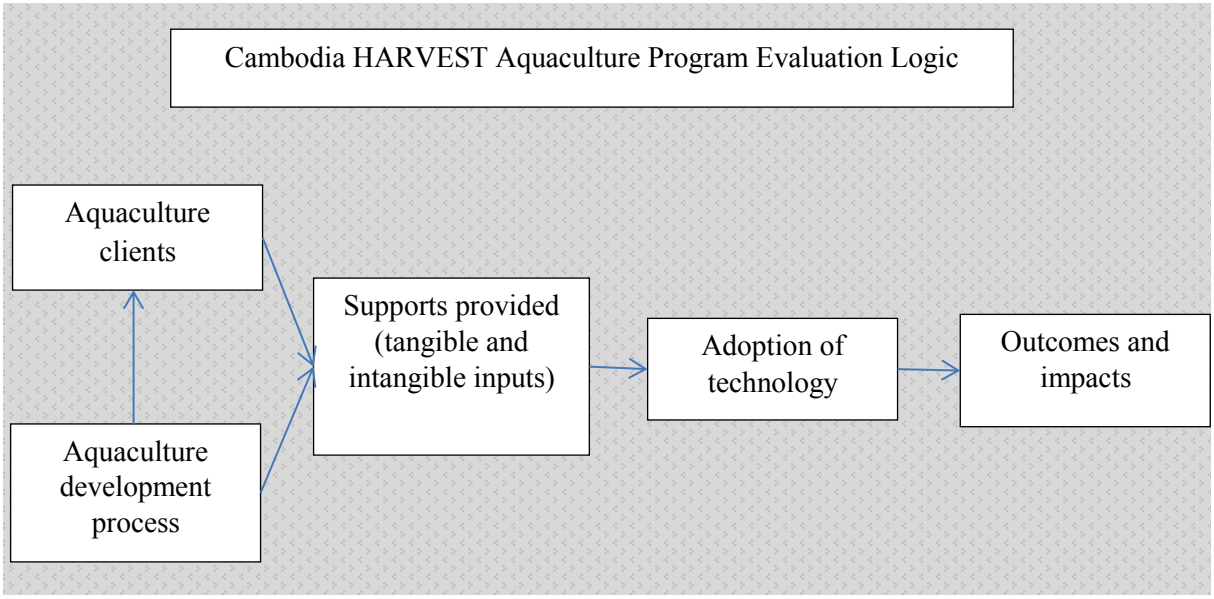

Figure 1. Evaluation logic

The Cambodia HARVEST Aquaculture Program chose the work model of having local organizations in each province as local partners in implementing aquaculture 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. To be able to join 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. Once clients had been recruited, the program provided training and extension services to teach them fish-raising techniques. 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 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 a week) and provided technology advice and also monitored the progress of each client. Therefore, during the Cambodia HARVEST Aquaculture Program life cycle,

each client technical advice from the program in multiple formats, both periodically and also on demand.

Study Design

This Cambodia HARVEST Aquaculture Program evaluation was designed in two phases. Phase One involved collection of qualitative data using focus group discussions. The aim of the focus group discussions was to understand the agricultural 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.

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. They 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 Moung Rusey 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.

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.

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 out of the literature 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. After several rounds of feedback among the team members, the nearly final version was in place. To ensure that the questionnaire covered important aspects of the Cambodia HARVEST Aquaculture Program, the team decided to conduct a pre-survey involving focus group discussions in all target provinces in mid-February 2015. Results from this qualitative survey were carefully integrated into the questionnaire. Then the questionnaire was reviewed by a panel of experts. Finally, the questionnaire was translated into Khmer. To ensure proper translation and proper language usage, the first version of the translation was reviewed by an experienced Monitoring and Evaluation person.

Sample selection

This evaluation survey utilized the cluster sampling method. The total number of 1,571 Cambodia HARVEST Aquaculture Clients across all four target provinces represents the population for the sampling frame. 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 hard copy 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.

Results

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

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 (mis)perceptions are reported -- they 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 tries to report/capture 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.

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.

After recruitment of clients was completed, the Cambodia HARVEST Aquaculture Program provided overall training on basic fish-raising skills to lead clients and/or other normal clients (depending on how many participants the training sessions could accommodate).
In general, the training contents covered three main skills: pond preparation, fish feeding and water quality management, and the training was 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.

As mentioned above, 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.

The first step in technology adoption was that, after each training, the trainer visited each client's farm to provide support so 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:

> *"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 Kaun Kha Ek village, Robas Monkol 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.

Case 2: Promoting local aquaculture fish market 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 of aquaculture fish demand in the 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

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.

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 "model farmer". Model 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]

Model farmers can be both a fish raiser and fingerling producer, as 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 model farmers 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 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 model farmer of the Panha Chi village, Tabaung Krapeur commune, Santuk district, Kompong Thom province with experience in system 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 model 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 his/her ideas.

To get things done, a model farmer needs material and technical advice from relevant organizations -- i.e., fishery administration, NGOs and/or donor. 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 model farmer can deliver to a poor farmer. For instance, a model farmer can manage a community revolving fund.

Box 3: 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]

Results of the Household Survey

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 heads of household had 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; approximately 90 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	**Average, SD**	**Percent**	**Average, SD**	**Percent**	**Average, SD**
Cattle	35%	3.1(2.0)	53%	4.1(3.4)	51%	4(3.3)
Buffalo	8%	1.2(0.4)	8%	3(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 than that of selling fish and of selling vegetables. This may reflect high 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.

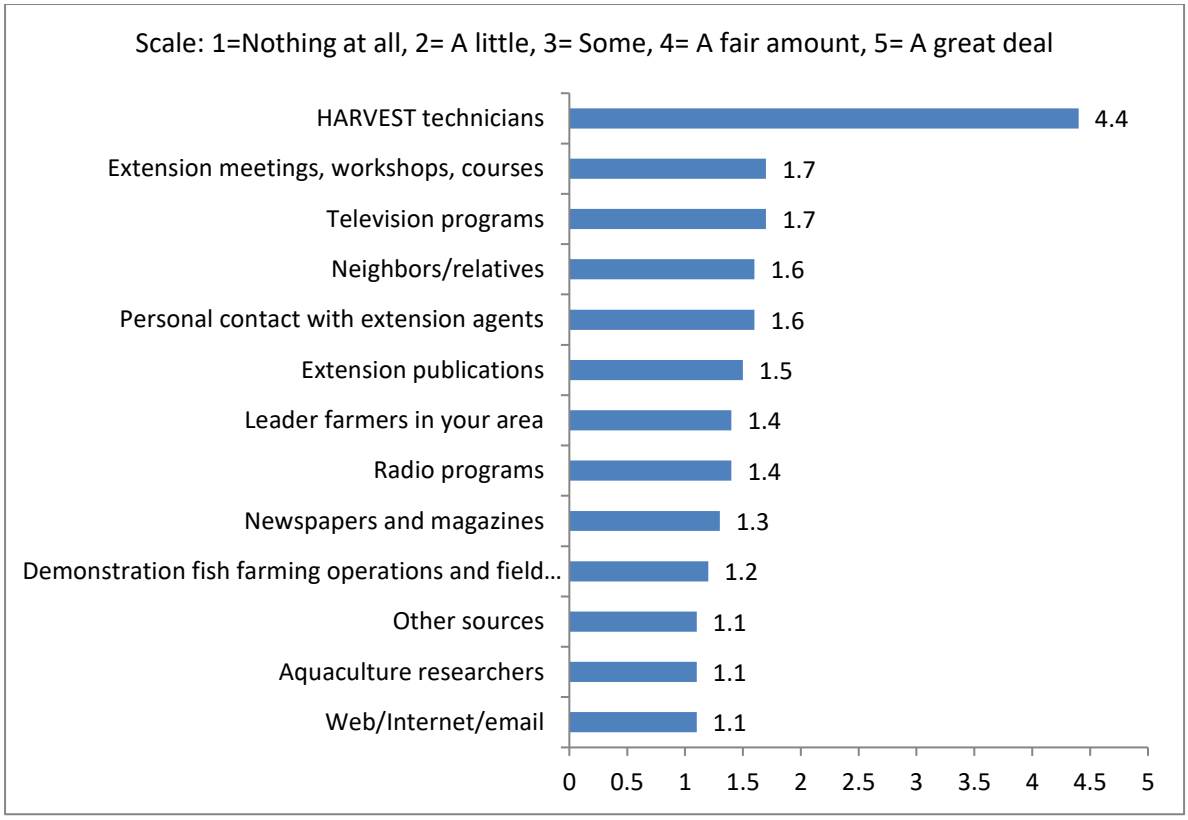

Figure 2. Sources of information (N=324)

Fish production

Table 9 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.

The Cambodia HARVEST Aquaculture Program worked with clients with pond sizes ranging from less than 100 m^2 to over 400 m^2. Therefore, pond sizes are divided into three categories: (i) less than 100 m^2, (ii) 100 m^2 to 400 m^2, and (iii) larger than 400 m^2. Figure 3 below illustrates percentages of respondents by pond size and province. In all four provinces, few households owned ponds smaller than 100 m^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 400 m^2, ranging from 45.1 percent to 57.0 percent. Fewer of the sample clients reporting having fish ponds over 400 m^2 in 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	Farmer currently raising fish		Number of cycles		Fish produced (kg)	
	Freq.	Percent	Freq.	Average (SD)	Freq.	Average (SD)
Battambang	108	77.7%	108	1.69 (0.68)	104	581.0 (582.4)
Kampong Thom	58	72.5%	58	1.55 (0.54)	56	384.3 (468.4)
Pursat	107	72.3%	107	1.71 (0.73)	104	545.2 (499.1)
Siem Reap	51	73.9%	51	1.43 (0.67)	50	602.0 (693.2)
Total	324	74.3%	324	1.63 (0.68)	314	537.4 (559.4)

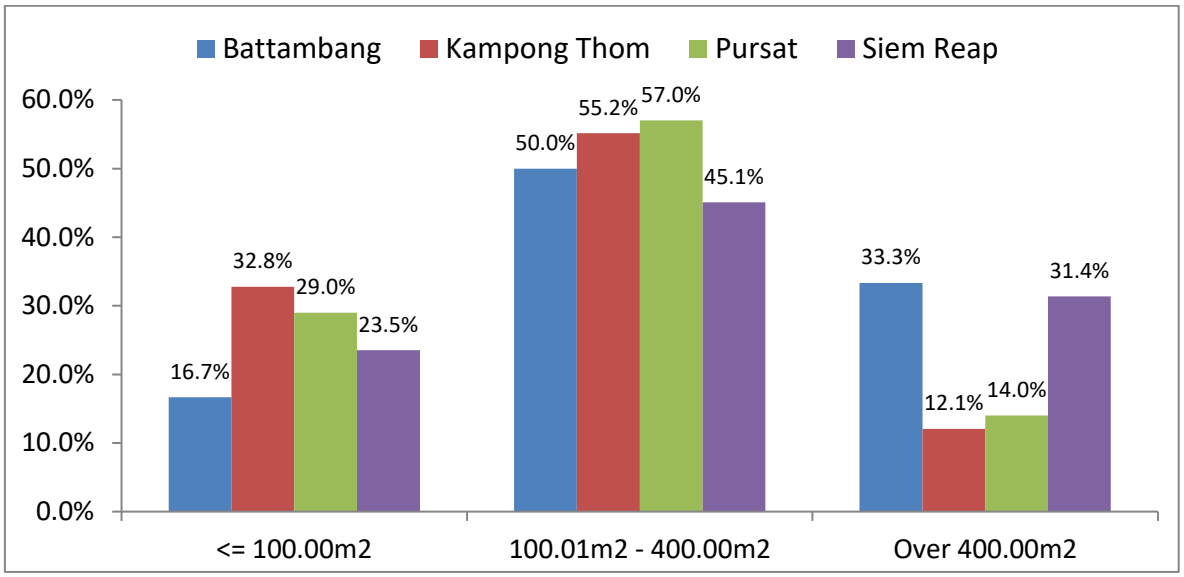

Figure 3. Households, by province and size of fish

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 ponds of less than 100 m^2, the average production per cycle was 257 kg. For ponds of between 100 m^2 and 400 m^2, the average production per cycle was 430.4 kg. For ponds of more than 400 m^2, average production per cycle was 979 kg.

Table 10. Fish produced, by pond size and province.

Province	<= 100.00 m^2		100.01 m^2 - 400.00 m^2		Over 400 m^2		Total	
	Freq.	Average	Freq.	Average	Freq.	Average	Freq.	Average (SD)
Battambang	18	230.7	51	407.7	35	938.5	104	555.7 (558.6)
Kampong Thom	19	161.4	30	339.2	7	911.4	56	350.4 (401.2)
Pursat	30	373.2	59	502.6	15	979.0	104	534.0 (499.3)
Siem Reap	12	157.7	23	414.3	16	1219.9	51	606.6 (689.9)
Total	79	257.0	163	430.4	73	1006	315	520.3 (543.1)

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 12 below provides a summary of fish species raised by respondents by province. The most commonly raised fish species was Pangasius catfish, 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 socioeconomic explanations for clients' preferences for particular species.

Table 12. Fish species raised, by 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%
Pangasius catfish	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%

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 are too extreme. Therefore, this graph shows only 30 clients with 30 fish pond sizes. The smallest pond size among the sample clients is 25 m^2; the largest size is 750 m^2. The lowest production of fish in the previous 12 months was 65 kg, and the highest production was 1,178 kg.

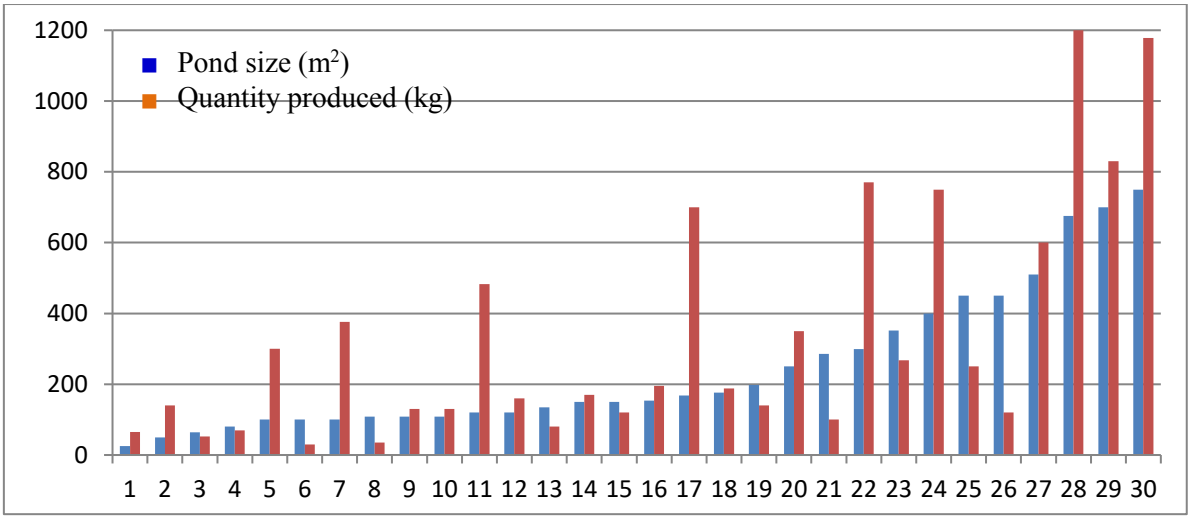

Figure 4. Climbing perch—comparison of pond size and fish production (n=19)

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 9,979.60 kg. With the total pond size of 7,336 m^2, the average production per square meter is 1.36 kg.

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 17,846 kg. The total pond size was 12,382 m^2, so the average production per square meter was 1.44 kg.

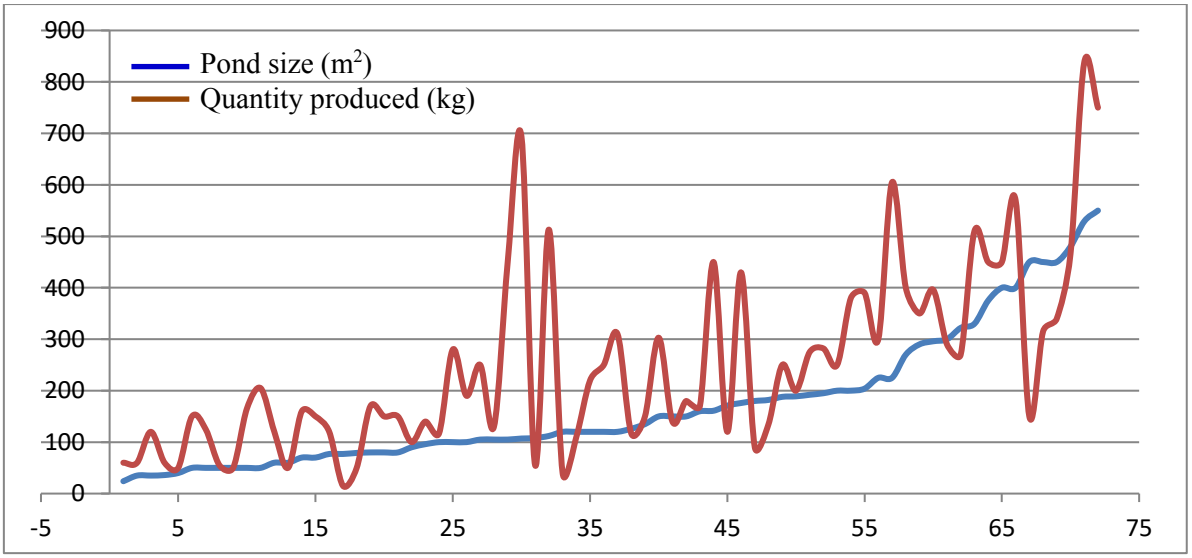

Figure 5. Walking catfish—comparison of pond size and fish production (n=72)

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 represents 106 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 80,796 kg and the total pond size of 36,150 m^2, the average production per square meter was 2.24 kg.

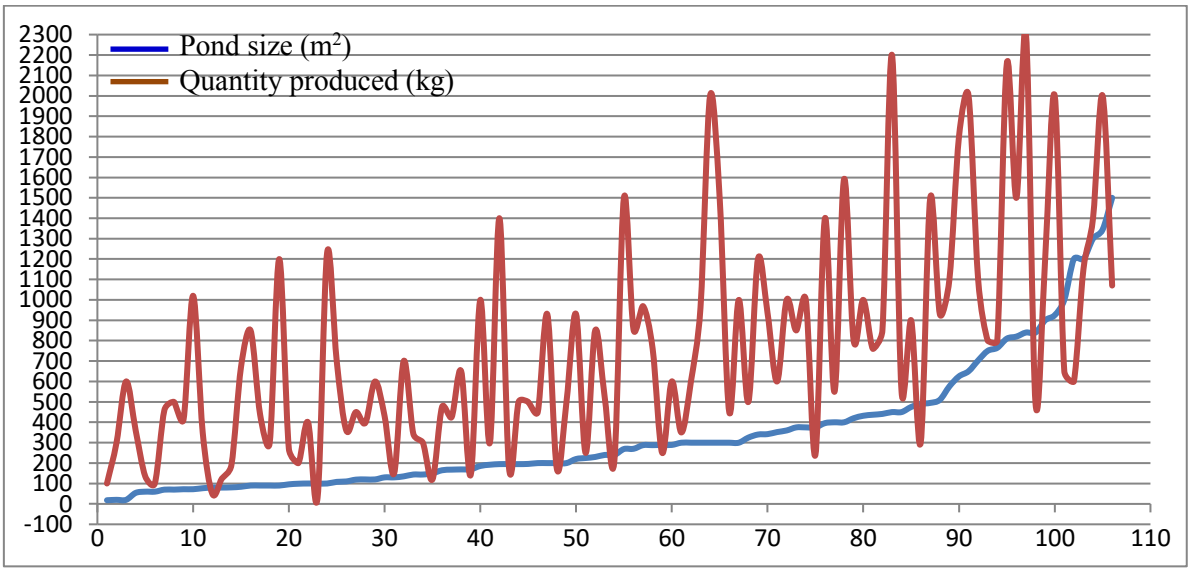

Figure 6. Pangasius catfish—comparison of pond size and fish production (n=106)

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 28 m^2, and the highest was 675 m^2. The range of production was between 315 kg and 580 kg.

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

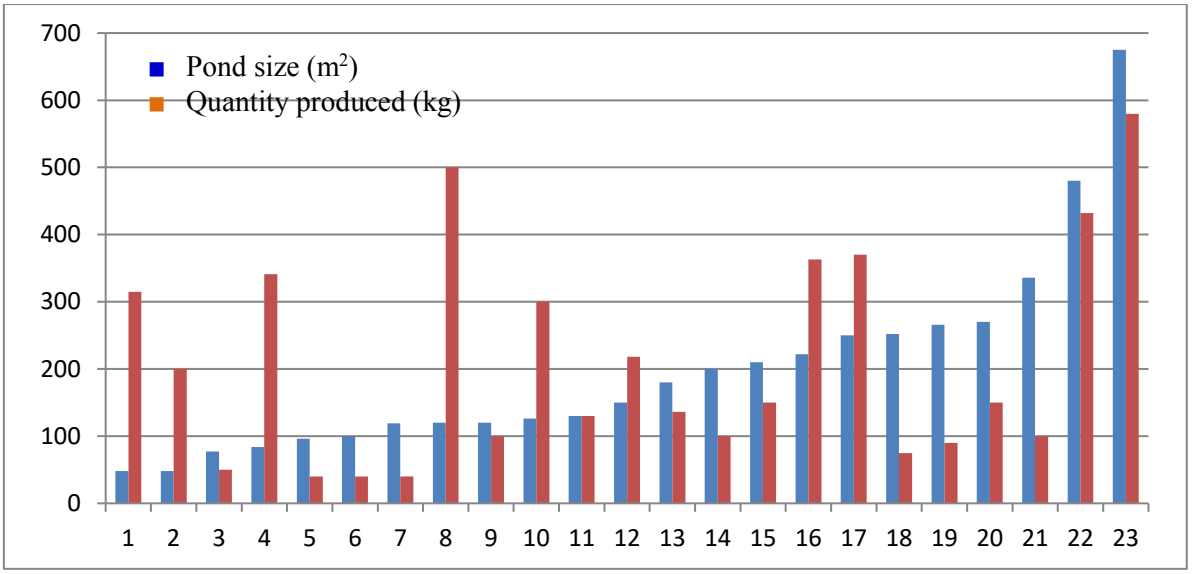

Figure 7. Nile tilapia—comparison of pond size and fish production (n=23)

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 10,329 kg and total pond size of 8,870 m^2, the average fish production per square meter was 1.16kg.

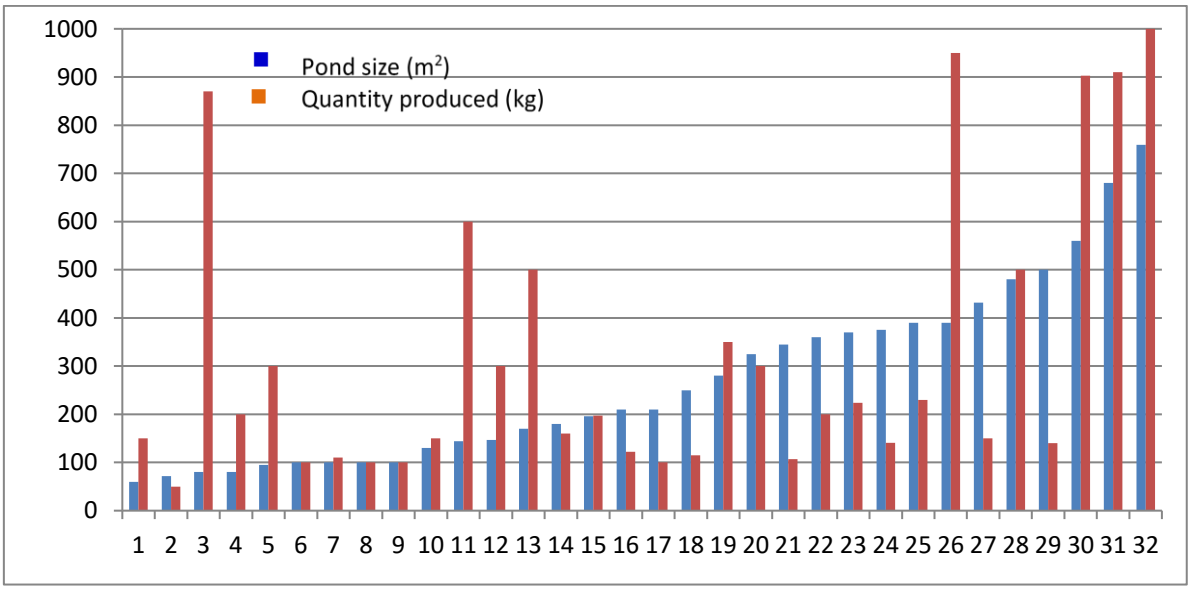

Figure 8. Red tilapia—comparison of pond size and fish production (n=32)

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

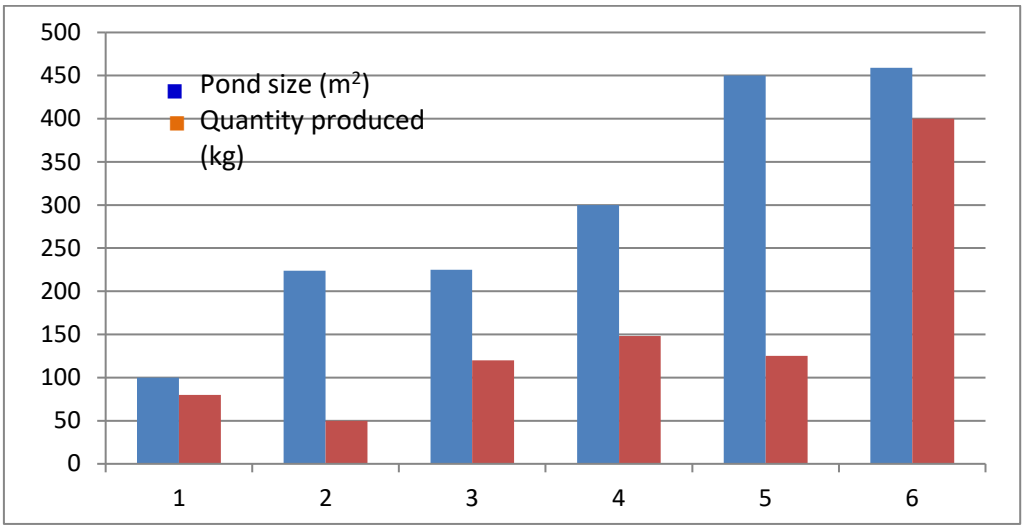

Figure 9. Silver barb—comparison of pond size and fish production (n=6).

Average fish production by species is provided below in Table 13. Pangasius catfish produced the highest yield per square meter (2.24 kg), followed by walking catfish and climbing perch, with average production of 1.44 kg and 1.36 kg, respectively.

Table 13. Average fish production (kg/m^2)

Fish species	Average product (kg/m^2)
Climbing perch	1.36
Walking catfish	1.44
Pangasius catfish	2.24
Nile tilapia	1.06
Red tilapia	1.16
Silver barb	0.53

Fish production by species is provided below in Table 14. A large proportion of all sampled clients in all four provinces reported raising Pangasius catfish (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 360.1 kg, 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 417.1 kg of climbing perch, all respondents (n=41) sold 355.7 kg. Out of the average production of 360.1 kg of walking catfish, 82 out of 85 respondents reported selling 292.5 kg. Out of the average production of 378.2 kg of Nile tilapia, 26 out of 30 respondents reported selling their fish (251.1 kg); out of 763.6 kg of Pangasius catfish, 108 out of 115 respondents reported selling their fish (707.7 kg); out of 181 kg of silver barb, seven out of eight respondents sold 148.1 kg; and out of 362.1 kg 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.	Average (SD)	Freq.	Percent	Average (SD)	Average (SD)
Climbing perch	41	417.1 (403.5)	41	100%	355.7	631.0 (680.3)
Walking catfish	85	360.1 (479.0)	82	97%	292.5	446.4 (622.4)
Nile tilapia	30	378.2 (541.9)	26	79%	251.1	411.4 (678.2)
Pangasius catfish	115	763.6 (587.6)	108	89%	707.7	834.0 (613.0)
Silver barb	8	181.0 (138.5)	7	78%	148.1	276.9 (243.5)
Red tilapia	43	362.1 (415.3)	42	91%	296.9	575.8 (733.8)
Total	315	520.3 (543.1)	298	92%	451.2	631.6 (676.5)

Drivers of adoption

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.

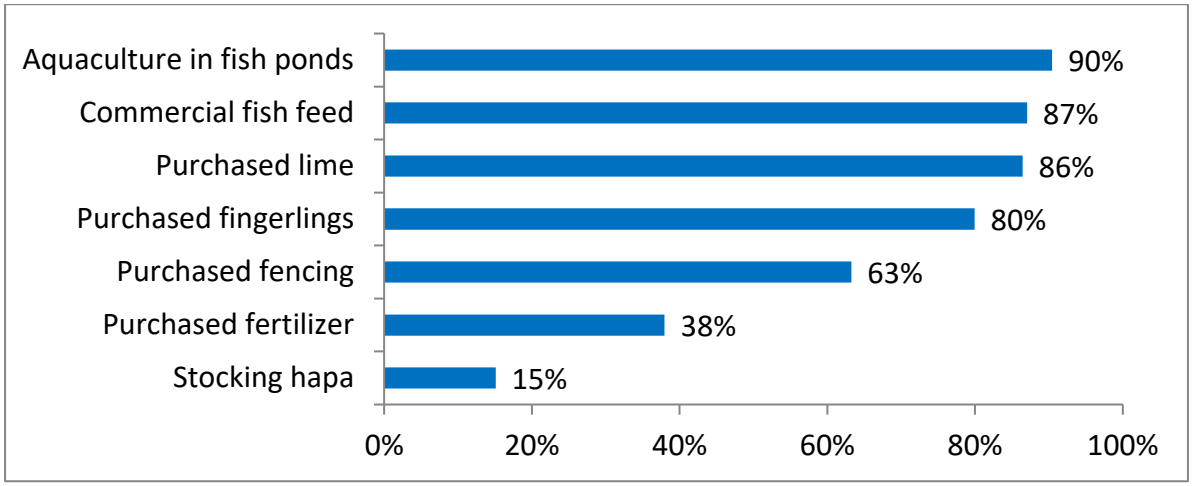

Figure 10. Adoption of fish farming technologies (n=324).

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 a greater operational cost per cycle than any other input.

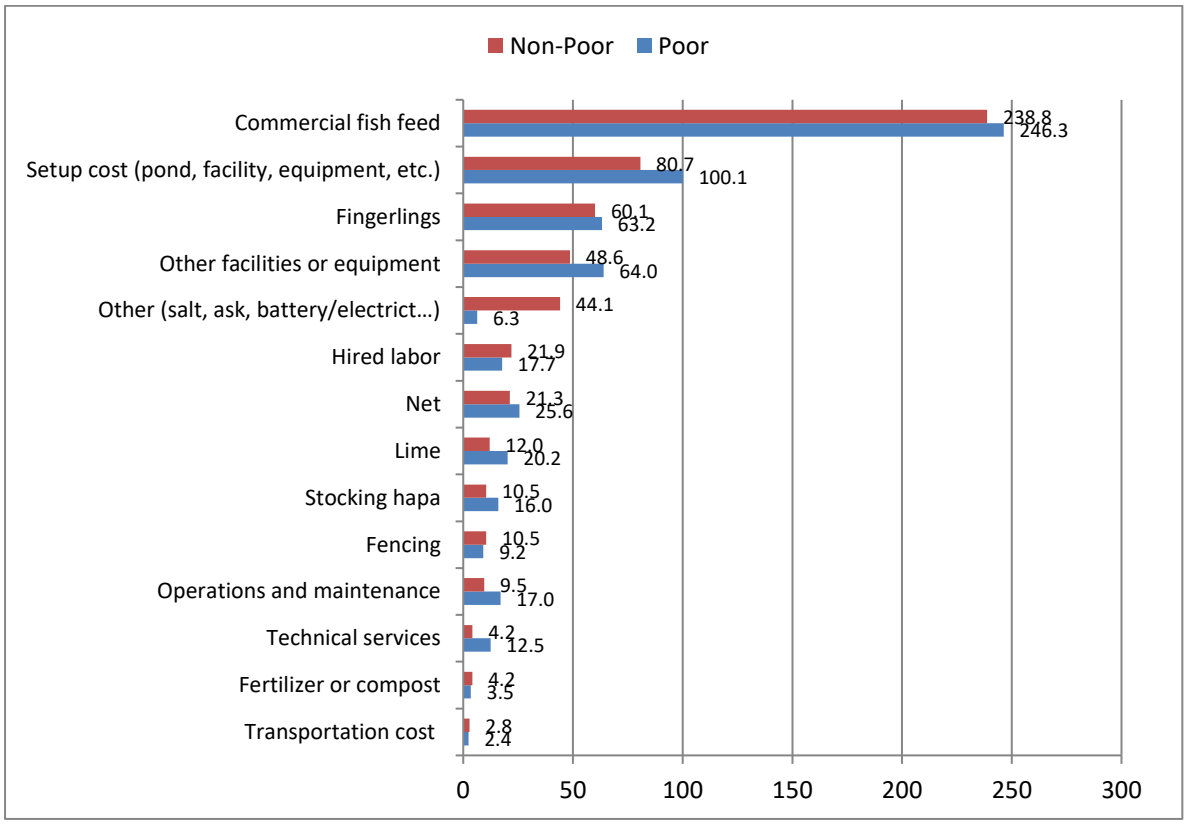

Figure 11. Average expenditure on inputs by wealth group (USD).

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 fresh water 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.

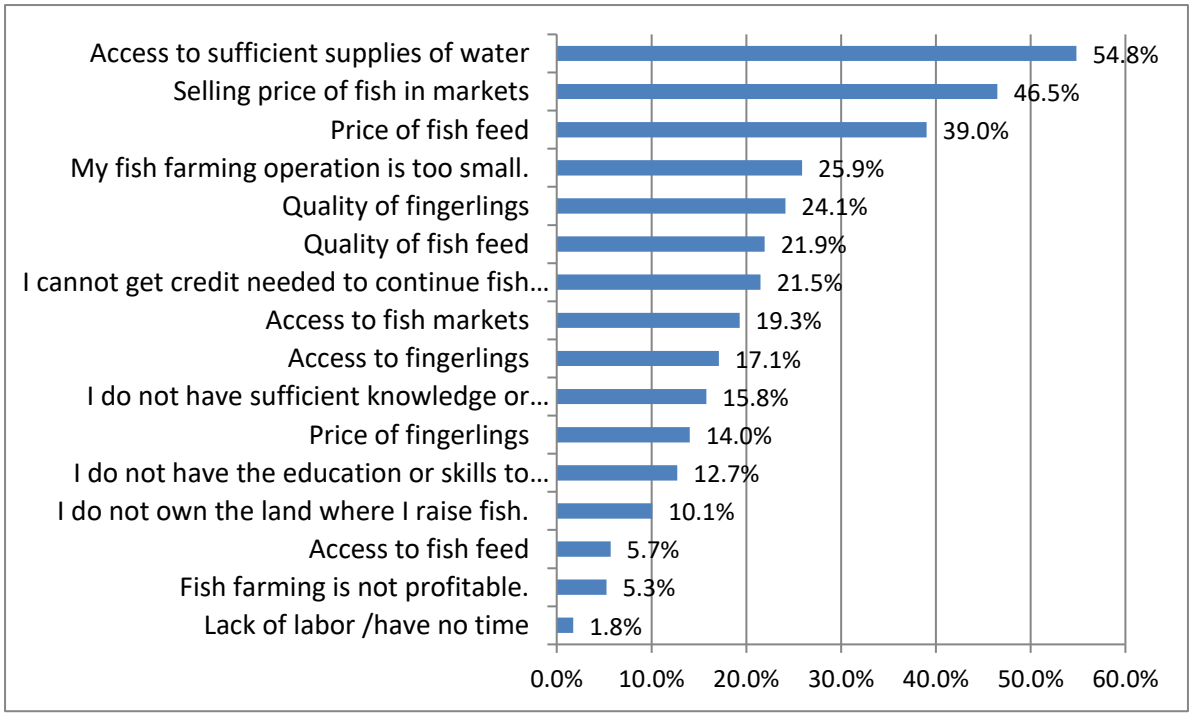

Figure 12. Barriers to adoption of improved farming practices or technologies (n=228).

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 100 m^2 and 400 m^2. Only 56 and 48 respondents owned fish ponds smaller than 100 m^2 (category 1) or over 400 m^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.

	<= 100 m^2 *(n=56)*	100.01 m^2 – 400 m^2 *(n=124)*	Over 400 m^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%

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.

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%

Responses to questions about the reasons for stopping fish production are provided below in Figure 13. The four most common barriers to adoption of continuing to raise fish were access to water, price of fish feed, low selling price of aquaculture fish, and profitability.

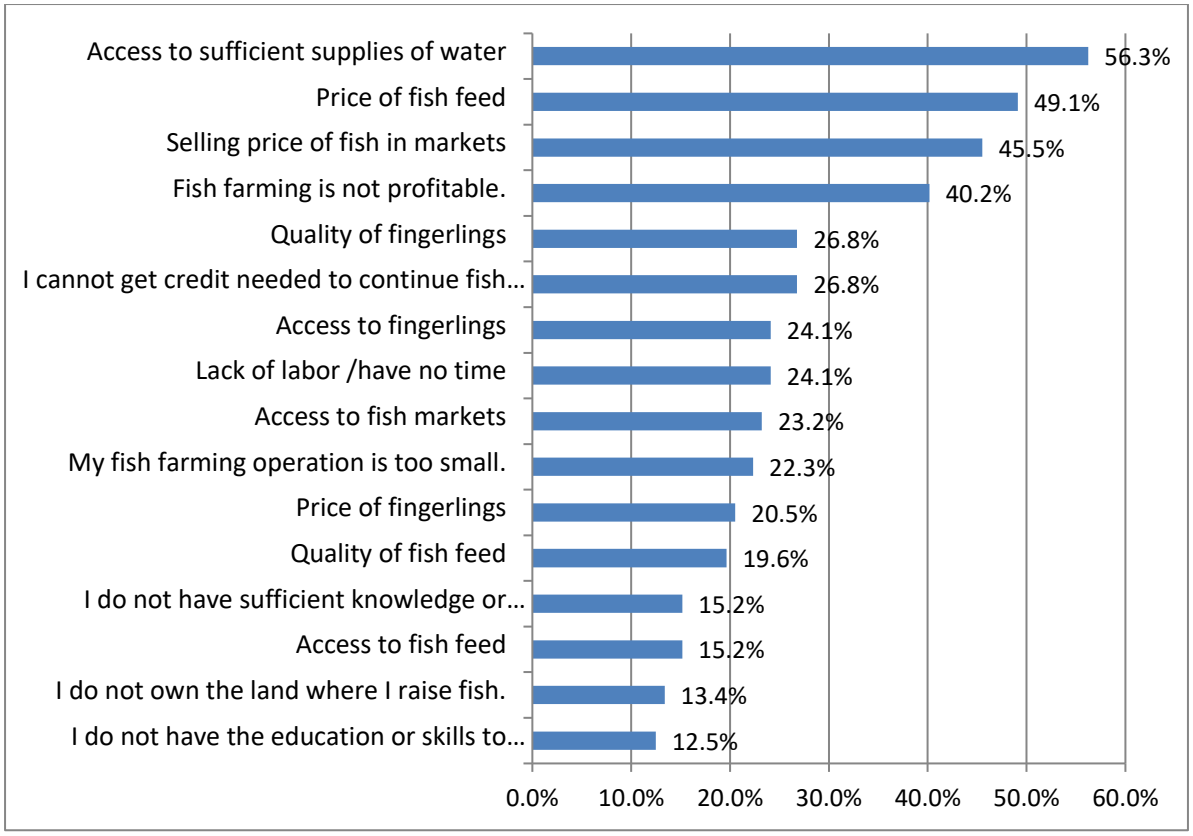

Figure 13. Reasons for disadoption of aquaculture practices (n=112).

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.

If 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.

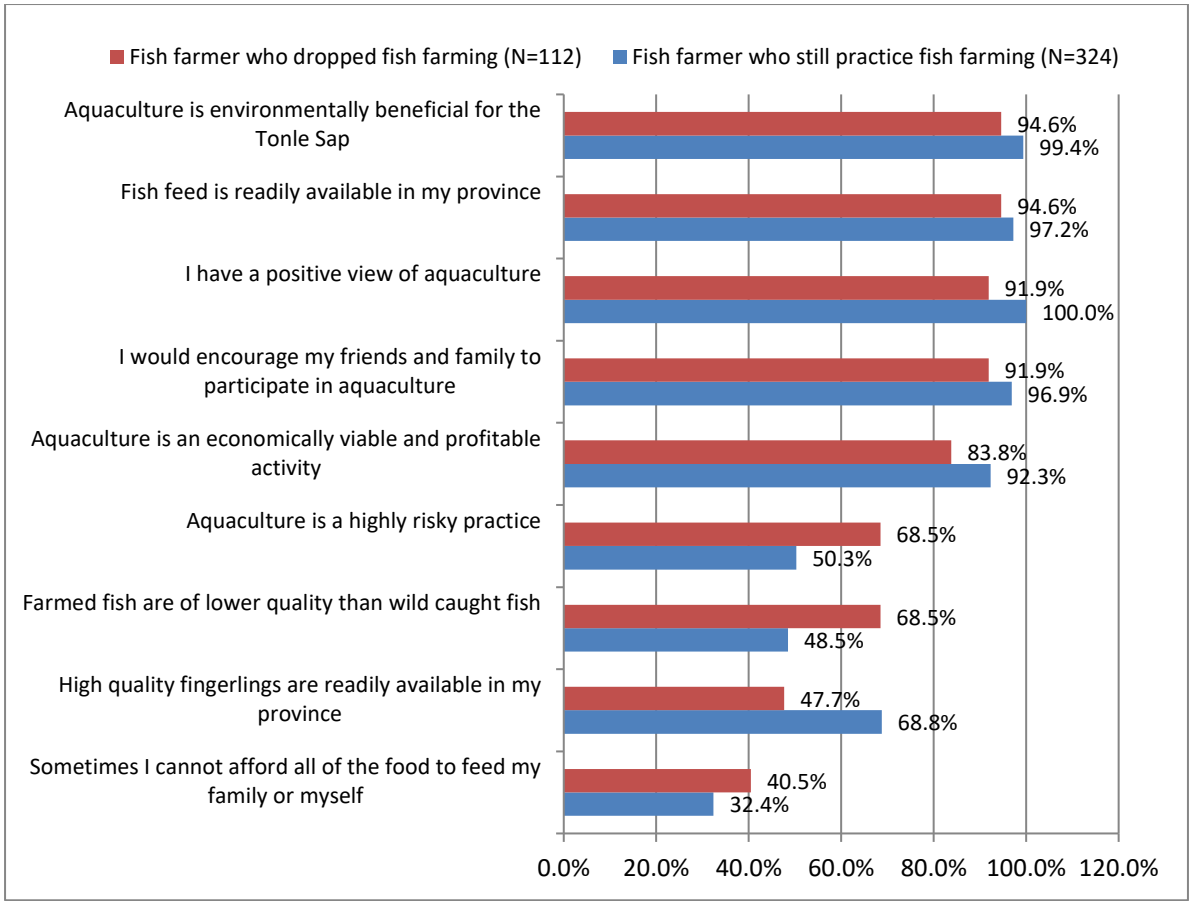

Figure 14. Comparison of clients' perceptions related to raising fish.

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.

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 life cycle, 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. 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.

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5. A Qualitative Evaluation of Recommended Complementary and Transitional Feeding Practices

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Acronyms

BCC	Behavior change communication
BFCI	Baby-Friendly Community Initiative
CDHS	Cambodia Demographic Health Survey
FSNG	Food Security and Nutrition Group
FSNT	Food Security and Nutrition Technician
HARVEST	Helping Address Rural Vulnerabilities and Ecosystem Stability Program
MSU	Michigan State University
MOH	Ministry of Health
NNP	National Nutrition Program
NGO	Non-governmental Organization
RGC	Royal Government of Cambodia
TFG	Three food groups nutrition education message
USAID	United States Agency for International Development
VHSG	Village Health Support Group
VHV	Village health volunteer

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Executive Summary

Background

This report presents the results of a qualitative evaluation of select elements of the nutrition education program of the Feed the Future Cambodia Helping Address Rural Vulnerabilities and Ecosystem Stability (HARVEST) project. The study examines the current practices and beneficiary perceptions surrounding key child feeding recommendations during the final stages of HARVEST's nutrition education program.

HARVEST aims to increase incomes and improve food security and nutrition for 70,000 households living in the provinces of Pursat, Battambang, Siem Reap and Kampong Thom. The primary efforts to achieve these objectives include the development of agricultural value chains in rice, horticulture, and fish; providing support for sustainable natural resource management and climate change adaptation; and efforts to strengthen the links between agricultural production and nutrition (Fintrac 2015).

Improving child nutritional status through increased agricultural production is a complicated undertaking. While many agricultural programs focus on improving food availability the ultimate effects on child nutrition will hinge on several mediating steps. Key among these is the promotion of good complementary feeding practices for young children 6-24 months of age that are transitioning from breastfeeding to family foods. Without attention to such practices it is unlikely that agricultural programs will be successful at improving the nutritional status of children under the age of two.

This study focuses on two child feeding practices promoted by HARVEST: the use of enriched porridge and the inclusion of the "three food groups" (TFG) in child meals. The study was conducted during the final stages of the HARVEST program and aims to assess the following two questions:

1) What are the current child feeding practices for young children and to what extent are caregivers practicing the recommendations on enriched porridge and the TFG?
2) What are the constraints cited by caregivers to adopting these practices?

By understanding current practice as well as caregivers' attitudes and decision-making around these recommended practices, we hope to gain a greater understanding of how these messages can be tailored to the rural poor in Cambodia. In particular, we hope to understand what households are *willing to do*. Findings from this case study are therefore meant to provide formative research that can inform USAID and the RGC's desire to adapt current messages on complementary feeding (MOH 2014).

Study Design and Methods

This study takes a qualitative approach. Qualitative inquiry is appropriate when it is important to assess actual behaviors and to gain insight into the reasons behind these behaviors. Accordingly, two main data collection techniques were used: participant observation and in-depth interviews.

Sixteen villages, four in each province, were randomly chosen from a census of Phase II HARVEST villages. The study was conducted in two distinct stages. The first stage was conducted in half of the study villages and relied on participant observation in households with

children aged 6-24 months (hereafter "young children"). Ethnographic observations of the preparation and consumption of two consecutive meals were conducted in each household (n=20), with special attention on the feeding habits of the child aged 6-24 months. The purpose was to observe the preparation of foods that are served to children aged 6-24 months and to understand how current and recommended child feeding practices fit within the household's usual habits of food preparation and family meals. Notes were taken during the observation and expanded after leaving the site. Each observation lasted between 5 to 7 hours.

In the second stage we used in-depth interviews in the full sample of 16 villages to follow up on observed behaviors and to explore decision-making around child feeding patterns in greater depth. In these interviews we sought to understand why certain behaviors were undertaken as well as caretakers' perspectives on recommended child feeding practices. Interviews averaged 70 minutes per household (n=44) and were conducted with the primary caretaker of the child aged 6-24 months. Interviews were audio recorded, translated and transcribed verbatim. Thematic analysis with conceptually clustered displays (Miles, Huberman and Saldaña 2015) was used to analyze the data for patterns across the sample.

Results

Current Practices: The Use of Enriched Porridge

Results from this study indicate that there is little evidence that households used enriched porridge in these study villages. Among households in which we conducted in-depth interviews, none were currently preparing enriched porridge as taught by the official HARVEST curriculum. A minority of caregivers said they had used it at some point but had moved on to other complementary foods. The vast majority of caregivers interviewed did not use enriched porridge for any sustained period of time.

The results support the notion that preparing enriched porridge, or any special dishes for young children, is rare and not the norm. Instead, the data show a consistent pattern of caregivers creating complementary and transitional foods from dishes that are prepared for the rest of the family. With few exceptions, this practice was true for study children in all ages between 6-24 months. This indicates that caretakers do not change their approach as their child moves from older infancy to the toddler stage. It also indicates that caregivers do not appear to be following the age-specific feeding recommendations promoted by HARVEST or by the MOH.

The data also revealed a number of common strategies that caregivers use to prepare foods they feel are appropriate for young children. Among these are serving the broth from the family soup with rice; adding water to stir-fried dishes to form a thin sauce to serve with rice; and mashing soft vegetables and/or finely chopped meats or fish into the child's serving of wetted rice. Caregivers also purchased ready-made foods for breakfast and snacks. Hence, rather than preparing separate dishes for young children, caregivers rely on complementary foods that align with plans for family meals.

Current Practices: The Three Food Groups

HARVEST teaches that young children's meals need to include each of "the three food groups" (TFG) (USAID 2012). The three food groups include 1) energy foods that provide calories; 2) protection foods that are high in micro-nutrients; and 3) body-building (or construction) foods that are a good source of protein.

The results indicate that the TFG is not applied in an intentional way by caretakers. In particular, the data revealed that young children were more likely to receive TFG when meals for the rest of the family included dishes with the TFG. This is largely due to the fact that caregivers adapt child meals from what they prepare for the family. In this sample, observation and interview data revealed that young children were more likely to receive TFGs during meals in which a complex soup is prepared than other times of the day. Observation, for example, revealed that breakfast was a time where less cooking occurred and only 29% of young children were served foods with TFGs. By contrast, 63% of households served lunches to young children from family meals that contained all three food groups.

Even when children are fed meals derived from diverse dishes (such as a complex soup) a young child's portion is often altered in ways that lower the nutritional density of the dishes. Caregivers, for example, often omitted nutrient-rich ingredients from the family dish (eg. meat, fish, or vegetables) or they diluted the child's portion with additional broth. These practices lead to child servings that are less diverse and less nutrient-dense than the adult dish since they have a higher ratio of broth to vegetables, protein, and/or rice. Observation, for example, revealed that 57% of caretakers who prepared a family meal with TFG altered the composition of the family dish before they served the child, most often removing pieces of fish and vegetables and in extreme cases omitting both.

Finally, the data revealed important patterns about the nature of snacking within these rural households. The proliferation of prepared snacks in rural areas has made it possible for children to consistently eat snacks with low nutrient density. Interviews revealed that 88% of the sample regularly purchased non-nutritious snacks for their young children. During our visits, we observed young children consuming purchased snacks directly in 71% of the households. Understanding snacking behaviors is important as the availability of these foods creates may make small children less interested in foods from meals. In addition, they provide a way for the household to spend money that could be otherwise be spent on foods that provide better diet quality.

Constraints to Adopting Promoted Practices: Enriched Porridge

Observation and interview revealed there are many constraints to the adoption of the enriched porridge message. Overall, enriched porridge is viewed as a dish that has high costs relative to its perceived benefits. Most view enriched porridge as a dish that is only for small children. In addition, it is time-consuming and expensive to prepare and offers low benefit relative to their current child feeding practices.

The financial and time costs are difficult for poor households to bear, particularly given the risk that food will be wasted if the child does not eat it. Some feel that they may be setting themselves up for demands that they cannot meet in the future by creating a taste for enriched porridge in their young child. For caretakers who are better off, they are less concerned about time and cost to acquire the ingredients, and are mostly concerned about the time and effort to prepare it as a separate dish. Even for families that do not question the benefits of enriched porridge, the high time and money costs means that it is not something they feel they can do for every meal.

Constraints to Adopting Promoted Practices: The TFG Message

Apart from the households that do not have consistent access to foods from the TFG, there are two main factors that limit effective adoption of the TFG message. First, there was a lack of clear understanding about the TFG message among caretakers and little practical knowledge about how to accurately apply the TFG message.

Second, even when meals with good diversity are provided to the family, many caregivers cited that young children could not eat certain foods because of fear of choking or other beliefs about preferences. We found limited willingness to take extra food preparation steps (eg. removing bones, boiling or dicing harder vegetables) to make such meals edible for the young child. Instead, the data reveal that caregivers often remove select vegetables and protein from the family dish when serving their young child. It was not clear, however, whether this behavior is driven more by a lack of understanding of their importance to a young child's diet or due to unwillingness to do the additional work to facilitate children's consumption of them.

In sum, households would benefit from the delivery of more simple, actionable messages about how to apply the principles of TFG. In addition, it is important to ensure that all NGO partners deliver nutrition education in a way that conforms with underlying nutritional principles, including the concept of diet diversity and the nutrient density of meals.

Recommendations

Enriched Porridge

The results on the use, constraints, and attitudes toward enriched porridge indicate that there continues to be resistance to adopting enriched porridge. Overall, caretakers have good awareness about enriched porridge and its purpose. Caregivers, however, do not want to prepare complementary foods separately from the family meal; they seek ways to save time and cost in preparing foods for their young child.

As a result, new projects need to partner with the NNP to find novel ways to get caretakers interested in enriched porridge. Enriched porridge is a tough sell and households have learned about it through multiple channels. Thus, a significant constraint is that caregivers have already formed opinions about enriched porridge and are quick to defend their position or misrepresent their efforts for fear of being "blamed" by authority figures.

If USAID is going to continue to support the current NNP policy on enriched porridge (see Figure 2) more emphasis needs to be placed on how to ***properly prepare enriched porridge from family foods*** that are already being cooked. Significant misconceptions (some due to improper nutrition education by NGO partners) exist about how to make enriched porridge from soups such as *somlow prohail*; the interpretation varies considerably from the official NNP message provided in the video produced by UNICEF (2012) that features Dr. Sophonneary. More practical examples that draw on family foods aside from *somlow prohail* would also be helpful.

A second area that might be exploited is the trend toward purchased pre-prepared foods. If appropriate incentives can be provided to ***local entrepreneurs to make enriched porridge in villages*** and it can be offered at a reasonable price for the target population, it might be appealing to caretakers who find it difficult to cook diverse dishes in the morning. There are multiple challenges with this kind of programming, including identifying the correct incentives and means to target to children 6-24 months, monitoring such programs, and ensuring that leakage does not occur.

Overall it's important to note that caretaker attitudes toward enriched porridge are a significant constraint that must be overcome for progress to be made on this front. Caregivers need to believe that ***enriched porridge is a necessary food for young children and that it will make a***

difference to their future. There is evidence that older (alternative) caregivers were less open to this message as they felt that they had raised many children and they had "survived." As such, targeted programs for older caregivers, for example grandparents, might be developed to include them in the development of messages and programs. There is evidence from Africa that this has been successful in community-based nutrition education programs.

Three Food Groups

Recommendations on the TFG message are three-fold. First, messages about TFG and about dietary diversity need to focus on ***practical and actionable messages rather than nutrition and health facts***. The most important thing that participants need to know about the TFG is that there should be one food from each of the three groups in every meal, and there should be local examples of how to achieve this. In addition, lessons should not just focus on ideal vegetables, but also those that are eaten by families and typically not altered for young children. Beyond this, information about specific vitamins and minerals and obscure deficiency diseases is unnecessary.

Second, programs need to get across the idea of ***nutrient density to caregivers***. Caregivers react favorably to tips that allow them to use family foods to prepare complementary foods for their children. However, little attention was placed on the proper way to do this and educators often reinforced the current practices that do not provide good nutrient density. More attention needs to put on simple ways to teach people about creating complementary foods that are nutrient dense as well as diverse.

Third, programs need to ***address the emerging role of purchased non-nutritious snacks in rural areas.*** Behavior change communication campaigns for high quality complementary foods need to also address their competition. Cheap junk food is present in many villages and presents a path of least resistance to persist with young children to eat more healthy complementary foods.

Finally, as with enriched porridge ***separate nutrition education programs and messages*** might be considered for older, alternate caregivers who have different histories and experiences with food and childrearing and thus different attitudes toward nutritional messages. Grandmothers may be more likely to adhere to messages if they can tailor them in ways that incorporate their own experience and knowledge. Young mothers, by contrast, may respond to different messages that appeal to an identity that reflects modernity and new ways of thinking.

Introduction

In recent years we have seen increased investment in nutrition-sensitive agricultural programming (Herfurth and Harris 2014; Ruel. et al. 2013). Improved nutrition for children less than two years of age is important because the long-term consequences of nutritional deprivation are particularly great at this stage of development. In particular, children undernourished at a young age grow to be stunted adults with lower physical work capacity (Hoddinott et al. 2008). They are also less likely to reach their potential in terms of mental development and as a result their human capital development is permanently diminished. Poor human capital formation is not just an individual problem but results in lower productivity in the aggregate, and thus has implications for the economy as a whole (World Bank 2006).

Increased agricultural production is expected to improve the nutritional status of women and children through several pathways. Agricultural programming can improve food availability, increase income that can be used to purchase more and better quality food, and improve women's control of productive assets (see Figure 1). Efforts to raise the nutritional status of children via increased agricultural production, however, will hinge on several assumptions, including the use of appropriate caring practices for young children. Caring practices are important elements of the health and nutrition education that now accompanies agricultural programming. Among these is the promotion of good complementary feeding practices for young children, i.e. feeding practices for children 6-24 months of age that are transitioning from breastfeeding to family foods. Without attention to such practices, it is unlikely that agricultural programs that are expected to improve child health and nutrition via increased agricultural production will be successful.

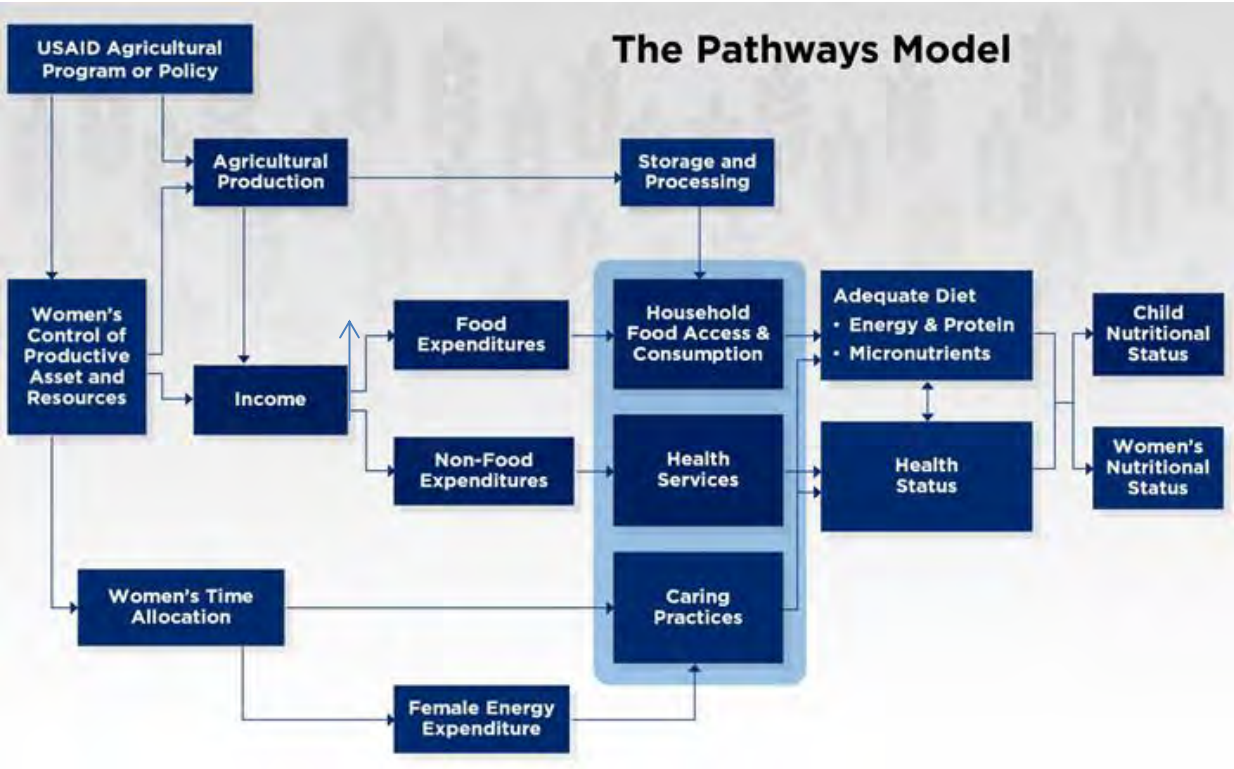

Figure 1: Conceptual model showing the pathways between improved agricultural programming and improved nutritional status (Chung et. al. 2015, adapted from Herfurth and Harris 2014).

Caring practices for improved child nutrition are an important concern for the Feed the Future Cambodia Helping Address Rural Vulnerabilities and Ecosystem Stability (HARVEST) project. HARVEST aims to increase the incomes and improve food security and nutrition for 70,000 households living in the provinces of Pursat, Battambang, Siem Reap and Kampong Thom. The key efforts to achieve these objectives include the development of agricultural value chains in rice, horticulture, and fish; efforts to strengthen the links between agricultural production and nutrition; and support for sustainable natural resource management and climate change adaptation (Fintrac 2015).

The objective of this study is to examine the current practices and beneficiary perceptions surrounding key child feeding recommendations that were promoted under HARVEST's nutrition education program. In particular, this study examines the application of two specific recommendations on the use of enriched porridge and the "three food groups" (TFG)– foods that provide calories, micronutrients and protein – with young children aged 6-24 months. The study takes a qualitative approach so that child feeding practices may be understood in the context of family food consumption, caretaker obligations, and household livelihood strategies. It draws on participant observation of family meal preparation and child feeding events, as well in-depth interviews with caretakers about current child feeding practices, knowledge of recommended messages, and attitudes toward their application. The overall goal is to understand beneficiary perceptions of recommended child feeding practices toward the end of the HARVEST program and to inform continuing efforts at USAID to improve child nutrition.

Project Background

In Cambodia, the most recent Demographic and Health Survey (NIS 2015) reveals that children under five years of age still suffer from high rates of stunting (32%) and wasting (10%). Accordingly, the Royal Cambodian Government (RCG) decided to fast-track efforts to improve child and maternal nutrition over a period of five years (MOH 2014). In 2014 the government unveiled a plan to scale up the delivery of nutrition-specific interventions in several core areas. Among these interventions is an effort to improve behavior change communication (BCC) targeted toward practices carried out in the first 1000 days of a child's life (MOH 2014). One of the key recommendations that this effort promotes is to provide young children with an enriched porridge of an easily digestible consistency and that contains specific nutrients that will enrich the quality of the young child's diet. The MOH recommendations are given in Figure 2.

Since HARVEST's beginning, the messages promoted by its nutrition education program have been aligned with the priorities of the RCG for improving the nutritional status of young children. In particular, HARVEST developed a family nutrition curriculum in collaboration with PATH (USAID 2012) that was implemented throughout Phase I of the project. This curriculum included lessons on complementary feeding as part of its effort to improve food utilization within households and therefore improve the nutritional status of young children.

Over time, pedagogical changes were made to the nutrition education program that were not entirely recorded in curricular records. A key change was to create village-level learning groups that were more amenable to learning about nutrition and thus more likely to lead to experimentation with new behaviors. Initially, during Phase I of HARVEST, nutrition education lessons were delivered through traditional stand-and-deliver sessions that were presented to home gardening participants who were required to attend. In addition, cooking demonstrations with tastings were held once or twice in villages. These demonstrations

included an important lesson on how to make nutrient-rich *bobor khab krub kroeung* (or enriched porridge) for children aged 6 to 24 months (USAID 2012).

RECOMMENDATIONS ON COMPLEMENTARY FEEDING			
Age	Texture	Frequency	Amount at each meal[1]
6 month	Start with thick enriched Borbor, well mashed foods, e.g. mashed cooked banana, sweet potato, pumpkin, etc.	Start foods 2 times per day plus frequent breastfeeds at least 8 times per day	Start with 2-3 tablespoonfuls per feed
7-8 months	Thick enriched Borbor , well mashed foods,	Increasing to 3 times per day plus frequent breastfeeds at least 8 times per day	Increasing gradually to 1/2 of Chan Chang Koeh at each meal
9-11 months	Thick enriched Borbor , finely chopped or mashed foods, and foods that baby can pick up	3 meals plus 1 snack between meals plus breastfeeds at least 6 times per day	Increasing gradually to 1 Chan Chang Koeh
12-24 months	Family foods, chopped or mashed if necessary, thick enriched Borbor	3 meals plus 2 snacks between meals plus breastfeeds as the child wants, at least 3 times per day	1 Chan Chang Koeh
If baby is not breastfed, give in addition 1-2 extra meals per day.			

Figure 2: Recommended Complementary Feeding Guidelines in Cambodia (MOH 2011)

Changes were implemented in early 2014 when HARVEST began work in a completely new cohort of villages as part of its Phase II work. The family nutrition education program shifted its focus to a community-based approach in which a smaller set of lessons were delivered to self-selected village groups that identified as being interested in food and nutrition. The average size was about 20 per village. These food security and nutrition groups (FSNG) were expected to consist of local champions of health and nutrition, and it was hoped that they would help spread key messages about nutrition and health. In addition to formal lessons, there was a budget for the groups to plan 'community-action' events in the village that would underscore key messages and skills among the entire community. Among the formal lessons there were modules on how to produce nutritionally-rich foods for children aged 6-24 months. These included conceptual lessons and cooking demonstrations that emphasized two key messages: 1) the importance of and practice of making enriched porridge; and 2) how to increase the diversity, and hence quality of young child meals. The latter was focused on the application of the concept of the "three food groups". The point was to encourage caretakers to include ingredients from each of three food groups – known colloquially as energy foods, protection foods, and body-building foods – into each child meal. Energy foods are those that provide calories; protection foods include those that are high in micro-nutrients; and body-building (or construction) foods are those that are a good source of protein. The TFG message was particularly important as children aged 12-24 months were introduced to family foods.

Cambodia's Ministry of Health (MOH) maintains that a major barrier to adoption of good complementary feeding behaviors is confusion among consumers about appropriate practices, most likely due to complex messages promoted by the various actors in the system (MOH 2014). However, other studies in Cambodia have suggested that knowledge alone is not sufficient to translate into a change of practices (FAO 2014, Omidakhash 2013). These studies argue that other barriers, such as lack of time for complementary food preparation or lack of taste for the recommended foods, prevent adoption. Recent studies have supported these

findings (Manhoff Group 2015, FAO 2015). In either case, little is known about what actions households are willing to take towards improved feeding practices including enriched porridge and transitional foods that offer better nutrient diversity.

The objective of this work is to focus on two of HARVEST's key recommended child feeding practices, the use of enriched porridge and the three food groups, and to assess the following two questions: 1) What are current household practices regarding these recommendations? 2) What are caregivers' attitudes and decision-making toward these messages? By understanding current practices as well as caregivers' attitudes and decision-making around these recommended practices, we hope to gain a greater understanding of how messages can be tailored to the rural poor in Cambodia. Findings from this case study are therefore meant to provide formative research that can inform USAID and the RGC's desire to adapt current messages on complementary feeding (MOH 2014).

Research Questions

This study takes a qualitative approach toward understanding current practices and caregiver perceptions of specific recommended feeding practices for young children, aged 6-24 months. It addresses two broad research questions and additional sub-questions:

1. What are caregivers' current child feeding practices for young children?
    a. Do caregivers prepare enriched porridge for their children? What is the nature of their practice and does it follow the recommendation?
    b. Do caregivers apply the "three food groups" recommendation? What is the nature of their practice and does it follow the recommendation?

2. What are the constraints to adopting these recommended practices?
    a. What are the constraints to applying the enriched porridge messages and how do caregivers' perceptions about these messages affect their interest to adopt it?
    b. What are the constraints to applying the "three food groups" message and what are caregivers' perceptions about these messages?

Hereafter, we use the term "young child" or "target child" to refer to a child 6-24 months of age in each household in the sample.

Study Design

This study takes a qualitative approach. Qualitative interviews and observational data can provide insights into caretaker behaviors and decision-making and are an appropriate means by which we may explore participants' perspectives on various interventions. In particular, qualitative work can focus on identifying *emic* or insiders' perspectives, and thus allow us to surface the "why's" and "how's" underlying participants' behaviors (Chung 2000).

The study was conducted in two distinct stages. First, we used participant observation in a subsample of villages to observe the foods that are served to children aged 6-24 months and to understand how these practices fit within the household's usual habits of food preparation and family meals. Second, we used in-depth interviews in a larger sample to follow up on observed behaviors and to explore decision-making around child feeding patterns in greater depth. The study sample, data collection, and analysis methods are described below.

Study Sample

The research covers the four provinces of Cambodia where HARVEST has operated: Pursat, Battambang, Siem Reap and Kampong Thom, all in the Tonle Sap region of the country.

Since the pedagogy of the family nutrition education program changed substantially between Phase I and Phase II of HARVEST, this study focuses only on villages that were involved in Phase II of the intervention. HARVEST Phase II began around February/March of 2014 with a new cohort of villages and households. The nutrition education program was scheduled to end in all villages by approximately January/February 2016. Data collection for this study occurred between June 28, 2015 and October 31, 2015, during the last eight months of HARVEST's Phase II activities.

Sixteen villages, four in each province, were randomly chosen from a census of Phase II HARVEST villages. Randomizer.com was used to generate a random number for each village in the province to ensure that each had an equal chance of being selected. A list of alternate villages was also generated in the case that sampled villages did not have households that fit the selection criteria.

In the first stage of data collection, participant observation was carried out in half of the sixteen villages. Within these eight villages, we aimed to conduct observations in three households per village. Each selected household had to have a child between the ages of 6 -24 months.

To identify eligible households for the participant observation, a bilingual field investigator met with the HARVEST Food Security and Nutrition Technician (FSNT) that was assigned to each of the selected villages. The investigator and FSNT reviewed the FSNG client roster to identify households with children in the appropriate age range that fell into three different categories: 1) households with Poor 1 or Poor 2 identity cards;[1] 2) households with an alternative caregiver, for example a grandparent, older sibling, aunt/uncle or other relation that cares for the children on a daily basis; and 3) any other households with a young child. Households that migrated seasonally out of the village or were related to village leaders, including the village chief or Village Health Volunteer (VHV), were eliminated from the list. In case the list of possible households was exhausted, we allowed investigators to include households that were not members of the FSNG group but had attended nutrition events or were familiar with FSNG activities. Since the family nutrition program had shifted to a community-based approach, we deemed this to be appropriate as we were interested in the overall influence of the program on child feeding practices. It is important to highlight that the FSNGs were not composed solely of households with children under the age of two. In addition, membership was voluntary. Hence, in some villages there were few children in the correct age range. We were therefore able to conduct 20 participant observations across the eight study villages.

During the second phase of data collection, we focused on in-depth interviews. For this work we added 8 villages to the sample, for a total of 16 villages (4 in each province). As with the participant observation, the field investigator met with the FSNT and identified appropriate households from the FSNG client roster. Again, in the case that we exhausted the list of possible households, we allowed investigators to include households that were not members of the

[1] Poor 1 is the poorest category of households in Cambodia and Poor 2 is the second poorest category, according to the RGC Ministry of Planning (KOC 2009).

FSNG group but had attended nutrition events or were familiar with FSNG activities. A total of 24 households were added to the sample in the new eight villages. In total, across the 16 villages 44 in-depth interviews were conducted.

Finally, we note that the HARVEST recommendations focus on complementary feeding practices, defined as feeding practices for children aged 6-24 months who are transitioning from breastmilk to family foods. This is a period of great vulnerability and the MOH encourages mothers to breastfeed through this transition. Caretakers, of course, make their own decision about when to cease breastfeeding and HARVEST does not have a separate nutrition education program for households with children who have been weaned, nor does it exclude their participation in the nutrition education programs. Accordingly, our sample contains children aged 6-24 months, some breastfed and some not breastfed. From a cost perspective, it was not feasible to sample only breastfed children as there were too few children in the 6-24 month age range in each village. The study therefore does not focus solely on complementary feeding, strictly defined as foods that complement breast milk, as not all children aged 6-24 months are still breastfed. To avoid confusion, we will use the term "complementary and transitional feeding" to describe feeding practices for children in our sample between the ages of 6-24 months.

Data Collection

Data collection was conducted in two stages, as detailed below. The first stage focused on understanding households' current feeding practices for children 6-24 months age; the second phase focused on understanding caretaker perceptions of the feeding practices promoted under HARVEST.

A bi-cultural, bilingual team trained in the techniques of qualitative research was assembled for this study. The field team consisted of one male and two females, each bilingual in English and Khmer. The team was sensitized to alternative definitions of caretakers beyond the concept of "mother" as well as the potential gendered aspects of childcare, food preparation, and livelihood obligations.

Phase I: Understanding current practices

Participant observation is a methodology in which the researcher studies the life of a group by sharing in its activities (DeWalt and DeWalt 2010). One advantage of collecting data by observation is that it allows the researcher to record what people actually do, instead of what they say they do. In this case, the observation included the preparation and consumption of two consecutive meals during one day, including any foods prepared for and fed to children between the age of 6-24 months and all other caring and livelihood behaviors completed by the primary caretaker.

The purpose of this work was to document current child feeding practices so that we could subsequently return to interview caregivers about their perceptions of the nutrition education messages presented through HARVEST'S nutrition training intervention.

Participant observation requires time to develop relationships with the village. As such, we restricted work to half of the study villages (2 villages per province, for a total of 8 intervention villages). Households with male caretakers were not excluded, but were rare.

The investigator visited each household unannounced. While the FSNT facilitated the introduction, s/he was only aware that the investigator wanted to observe cooking and meal times, but was otherwise unaware of the details of what the investigator needed to observe and record. At the introduction, households were told that they would be visited by the field investigator, but they were not told which day the visit would take place. Visits occurred one day to two months later. On the day of the visit, the investigator arrived early in the morning before breakfast and stayed until after the second meal of the day was completed. Holidays were avoided. During the visit, the investigator observed and recorded all food preparation, food consumption, and caretaking activity that occurred during the visit. She noted what foods were used to prepare a family meal, the techniques and processes used in the preparation, and how they were served to members, focusing particularly on the young "target child" of age 6-24 months. She estimated serving sizes to the target child and estimated how much they actually consumed. The investigator made written notes during the visit and expanded them into full ethnographic notes shortly after the field visit.

Phase II: Understanding perceptions of key messages

We used semi-structured, in-depth interviews to: 1) explore perceptions of the nutrition messages on complementary foods; 2) identify barriers to adoption and use; 3) add to information on current practices of complementary foods with the nutrition education participants; and 4) identify practices that caretakers might be willing to adopt. Khmer native speakers conducted the interviews using interview guides that asked open-ended questions that allowed respondents to answer in their own words, using their own logic. Investigators were guided by an interview protocol but were able to ask follow-up and clarifying questions. Interviews were recorded and later translated into English. The average interview time was 70 minutes per household.

The interview guide was pilot tested in non-study villages prior to data collection with the principal investigator in June 2015. The guide was further refined in July and August and data collection took place in September and October 2016. Interviews were carried out in the eight participant observation villages (n=20) and in the eight newly sampled villages (n=24). Overall, data collection covered 16 randomly sampled villages and included a total of 44 in-depth interviews.

Data Analysis

Participant observation notes were reviewed and summary memos were created for each household. Memos compiled the recipes of all dishes prepared during the observation, the composition of the meal served to the target child, and consumption by target child.

All interviews were translated from Khmer to English by two bilingual speakers, one of whom had collected the interview data in eight villages. The transcripts were read by the principal investigator and second author and, where necessary, the transcripts were clarified by checking against the original audio. The principal investigator identified appropriate concepts and themes to be coded and extracted from the data, and organized a system of analysis that relied upon thematic coding and displays. Displays are a systematic means by which textual data are reduced to more manageable proportions by topic (Miles, Huberman and Saldaña 2015). For this study, the displays took the form of data tables that collected raw and summarized data by household in rows for various variables or characteristics that are given by the columns. Displays can take many forms and the ultimate configuration is determined by the goals of the analysis. For this study, a series of displays were created to help reduce the data by research

question and topic area. Data were extracted thematically into the conceptually-clustered displays (Miles, Huberman and Saldaña 2015) and then analyzed systematically across the sample.

For this analysis we initially created twelve displays, five for the participant observation data and seven for the in-depth interview data. As the data analysis progressed, we created more displays to analyze the data further according to emergent themes in the data. The displays are shown in Table 1.

Table 1: Data Displays Created to Reduce and Analyze the Qualitative Data

Display Content	Participant Observation	In-depth Interviews
Initial Displays		
Enriched Porridge Practice and Attitudes	x	x
Composition of Adult Meals, Three Food Groups	x	x
Composition of Target Child Meals, Three Food Groups	x	x
Alterations to Target Child Meals	x	x
Snacking, Household & Target Child	x	x
Caregiver Knowledge about Enriched Porridge		x
Caregiver Knowledge about Three Food Groups		x
Emergent Displays		
Substitutes for Enriched Porridge	x	x
Family Foods	x	x
Meal Preparation Times	x	
Choking Concerns		x
Soup Composition and consumption	x	

Results

This section reports on the current child feeding practices as well as the constraints to practicing the recommendations promoted by HARVEST. In particular we focus on behaviors and perceptions that are related to two specific recommendations: 1) the preparation and use of enriched porridge; and 2) the use of the three food groups in the composition of meals for children aged 6-24 months.

Section 5.1 presents descriptive information about the sample. Section 5.2 presents the analysis of current feeding practices, as related to messages regarding the use of enriched porridge and the application of the three food groups concept. Section 5.3 examines constraints to adopting these recommendations, including caregiver knowledge and perceptions about the recommendations.

Sample Description

Table 2 presents the composition of the study sample. The study includes two nested samples. Participant observation data were collected from Sample A during Stage 1 (n=20). Following the participant observation, in-depth interviews were conducted in Sample A and Sample B during Stage 2 (n=44). No participant observation was collected for Sample B.

Table 2: Age Distribution of Target Child by Sample

	Sample A	Sample B	Total Sample
	Participant Observation + In-Depth Interviews	In-Depth interviews only	
Age of Target Child			
6-8 months	0	2	2 (5%)
9-11 months	5	4	9 (20%)
12-24 months	15	18	33 (75%)
Subsample Total	20	24	44 (100%)
Breastfed	10	11	21 (48%)
Average Age (mos)	15.7	17.6	16.8
Totals	20	24	44 (100%)

Table 2 illustrates that the age distribution of the sample heavily favors children in the toddler age range (12-24 months). Older infants (6-11 months) represent 25% of the sample, with most falling within the 9-11 month range. Only 2 children fall within the 6-8 month age range in which enriched porridge is recommended as the sole form of complementary food.

By contrast, 80% of the sample represents children in age groups in which complementary feeding recommendations allow for the introduction of "family foods." Specifically, the MOH recommends enriched porridge as a preferred food for children 9 months of age or older, but adds that children may now consume enriched porridge that is prepared from ingredients obtained from the family meal (see Figure 2). Vegetables and protein sources should be mashed into the softened rice to make a thick pap similar to enriched porridge. At 12 months, enriched porridge is still recommended, but caretakers may now serve the child family foods that are softened or mashed. HARVEST emphasizes that family foods should include diverse foods, such as a source of protein (or body building foods), a micronutrient source (protection foods), and a staple food (or energy food).

The age distribution of the sample sets the focus of the study. With few households representing the 6-8 month age group, it is not appropriate to examine the use of enriched porridge as a sole complementary food. Rather, with the majority of cases in the older infant (9-11 month) and toddler (12-24 month) age range, the focus of the study will be on a transitional feeding period that covers the introduction of family foods. This is a useful period to examine because children at this age are vulnerable and we know little about what is happening in rural Cambodia during this period. The study helps to inform us about households' current practices and thus suggests what caregivers are willing to do.

Finally, Table 1 also shows the prevalence of breastfeeding within the sample. Approximately half of the target children were breastfed during the study. Since half of the sample are not breastfed, feeding patterns for these children are not technically considered to be complementary feeding. To speak of complementary feeding patterns would imply that children aged 6-24 months are breastfed. However, HARVEST does not limit participation in its food security and nutrition groups (FSNG) to only caretakers who are breastfeeding, nor does it provide formal recommendations for children who are not breastfed. We therefore did not exclude these households from the study. The composition of the sample does not change the usefulness of the results in helping us to understand what caretakers are willing to do

regarding child feeding during this vulnerable period of transition. To avoid confusion we use the term transitional feeding practices, rather than complementary feeding practices.

An Examination of Current Transitional Feeding Practices

The analysis relies upon two sources of data. First, participant observation is used to observe the foods that are actually served to young children and to understand how these practices fit within the household's usual habits of food preparation and family meals. Second, data from in-depth interviews were used to follow up on observed behaviors and to explore decision-making around child feeding patterns in greater depth. Interviews were carried out in 44 households, located in 16 HARVEST villages. Participant observation took place in a sub-set of these villages, and included 20 of the same households.

Enriched Porridge and the Concept of Separate Dishes for Young Children

Enriched porridge has been a major part of the Kingdom of Cambodia's nutrition education campaign (MOH 2011), as well as a prominent part of HARVEST's nutrition education program (USAID 2012). Results from this study indicate that there is little evidence that households were using enriched porridge in the study villages. In particular, among the 44 households in which we conducted in-depth interviews, none were currently preparing enriched porridge, as taught by the official HARVEST curriculum. This included two households with children between ages 6-8 months, which under HARVEST and MOH recommendations should have been feeding their children enriched porridge and breastmilk.

Direct observations of child feeding practices support these findings. Among the 20 households for which we conducted participant observation, none were observed to prepare enriched porridge for their young child. In addition, when asked about the practice of using enriched porridge in the village, caregivers were straightforward in stating that the practice is not widespread.

> *"There is nobody eating it."*
>
> *"In each house I do not see anyone preparing enriched porridge."*
>
> *"For cooking our main meal, we know our role. We know we have to do it. But for making such borbor, every mother including myself, we are lazy. If you ask them whether you have made the borbor for your child, they would say they have never made it all. You can take notice of this."*

Although there was little evidence of enriched porridge use, this should not be surprising as most children were above the age of 9 months. Nevertheless, many caregivers stated that they had tried it in the past. Among those interviewed, 77% of households claimed that they had fed it to their young child at some point in the past. However, of this group, the majority described very limited experiences with enriched porridge (60%); some said they tried it only at cooking demonstrations, while others said they made it a few times but did not continue. A minority (22%) said that they gave their child enriched porridge regularly in the past, but had since moved on to other complementary and transitional foods. Finally, a small number of caregivers gave very inconsistent accounts about their experience with enriched porridge, and thus shed doubt on their claim that they had ever prepared it. One mother for example maintained that she fed her child enriched porridge regularly between the ages of 6 and 8 months. Yet during the interview she stated multiple times that the child refused to eat it. Another said that she

fed her child enriched porridge when the child was younger, but was inconsistent about the periods in which she fed her child the porridge. At first she said it was between 6 and 8 months of age; another time she said it was between 8 and 12 months and another time she said she had discontinued the practice at 19 months of age. For these cases we can only assume that respondents were keen to display good intentions, but did not use enriched porridge regularly. Had they done so, their accounts would have been more consistent. In sum, the interview data indicate that the vast majority of caregivers interviewed did not use enriched porridge for a sustained period of time, while a minority said they had but had since moved on to other complementary or transitional foods.

If enriched porridge has not been widely adopted in the study villages, what are the complementary and transitional foods that are being used in its place? What are families feeding their young children?
The analysis supports the notion that preparation of special dishes for young children, such as enriched porridge, is rare and not the norm. Instead, the data show a consistent pattern of caregivers creating complementary and transitional foods from dishes that are prepared for the rest of the family. In the observation data, for example, this was true of both meals we observed in each household. At breakfast, for example, young children consumed some form of the meal served to the rest of the family. At lunch the pattern was the same in all households observed but two. In one house, a 7-month-old child was fed only watery porridge in a bottle and in another the caregiver prepared a simple soup for the child and made a thick, enriched pap out of family rice. These were the exceptions.

This same pattern was supported by the interview data with 44 households. Through interviews, caregivers described the preparation of each main meal and the nature of household mealtimes. At the end of the narrative for each meal, caregivers were asked if the target child had eaten anything and if so, how it was prepared and served. Invariably, caregivers described a process in which children were either fed the same preparation as adults or a slightly modified version. This was true for breakfast, lunch, and dinner for 88%, 96%, and 94% of households respectively. In addition, this was true in all age ranges. Taken together, these findings suggest that caregivers prefer to discontinue feeding their children enriched porridge early, if they have been doing so at all, and shift to a modified form of family foods.

Strategies that Caregivers Use to Avoid Preparing Separate Dishes

The overall strategy for caregivers appears to be one of balancing the different needs of the young child against time constraints and available family resources. Under these constraints, caregivers clearly seek strategies that allow them to feed all members of the family from a single preparation. Our ethnographic data are detailed and illustrate many examples of this behavior.

Family Soups. By far, the most common strategy was for caregivers to prepare soups that could easily be altered and fed to young children. For breakfast, lunch and dinner, soups, such as *sgnao, somlaw prohail, somlaw mchuu,* or *somlaw ka kor* are prepared as a main dish and served with rice. Each soup is cooked with varying kinds of vegetables, meat or fish in a broth. Some are simpler, like *sgnao* or *somlaw mchuu*, while others contain chunks of vegetables and meat and can include nutrient-rich ingredients. Each soup has its unique set of seasonings and typical ingredients, but cooks can adapt their recipes to accommodate the foods that are available.

Preparing soup is such a central strategy for caregivers that some indicated it is a necessity when one has a small child. With soup, the broth can be removed and used to soften rice for the small child.

> *"Since I have a young child I have to make soup every day so that I can use water from the soup to mix with rice. If there is soup he can eat more."*

> *"We try to make it every day so the kids can eat it. Without somlaw [soup] they cannot eat."*

Soups therefore are a dish that can do double-duty for caregivers. Soup broth provides an easy way to turn the staple food, rice, into a complementary or transitional food that young children can easily eat. If the soup has strong spices, such as chilies, the child's portion can be removed before the spices are added to the pot. At the same time, family members can consume the soup, chunks and all, as a main dish with rice. For adults, soup is a satisfying dish that is perceived to stave off hunger and can be changed up to avoid monotony.

> *"We rarely cook any dry food. We prefer soup and would not feel like we are full without having soup."*

> *"In the day time I have to work. Soup will keep my energy stable and I won't become easily hungry. The nutrients from vegetables will keep my body strong. If I don't eat soup for one or two times I will feel exhausted so soon. In the evening we can eat either dry or fried dishes or soup because we don't have to work anymore… I have a child who needs breastfeeding so I will get hungry very soon if I don't eat soup."*

Typically, soup is served family style. Rice is served into separate bowls and family members spoon soup from the serving bowl into their individual bowls as they eat. They will consume a spoonful or two of the mixture from their own plate and then repeat the process of pouring more soup onto their rice from the serving bowl. For small children, however, soup is usually added added to a small bowl of ricein one serving. Most caregivers will spoon the mixture into the child's mouth in small amounts. For some, the broth with rice is eaten plain with no other ingredients. Some caregivers crush softened pieces of the solids from the family soup into the child's bowl.

Feeding a young child is a slow process and is hard to do while the caregiver is eating. As such, caregivers stated that they frequently feed the child before the family meal, just after the meal has been prepared. Alternatively, caregivers can serve everyone together, including the small child, and then eat themselves after the child is done. In our observations, it's common to see caregivers spoon-feed young children until the age of 1.5-2 years. Some children as young as 10 months were self-feeding. Most children appear to be completely feeding themselves by age 3.

In the study villages, caregivers said that broth with rice was most commonly fed to young children for lunch and dinner, but might also be served at breakfast. These findings were supported by the participant observation data. In 75% of households we observed young children were served broth with rice for lunch on the day of our visit; by contrast, only 20% served the same for breakfast

Stir Frying and Dry Foods. While broth and rice is a common meal for young children, caregivers also described techniques for making complementary and transitional foods out of family meals that did not involve soup. Most explained that their household needed variety in its meal preparations and they described alternating between soups, stir-fried dishes, and "dry" foods. Stir-fried dishes might include a little liquid that makes a thin sauce. A dry dish, by contrast, has no liquid and might include dried fish or meat that is grilled or fried. In their descriptions of meals, caregivers described common strategies to turn dry dishes into complementary and transitional foods for young children. One mother of an 8-month-old described how she fed her son when she made fried pork for the family.

> *"If there is fried pork, I will have the fried pork chopped up really well and then I'll mash it with the rice before feeding my son… I use a rice spoon to mash [the rice] on a plate. I have to first mash the rice well and then put the chopped up pork onto the plate and then I mash it again. This is the case when there is no soup water."*

She then went on to describe what she does when she makes a stir-fried vegetable dish for the family. Some vegetables are "soft" and can be mashed after frying; others however, like yard long bean and water convolvulus, are too "hard." If she stir-fries a dish with a vegetable that cannot be mashed, she will mash the rice with "the liquid from the fried dish" and leave the vegetable out of her son's portion. Other caregivers described similar processes of adding water to a stir-fry to make a watery sauce that can be mixed into rice for their young child. Said one grandmother, "Because we have young children, for every fried dish we have to add water to it."

Porridges. Finally, traditional porridges are another example of a convenient complementary or transitional food that can meet the needs of many family members with a single preparation. Traditional porridges, such as white porridge (*borbor sar)* or purchased market porridge (*borbor kreung*), are eaten by all members of the family.

> *"If I do not go to the field I prepare white porridge for eating during the day. But that's for all of us, not just my kids. We don't have separate porridge for them."*

Traditional porridges are fast to prepare and do not require acquiring extra ingredients when there is no money. One woman described how the whole family ate porridge at times when she has no rice and it is hard to get fish.

> *"Sometimes I make porridge mixed with different types of vegetables. This is our food when we have a shortage of rice….because we do not have money to buy things to make dishes. So making porridge is the best way to save the situation."*

Interviews with caretakers indicated that small children will eat white porridge at any meal, but in this sample they identified porridge most often as a breakfast food for young children. Direct observation of mealtimes supports the notion that porridge is a common food for young children. In one-third of the observations, young children were either fed white porridge or market-purchased porridge at breakfast.

Traditional white porridge, *borbor sar*, was observed to be thin in consistency. White porridge is made of rice, water, and salt and does not commonly include vegetables or meats. In only one instance we observed micronutrient-rich vegetables, pumpkin and ivy gourd leaves, added to the *borbor sar*.

Market porridges also tend to be a watery, soup-like dish that contains rice boiled to disintegration, with various meat and vegetable garnishes that may be added to family portions. Portions for small children, however, were typically watery and served plain, with most of the nutrients in the form of energy from boiled rice.

During the intervention, HARVEST maintained that many caretakers were averse to making enriched porridge. In addition, they also reported resistance to making porridge thick, as instructed by the National Nutrition Program (NNP) and in HARVEST cooking demonstrations and recipes. Committed to nutritional improvement in children under two years of age, HARVEST encouraged caretakers to add nutrient-rich vegetables to *any* porridges they made or purchased. However, during our observations, we saw only two cases in which mothers added vegetables to regular white porridge. Some, however, did not understand this practice. Said one grandmother, "We make porridge, why would we add vegetables?"

Purchased Foods: The Exception. Target children, regardless of age, typically ate some derivative of what was served to the rest of the family. However, participant observation revealed two exceptions to this rule. First, when households purchased breakfast from local vendors, different foods might be purchased for each family member. In some study villages, purchasing breakfast was a common practice, even among the poor. Hence, different members could be eating noodles, porridge, or locally made snacks or desserts, *noms*. In this case, small children often share a purchased dish with others in the family and may even choose the dish or snack. Second, we noted that when the adults do not eat breakfast there is often no early morning cooking. Under these circumstances young children might be fed leftovers for breakfast, such as plain fried rice, rice with fish sauce, or purchased foods, such as *borbor kreung*, or fried or sweet snacks.

Application of the Three Food Groups Message

The previous section illustrates that enriched porridge was not widely adopted in these study villages. It also illustrates a strong desire to feed young children from preparations that are served to the whole family. In our sample this was observed for children in all age ranges. If households are not making enriched porridge as suggested by the program, have they been able to apply other educational messages about diet quality?

HARVEST promoted educational messages about diet quality that follow those put forward by the Baby-Friendly Community Initiative materials created for Cambodia (FAO 2014). In particular, HARVEST emphasizes the principle of including elements of the "three food groups" (TFG) in a young child's meal. Each meal should include a body-building food, a protection food, and an energy food (USAID 2012). Energy foods are those that provide calories; protection foods include those that are high in micro-nutrients; and body-building (or construction) foods are those that are a good source of protein.

To examine the application of this message into young child meals, we draw upon 1) participant observation data to understand the ingredients that are used in a young child's meal and to examine what the child actually consumed; and 2) in-depth interviews that asked caregivers about decision-making around the composition of dishes provided to young children vis-à-vis adults and the rest of the family.

Since we found that adult meals are usually the source of foods for young children, we begin with an analysis of the TFG in adult preparations. The analysis examines the number of food groups included in dishes served to adults and to young children and considers implications for diet quality. Counting and comparing the number of food groups, of course, is only a crude proxy for the quality of the meal, but it does illustrate the extent to which participants behaviors adhere to this message. For these results, we underscore that the findings are qualitative and therefore speak to the composition of adult and young child meals with respect to the TFG.

The Three Food Groups in Adult Meals

Two important patterns emerged from the analysis of adult meals. First, the data show that adult lunches and dinners were likely to contain better food diversity than adult breakfasts. An analysis of the participant observation data, for example, showed that adults in only 25% of households consumed a breakfast that included all three food groups. The average number of food groups consumed at breakfast was 1.7 and protection foods were typically limiting; only 33% of households included a protection food in adult breakfasts. These findings are consistent with observations of the context surrounding these meals. Mornings are often busy and caregivers have various livelihood activities they must attend to. Said one caretaker,

> *"We are all busy with our own work, so I can't prepare food for him except at lunchtime. If I don't try to earn additional money, it will be tough for our family financially."*

As such, caretakers may opt for simple meals that do not require much preparation and do not include vegetables or fruits. Accordingly, the observation data show that households that did not provide protection foods at breakfast were more likely to serve meals that required simple cooking processes, such as white porridge, market porridge, leftover rice, or eggs.

The interview data support these findings. Caregivers described the dishes they typically consumed at each meal in the day. From these narratives, we categorized the ingredients and tallied the number of food groups contained in the dishes that were typically served to adults at breakfast. The interview data indicate that approximately 27% of households said that the breakfast dishes consumed by adults included three food groups. Similar to the participant observation data, very few caregivers described breakfasts in which protection foods were served. In many cases this is due to the constraints imposed by a busy work schedule; in other cases it was because of the availability and convenience of purchasing breakfast foods.

> *"We eat only fried fish for breakfast…The fried fish can be cooked for my husband before he leaves for work. I am afraid if I cook soup, it will take me longer to cook. I often cook soup for dinner."*

> *"Sometimes we are busy. We buy them porridge or rice noodles [for breakfast]. There is no regularity because we are busy."*

Clearly, in this sample breakfast is not a very diverse meal. Breakfasts were simple meals that centered around a single food with rice.

The lunch data, however, showed that adult lunches were more complex and more likely to contain three food groups. Participant observation revealed that adult lunches contained an average of 2.8 food groups. In contrast to breakfast, over 70% of households provided a

protection food to adults at lunch, usually in the form of a soup such as *somlaw ka kor, somlaw mchuu,* or *somlaw prohail*.

Cooking in these households was more elaborate at lunch than at breakfast. During the participant observation, preparations of *somlaw ka kor* or *somlaw prohail* for example could take anywhere from 35 minutes to almost two hours to wash, chop, grind and season such dishes. Households that did not have a protection food at lunch were observed to serve simpler meals such as leftovers from breakfast, stir-fried dishes, or simple soups that lacked nutrient-rich vegetables.

> *In interviews, caretakers often spoke of dinner in similar terms as lunch and suggested that a dish that is cooked at lunch could just as easily be prepared for dinner. They also spoke of varying the dishes served in a day, such as alternating between stir-fried dishes and soups or preparing soups with different tastes. One woman explained, "I think that if we made soup both in the morning and the evening like this very often, we would be bored. So we have to mix it up and eat dried or grilled food [for a meal]."*

In addition, only 38% caretakers interviewed said that they habitually cook two complex meals, such as *somlaw ka kor* or *somlaw prohail,* per day. Twenty-nine percent reported cooking only one complex meal a day and 33% reported cooking one or two depending on the day and the circumstances. Taken together, this implies two things. First, it is likely that many adults have only one meal per day that offers good food diversity. Second, the diversity served in any given meal may depend on what is cooked earlier or later in the day. If a complex dish has already been cooked (eg. a soup with many ingredients), it may be followed by simpler meal. The interview data suggest that lunch and dinner meals have more similar qualities between them than to breakfast. However, given the flexibility and interdependence among meal preparations, it is important to look to the diversity of a given dish rather than make assumptions about the meal hour. Seasonality and other context-specific factors may also influence these patterns, but it was beyond the scope of this study to examine these patterns.

The Three Food Groups in Complementary and Transitional Meals

The findings on adult meals suggest that lunches and dinners are reasonably diverse, but that breakfast is not as diverse in terms of diet quality. What do these findings imply about the quality of complementary and transitional foods that are created from these preparations?

At first glance, the participant observation data suggest that the pattern is similar for young children. Observation of young child meals, for example, reveals that only 29% of young children were served dishes that contained three food groups at breakfast. By contrast, 63% of households served lunches to young children from family meals that contained all three food groups. Thus, as with the adults, lunch appears to provide higher quality meals to young children in about two-thirds of the households studied.

However, a closer look at the observation data illustrates that young children's meals are often served in ways that lower the nutritional density of the dishes they consume. Specifically, participant observation allowed us to record the manner in which adult dishes are served to the child. During the observation, the field researcher noted 1) if the caregiver omitted select ingredients from the family dish (eg. meat, fish, or vegetables); and 2) if the child's serving was further diluted by the addition of broth. The overall effect of these actions is important because they can lead to child servings that are much more dilute than the adult dish; in effect,

these servings have a higher ratio of broth to vegetables, protein, and/or rice. For small children, both practices are of concern as meals that are high in liquid will fill a child's stomach, but will not provide the nutrients needed. For this reason, HARVEST and NNP encourage caregivers to mash the nutrient-rich ingredients into the child's bowl to increase the nutrient density of the meal.

There is some evidence from the interviews that caretakers were cognizant of the effect that the volume had on young child appetites. Soup was often identified as a preferred food because it satisfied hunger. One caretaker commented, "If we don't have soup they will not be happy and they will cry. With dry food, the meal cannot make their stomachs full. When their stomachs are not full, they will make trouble."

But respondents showed less recognition of the effect that liquids had on nutrient density. Observations of child feeding practices suggest that the practice of serving broth with rice may be creating meals with high volumes of liquid, but low nutrient densities. During the observation, for example, we observed that 71% of the young children were eating meals that included broth with rice. Of these, roughly half of the children were not served the same composition of ingredients that were present in the adult dish; rather the quantity and selection of solid ingredients (eg. vegetables and protein) was selected by the caretaker. As a result, small children's meals often contained high ratios of broth to desirable ingredients such as animal or fish proteins, vegetables, and rice. Hence, even if all three food groups are present in the child's dish, the density of nutrients may be low if the caretaker withholds pieces from the soup or adds a greater ratio of broth. Furthermore, when it comes to actual consumption, about one-third of these children were seen to leave aside nutritionally important elements of the dish that were served, such as pieces of fish, pumpkin and other nutrient-rich vegetables.

Similarly, of the children who were served a meal that included all three food groups, almost all (86%) ate soup with rice. Of these, 57% of caretakers altered the composition of the family dish before they served the child, in some cases removing pieces of fish and vegetables and in extreme cases omitting everything but the broth. Hence, in our observations, many of the small children that were served family soup and rice appeared to be consuming mostly broth and rice with very small additions, if any, of nutrient-rich ingredients. As a result, even if the family meal contained all three food groups, the child's may have had only a small amount or may have not received three food groups at all. In sum, the results suggest that households that prepare meals with good food diversity for adults may not serve this diversity to their young child.

The previous paragraph discusses small children who received lunches that included all three food groups. About one-third did not. Among this group, about two-thirds also received a breakfast that did not include all three food groups. Furthermore, all of these children's parents had a similarly low-diversity lunch. Taken together, these findings suggest that households that do not prepare dishes of sufficient diversity for the adults are predisposed to overlooking food diversity for their young children as well.

In the next section we turn to examining the application of the "three food groups" recommendation to adult and young children's meals.

The Snacking Environment of the Young Child

Thus far, we have spoken only of main meals. Diet diversity can also be obtained through snacks. Indeed, HARVEST educational messages also encourage caretakers to give small children two snacks during the day, such as fruits like bananas, mangoes, and papaya.

The data, however, revealed important patterns about the nature of snacking within these rural households. First, during the participant observation, we observed fruit being consumed as a snack in only two households. At the same time, we observed that packaged snacks appear to have a presence in almost all households, whether poor or non-poor. In a family identified as Poor 2, for example, a mother described that she had to leave her small child in the care of her older siblings while she went to the fields to work. Purchased sweets are a regular way to cope with the lack of ingredients at home.

> *"Since the amount of food is limited, I leave all of the soup for them at home…In the morning I buy cakes for them to eat during the day so that they do not cry because they are hungry."*

Observation revealed that many kinds of purchased snacks are available in villages. Industrially-packaged snacks are sold in small, individual servings that are perfect for consumption by small children. These packets contain dry, shelf-stable products such as cookies or shrimp chips. In addition, snacks are also produced by local entrepreneurs. Some are just re-packaged, pre-made treats put into small servings. For example, in one village small children purchased small bags that held a few sheets of rice paper candy that came with a small dab of sweet chili sauce upon purchase. In some villages, perishable hand-made snacks are brought to the village by motorbike or bicycle. Mobile vendors will typically come with a large assortment of sweet and savory snacks, each packaged into small plastic bags for individual sale.

Surprisingly, a non-nutritious snacking culture was prevalent in all of the villages we studied, even among the poor. The data revealed that 88% of the households regularly purchased non-nutritious snacks for their young children. During our visits, we saw young children consuming purchased snacks directly in 71% of the households. Furthermore, in 63% of households there was evidence of a very blatant snacking culture, in which children whined to their parents for money to purchase snacks or in which caretakers placated their children by giving them money to buy their own snacks. In one household, the siblings of a young child, ages 3 and 5, begged incessantly for snack money and were rewarded throughout the day by their mother. When asked about their snack habits in the morning, she said,

> *"At 8 AM they will start buying snacks until 11 AM when they have to take a nap. After having a nap, they will ask for money to buy more snacks. To add it all up, they could spend up to 5,000 riels each per day. They stop buying snacks in the evening when they have to go to sleep."*

In most cases, older children in the family are responsible for buying snacks for the young children, but it was common for children as young as three to buy snacks for themselves. In one of the participant observation households, a mother explained that her 16-month old toddler had already started to ask for money to buy snacks. So acculturated are children to the practice that children as young as two years associate the sound of a moto with the possibility of getting a snack. During an observation one mother remarked, "When the moto comes, [the toddler]

screams because he wants a treat." Another mother explained, "In the morning, the mobile vendors stop in front of my house and my children run to them. I cannot prohibit them."

The interview data supported these findings. In the 44 households we interviewed, 90% of caretakers said that they purchased low-nutrient snacks for their children. Of these, roughly half of these indicated that the young child is allowed to choose the snack themselves or have an older sibling choose something on their behalf. One mother explained that her 11-month old child already knew all the mobile food sellers and knew how to signal for them to stop. The mother does not dissuade the child from approaching a mobile vendor and allows the child to choose her own snacks.

In some cases, caretakers suggested that snacking was interfering with their children's interest in eating at regular meals,

> *"It's hard to have a normal breakfast before having a cake since he asks for money to buy it. He won't stop crying until he gets the money."*
>
> *"Since [the child] eats snacks she stopped eating the enriched porridge."*

And others suggested that snacks are acceptable substitutes for regular food in the lean season. One mother from a Poor 2 household explained that her son "eats snacks continuously from morning until evening when he falls asleep." Yet, in the lean season she is not worried that he doesn't get enough food because when "he is served snacks, he will eat less rice."

Constraints to Adopting HARVEST-Recommended Feeding Practices

Why Don't More Caretakers Make Enriched Porridge?

In Section 5.2, our results indicated that none of the study households were *currently* making enriched porridge, as instructed by the official HARVEST curriculum. This was true across all age groups in the sample (6-8 months, 9-11 months, and 12-24 months). In addition, the data suggested that most households preferred to shift to family foods early in the young child's life. Even the minority of households that said they had ever made enriched porridge for their young children only did so for a short period of time. This too, was true across the all sampled age groups. In this section we explore household perceptions about enriched porridge. In particular, we focus on caretaker explanations of why enriched porridge is not feasible for their households.

The in-depth interviews revealed that awareness about enriched porridge was generally high. This is not surprising as HARVEST has not been the only source of information about enriched porridge; some had learned of enriched porridge from television, their health centers, or other NGOs. Of the 44 respondents interviewed, all but one were familiar with enriched porridge. Most, however, had only partial knowledge of how to properly make enriched porridge; many described superfluous ingredients or processes. One of the most common omissions was a description of the proper texture or thickness of the porridge. Most, however, were aware that it was good for children and had a clear opinion on whether it was feasible to serve it in their household.

The discussions with caregivers were detailed and provide an explanation as to why there is not enthusiasm to adopt enriched porridge or to continue feeding it beyond 9 months of age. The reasons were varied across the households, but overall, caretakers identified aspects that

contribute to the explicit as well as implicit costs of preparing enriched porridge. In addition although caretakers were cognizant of messages regarding the benefits of enriched porridge, the costs appeared to dominate their decision-making, especially as more discussion of the perceived benefits emerged.

Costs of Preparing Enriched Porridge

Caretakers were quick to identify the various costs associated with preparing enriched porridge. Chief among these were the extra time and expense of preparing a dish that only the small child will eat. In particular, time allocation of caretakers was a recurring theme among the interviewees, many of whom suggested they must balance caretaking activities with other livelihood activities. Furthermore, the extra costs would have to be incurred each day as it is not possible to store the enriched porridge for more than two hours.

Purchasing ingredients is expensive

Caregivers made it clear that there was nothing technically difficult about making enriched porridge. Nevertheless, it was perceived to be a "complicated" dish since it requires many ingredients, most which need to be purchased or gathered locally. There were many complaints about the cost of acquiring so many ingredients, particularly among those who have limited resources and feel that they cannot buy multiple ingredients.

> *"I don't have money to buy all types of food items like that. I can only buy a single food item as I don't have money."*

> *"Why is it difficult? Because we have to spend a lot of money on it. We are not rich like urban people."*

> *"It costs us more money. We have to buy this and that-- all kinds of things. Meat, everything we have to buy. We cannot get these things by ourselves. It's really hard."*

> *"Generally speaking, some days I don't even have 100 riel in my pocket. I want to copy what they were doing but it is impossible. If someday I have money I may be able to do it. I am so poor."*

Gathering ingredients requires time and effort

To make enriched porridge more accessible for poor families, HARVEST maintains that they went to great lengths to emphasize the use of vegetables that may be collected from open fields and riverbanks for free. But even the prospect of free ingredients did not make it more appealing to those who are very poor. Many said that they found it burdensome to spend time gathering these vegetables. One woman, for example, explained that she could only collect fish and vegetables for the same meal when her husband had no wage work. With two adults free, it is possible for one to go fishing while the other collects vegetables. Other caretakers explained that it wasn't always easy to find the right wild vegetables in their villages.

> *"It takes quite a long time since we need to collect different types of vegetables."*

> *"It is hard for people like my family to cook such a complicated food… Sometimes we can't find the vegetables around here and have to go somewhere else further out. It is doubly difficult in the wet season when it is flooded."*

"Ivy gourd is not even available along the fence. Edible amaranth is the same; it's difficult to get. Edible amaranth is used by villagers for their pigs' food."

The problem of needing time to collect wild vegetables underscored a frequently cited theme regarding the competing demands on caregivers' time. The literature on gender and development has long underscored the dual responsibilities that women have as caretakers and contributors to the household economy (Smith et al. 2003, van den Bold et. al. 2013). Very often, as caretakers women must make difficult decisions about how they will allocate their time across the various livelihood and caretaking activities for which they are responsible. In households with fewer resources, there is a delicate balance between achieving these two desired goals.

"In rural areas people don't have time to cook enriched porridge. We are always busy going out for work after cooking and eating."

"If I spend time cooking [enriched] porridge for my child I don't have time to work outside."

"[People] have to spend time collecting vegetables and boiling rice. For a half a can of rice it takes 30 minutes to cook properly. If we include the time to collect the vegetables, 30 minutes seems like the shortest time to have it ready."

Preparing enriched porridge requires extra time and effort

With respect to enriched porridge, many compared the process of acquiring and preparing the ingredients for enriched porridge to the prospect of cooking regular porridge and stressed the increased difficulties involved in preparing enriched porridge.

"It requires many vegetables that I have to collect. And, I also need to look after my grandson so it is a little difficult for me as an old person. Cooking white porridge is easier for me."

"[It takes] quite long as we need to cut pumpkin and yard-long bean. We need to collect leafy vegetables and cut them up. So this causes us to be lazy. For white porridge, it is easier since we just put rice in a pot and then we can do something else. We remove the pot from the stove, and then we just grill the prahok. We don't need to expend energy. That's why it is easy."

Even for households that did not have a hard time acquiring the ingredients, caregivers suggested that enriched porridge took extra time to cook. One grandmother who did not have a Poor Identity card said, "Finding the ingredients is not difficult, but I hate spending the time for it to boil."

Preparation time is clearly an issue, but more importantly, enriched porridge is perceived to be a food that is for small children only. Children eat only tiny portions, but it still takes time and effort to prepare a meal that is separate from the rest of the household. In addition, because it does not fulfill the food needs of other members of the household, preparing enriched porridge implies preparing two meals for the household instead of one. Most households we sampled only served one dish per meal, hence this was a significant effort.

"The porridge is only for our child. What about our food? It seems we have to pay doubly for our meals."

"Cooking a separate dish adds more work. It is easier to cook once."

"Enriched porridge is only for my child. What about the food for all of us? So we have to cook another meal for us as well."

Finally, for some households, the high costs in terms of time and money to prepare it means that it is not something they feel they can do for every meal. In addition, by creating a taste for enriched porridge in their young child, some feel that they may be setting themselves up for demands that they cannot meet in the future.

"I mix regular porridge with soy sauce for her…I don't want her to get used to the enriched porridge. If she gets used to it, then she will not eat our normal porridge."

"I don't want them to get used to it. Otherwise, when they get used to something more delicious they will not eat the regular porridge."

In sum, caregivers see enriched porridge as an extra preparation that requires extra work and cost for the household, in addition to the time and cost of acquiring the needed ingredients.

Benefits of Preparing Enriched Porridge

While caretakers were quick to identify the costs to preparing enriched porridge, they were also quick to provide additional reasons why enriched porridge did not work for their household. Many maintained that there was no benefit as their child would not eat enriched porridge. At the same time, many caretakers were vocal about their own dislike for enriched porridge and suggested that porridge is not something that other members of the household would like to eat. Overall, it appears as if the benefits to preparing enriched porridge were not palpable to the households. Costs appeared to outweigh the benefits, particularly if the small child could instead be fed from the family meal.

Many children do not eat the porridge

More than half of the caretakers interviewed maintained that their child would not eat enriched porridge and as a result there was no point in cooking it.

"Some people have time, but they don't cook the porridge since they are afraid that their children will not eat it."

"Unfortunately, my daughter didn't eat the enriched porridge at all. She ate a spoonful of the porridge and then spat it out suddenly. Then she never opened her mouth again… so I had no motivation to cook the porridge."

"If he doesn't eat it, why would I need to cook it?"

Waste was understandably a big concern to caretakers who said their child would not eat the porridge.

"The porridge was leftover so I felt too disappointed to continue to cook it… I had to give it to my dogs and pigs."

"I feel wasteful if the porridge isn't eaten. In addition, it can't be kept until the evening if it is cooked in the morning."

Many caretakers suggested that their children rejected the porridge during the first times it was presented to them; in addition, there were very few who said that they persisted in trying to feed the children enriched porridge. HARVEST educators said that they asked caretakers to persist and to keep trying to introduce the porridge to the child. Yet, mothers had little patience with this. One mother spoke of trying to cook the enriched porridge "countlessly,"

"I've tried hard to cook enriched porridge for my child but she won't eat it. I got furious and fought her, but she is a toddler. I felt exhausted from cooking the porridge."

The same struggle is reported in the US when mothers are asked to feed healthy foods such as vegetables to their infants and toddlers. The child-feeding literature on the US suggests that caretakers should provide a food to a child more than ten times to gain acceptance of the food (Kleinman and Coletta 2016). Yet there is some evidence that such behaviors lead to wasted food and a perception among low-income households that the financial cost of repeated introductions is too high. Daniel (2016) for example has argued that poor households perceive they cannot bear the cost of persistent introductions that are required for taste acquisition of "healthy foods."The evidence from this study suggests that Cambodian parents are similarly unwilling to accept the time and money costs that are required for their child to acquire the taste for enriched porridge.

Young children in this study did not universally dislike enriched porridge, however. There were a minority of respondents who said that their children liked enriched porridge.

"My grandson will definitely eat enriched porridge if he is served it."

"I want to say that some kids really do not like the enriched porridge at all. But this is not the overall situation. Some kids do like to eat the porridge."

"Kids are so happy if we cook this porridge for them. Why would kids not want to eat delicious porridge? If we make it for them every day, they are happy as they can get delicious food every day. They will be grateful to mothers and grandparents who make such good stuff for them to eat."

Throughout the study, there was never one clear answer as to why some children do not eat enriched porridge. At times, we felt as if this claim were a polite way for caretakers to explain why they had chosen not to follow a recommended practice. In an early pilot interview, one caretaker spoke of her discomfort with not following the recommendations of her HARVEST instructor.

"Because they teach me, I have to follow their advice to some extent. I don't want them to say I don't use or practice the knowledge I learn. They come to teach us to make sure we are aware of it. If we don't follow their advice, when our grandchild gets sick and we send her to health center, the staff there will ask if we ever cook the enriched porridge for the child. And if I say 'no', it sounds bad, don't you think?"

And, indeed, some of the explanations seemed overly dramatic and unlikely.

> *"I took [my granddaughter] to the [cooking demonstration] but she did not eat the porridge at all. She said, "It's not delicious." She only ate one or two mouthfuls. She said, "Grandma, let's go back and eat our white porridge at home."*
>
> *"I tried to make it for [my daughter] but she got diarrhea."*
>
> *"My son vomited after being served with the porridge. "*
>
> *"I used to cook enriched porridge, but my grandson got thrush over his tongue after eating it…so I assumed that the enriched porridge caused the tongue thrush. He even used to have diarrhea from eating it. I also learned that enriched porridge spoils easily."*

The desire to be polite is strong. In the last quote above, the caretaker gave three different reasons for not cooking enriched porridge, but soon after politely told the interviewer that she will try cooking it again.

The claims of children's refusal to eat enriched porridge is at odds with our observations of consumption at HARVEST cooking demonstrations. At the four cooking demonstrations that the first author attended (one in each province), infants, toddlers, and older school-age children were all observed to be eating the enriched porridge. In addition, they described the porridge as 'delicious.' When we asked some of the respondents why children eat the porridge at big events, one woman suggested that there is excitement and activity at cooking demonstrations. Children, she said, will eat the porridge at the event but not at home. In our observations, we agree that there is a great deal of excitement at cooking demonstrations. We also note that there is a special effort to make the porridge tasty. In one village, we noted educators pouring low-sodium soy sauce on children's bowls and in another we saw them add a package of Knorr Chicken Powder to the porridge. This may explain why the porridge is perceived to be 'delicious' at some demonstrations and tasteless at others. It may also explain why the porridge might be considered tasteless when made at home. One mother commented that when she made the porridge at home her child did not eat it because she didn't include "all the ingredients." She remarked, "I just added salt but not MSG." Several caretakers commented on the lack of MSG or sugar in the enriched porridge and suggested that their family dishes were tastier and that is the reason why their children rejected the porridge.

Other household members do not eat enriched porridge

For caretakers who must cook for all members of the household, the possible benefits of introducing a new food such as enriched porridge could also include fulfilling the foods needs of other members of the family. However, interviews revealed that enriched porridge does not fit this profile. Caregivers suggested that enriched porridge was not something that was highly desirable for adults to eat. Taste appears to be an important part of the explanation. Many, for example, commented on the smell or taste of the enriched porridge, showing their own distaste for the dish.

> *"The porridge tastes very strange. It's less salty. The taste is very light in comparison to our dishes."*
>
> *"When we cook it we are not allowed to use MSG or even salt. Generally speaking if I ate it myself it would not be delicious at all."*

"I was trained not to add salt or sugar to the enriched porridge so the flavor is tasteless."

"Enriched porridge? Some mothers call it porridge for pigs. Porridge for pigs! You put amaranth in it. It's a little bit red and a little bit green and it stinks like ivy gourd leaves and other stuff. Porridge for pigs! Only the kids can eat it. Mothers cannot!"

The comments from adults on the taste of enriched porridge might be the most telling as they suggest that caretakers themselves do not like the taste of enriched porridge. This suggests there is little benefit to other members of the family when there is leftover enriched porridge. Thus any prepared porridge that is not eaten by the young child would be wasted. This is an important consideration given caretakers' comments that they are unwilling or unable to prepare separate meals for children.

Perceived nutritional benefits of enriched porridge

Although most caregivers can recite simple messages about the benefits of enriched porridge, for example, how it "makes your child grow" or "makes your child smart," there is some question of whether caretakers truly think it is worth the effort to make it.

In particular, some caretakers suggested that they did not believe that enriched porridge is essential to a young child's health, and that they did not perceive that it offered benefits over other foods that can be derived from the family meal. Some were very honest with us about the marginal difference enriched porridge might make in the future of their children.

"[People] may think that their children will be still alive even though they don't eat enriched porridge. They may not think of the porridge's benefits on their children's health."

"[Enriched porridge is] very easy if we really want to make it. The problem is that we are lazy. You just put a certain amount of rice into a pot and keep boiling it. Cut vegetables and other ingredients and put them in the same pot. Wait until it is soft and then we crush it. It's not difficult to make. But we are lazy… I feel that by feeding [the kids] plain porridge with prohok they will survive. So why bother spending energy making it?"

"In my generation, I never cooked enriched porridge. I have helped raise almost ten grandchildren but I have never cooked enriched porridge… Back in my time I just fed my children cold rice and they survived until now. People say that children in the past were raised this way, and that is why they are not intelligent. I don't believe this. Children are intelligent because they study hard."

Finally, as we examined the transcripts from discussions of usual family meals, we were surprised to find that 16% of the interview sample said something to the effect that they thought *somlaw prohail or samlaw ka kor* with rice was equivalent to enriched porridge. The majority of them were located in the Kampong Thom and Siem Reap villages. This is not a coincidence as the caregiver statements from the transcripts match statements given by NGO workers to the MSU team during early scoping visits to HARVEST villages. In particular, it appears that some lessons included messages about how enriched porridge may be created from soup. This

message appears to be derived from the NNP video that shows how to make enriched porridge from family foods (UNICEF 2012). The video states,

> *"Bobor khap krop kroeung is still the best food for children aged 6-24 months old.*
>
> *But we have seen mothers and caretakers stop feeding it when kids are 9-10 months old because they are busy and instead give family foods when they are 9-10 months.*
>
> *We will show you how a method for making bobor khap krop kroeung using food from the family pot but ensuring that it is as nutritious as bobor khap krop kroeung.'*
>
> *First take rice form the pot and put it on a plate. In order to have soft rice which baby can eat easily you should move the rice pot position down while warming. This will make water flow to the lower part of the pot, which makes the rice there softer.*
>
> *Then take pieces of fish or meat and veg from the soup or dishes (samlow, chaa, sgnao) to mash with the rice until they become soft and thick, similar to bobor khap krop kroeung.*
>
> *It means it should be thick and should not run off the spoon when you hold it sideways."*

A similar recipe appears in the BFCI flip chart. Some HARVEST contractors in Siem Reap and Kampong Thom appear to have taught this message to their clients. While the message appears to have been approved by NNP, it's not clear that the clients understood specific aspects of the process. First, clients used this lesson to justify their use of soup with rice as a complementary or transitional food. However, the lesson states that high-density foods can be taken from family dishes and mashed into softened rice. It does not tell learners that they should take soup broth and add it to the rice. Second, the clients did not absorb the message that the resulting food should be thick like enriched porridge.

We did not observe any such lesson so we cannot say what happened in each situation. However, our discussions with one NGO verified that they did teach participants "to make enriched porridge from soup." While this approach definitely appeals to participants in terms of saving time and effort, there are potential problems if there are no steps taken to correct the tendency to water down the child's portion (as described in section 5.2.2.2). In addition, there is a danger that participants might confuse this version of enriched porridge which is suitable (if made properly) for children 9 months and older. According to HARVEST and NNP guidance, this form of enriched porridge should not be served to older infants aged 6-8 months. Hence, confusion over what is recommended and not recommended by age group might ensue, and will further discourage caretakers from making enriched porridge the proper way.

Constraints to Adopting the Three Food Groups Message For Young Children

In Section 5.2.2. we reported that some meals were less likely to offer all three food groups than others. Breakfast, for example, was less likely to offer good food diversity, while meals that included soup, often lunch or dinner, were more likely to include three food groups. In addition, for meals involving soup, young children's servings often suffered from a dilution of nutrients provided in the family dish due to serving practices on the part of the caregiver.

Why do caretakers not provide more diverse meals to their young children? Is it because they do not understand the three food groups (TFG) recommendation, or is there another reason?

Overall, our data indicate that there are at least four layers of explanation. These include: 1) a household's inability to gain sufficient access to diverse foods; 2) a caretaker's reluctance to serve young children with specific foods; 3) a caretaker's unwillingness take extra steps to modify family foods for small children; and 4) a lack of understanding of nutrition education guidance about the three food groups.

Availability and access at the household level

Caregivers maintain they want to provide their families with more diverse meals but they are constrained by what is available or accessible to them. Hence the first level of constraints involves the availability and access to good, nutrient-dense foods at the household level. In terms of availability, in some locales the market for nutrient-rich foods is offered irregularly or at limited hours. Hence, the availability of vegetables or protein-rich foods is limited even if one can afford them. One caretaker, for example, explained how the lack of outlets for food in the morning constrained what she could cook for breakfast:

> *"Soup is never cooked for breakfast, only for lunch and dinner. It's too early to find any ingredients, especially vegetables, to cook soup at breakfast."*

Poverty is an important contributor to lack of access to nutrient-dense foods. Clearly, households that are well-off and have land can grow vegetables or buy them from neighbors.

But for poor households, the limited ability to access nutrient-dense foods was a constant theme in our interviews. As suggested earlier in the section on porridge, a limited ability to access these foods is related to a limited control of many resources. Many mentioned constraints on time; others mentioned a lack of financial or other forms of resource, such as land, equipment, or social relationships. One woman, for example, said she was constrained in fishing because she could only borrow fishing nets when the neighbors were not using them. Others spoke of lacking of land to grow vegetables. And others alluded to the limits to their own social capital when it came to acquiring food from others. For example, when asked if it were possible to obtain vegetables from neighbors, caretakers made it clear that one could not make a habit of this practice.

> *"Oh, it is not that easy! I can't do that. Buying is possible, but I can't ask someone for something [for free]. It isn't bad if they give us some, but I'd feel ashamed if they refuse to give it to me. Those vegetables are planted for sale and I am afraid those vegetable owners will blame me and say I'm lazy."*

> *"Some vegetables need to be bought. We can ask our neighbors for those vegetables once or twice, but it's not possible to ask them a third time. They can sell those vegetables for money."*

> *"We have no land for growing vegetables. We live on a plot that belongs to someone else so I cannot grow them because it isn't my land."*

And clearly, for households that had significant debt, were elderly, and/or had too many demands on their time to forage for their vegetables, they frequently had to make do with whatever food they had. With few resources to draw on, these households had poorer access to higher quality foods; therefore, they frequently had to serve simpler meals that required no purchases.

"How can we have a variety of vegetables without money? Those who cook the three food groups are those who have money. For a poor family like me it's impossible!"

"My food does not cover all of the three food groups. I don't have money to buy those foods. If I need to buy them, 10,000 riels is not enough to pay for such foods. One kham of pork, do you know how much it costs? It's almost 2,000 riels."

"I could not add pumpkin to soup every day. When I cook somlawr prohail and I have money to buy pumpkin, I will add it."

"There will be no meat unless I have money to buy. My child eats the porridge though it has no meat."

For the very poor this was a constant theme. And under these circumstances household offerings to all members were poor in food diversity. Households spoke of serving white porridge to the whole family when there are severe cash shortages and other restrictions on food access. They also talked of just eating rice with salt, and mashing it for their small children.

"We eat what we can earn. If we don't have money, we prefer eating rice with salt. Sometimes we eat rice with salt 2 or 3 times a day. My [young] child eats the same way as me."

"When my husband has work we at least have some money to purchase food like pork. However, if he doesn't have any work we will eat fish paste every day. "

For some, getting the ingredients to make one good meal a day is all they can manage. One mother said that if she cooks soup once during the day, she does not have money to make another soup that day. Another spoke of stretching resources by alternating between a meal with diverse ingredients and a meal of only rice with salt or fish sauce.

"We eat rice with soup for breakfast, but at lunchtime we have no more foods to eat but salt. So we have no choice but to eat rice mixed with salt. However, in the evening we will eat as usual as my husband can afford to find some fish or we may have some money to buy food. But sometimes my grandchildren can eat rice with fish sauce."

The data clearly show an inability of poor households to provide three meals a day that include the TFGs. This on its own is not a surprising finding. Worldwide, poor households tend to have less diverse meals and poor households have a hard time providing food and nutrition security to their families (Hoddinott 2011).

Altering the composition of foods served to young children

Even in households with the means to obtain the TFG on a regular basis, small children's meals do not necessarily contain the TFGs. This relates to specific patterns of intrahousehold food allocation from the family meal. In particular, a majority of households were able to provide a meal that included the TFGs to adults in the family for one meal we observed. Yet, caregivers often altered the composition of the same dish when they served it to young children. In particular, caretakers often watered down the child's portion with broth or withheld nutrient-dense elements of the family dish. Why was this the case? In-depth interviews revealed that there were two main reasons for this behavior.

Withholding foods that children dislike

First, in-depth interviews revealed that children's preferences affect caregiver decisions to withhold certain foods from servings given to young children. At times, caregivers said that they withheld foods that a child disliked, even though the food was regarded to be healthy for the child.

> *"He does not like eating cabbage, water lily or other hard vegetables. If I cook soup with this kind of vegetables, I just mix rice and soup water for him with no vegetables."*

> *"I mix rice with soup water. I also take fish from the soup to add to his rice. He doesn't eat vegetables. Sometimes he doesn't eat even fish, so I just mix rice and soup water."*

At the same time, some caregivers withhold nutrient-dense foods that children like. Caregivers often said that the child will eat an expensive ingredient to the exclusion of others. Many caretakers indicated that they prefer the child to eat more of a low-cost food such as rice.

> *"Sometimes I give her pork. But if she sees meat in the porridge she will not eat the porridge at all. She will eat only the meat. That's why I don't want her to see any meat in the porridge. If she sees no meat in the porridge, she will just eat the porridge by itself….[so instead I] just add some salt to porridge to make it a little salty."*

> *"She eats only vegetables and meat. She does not want to eat rice at all…if there is only rice and soup water in her bowl she will eat rice…If we want her to eat rice, we give her only a bowl of rice mixed with soup water only."*

> *"My son is served rice…I first give him rice and fish after… We have to stay there and serve him, otherwise we would eat only fried fish or fried meat, but not rice."*

> *"For me, if I cook soup with pork and if I mix rice with soup water and meat, she will eat only the meat, but not the rice. So sometimes I mix rice with only soup water."*

During the participant observation, we saw evidence of withholding fish and meat from young children's servings. While meat or fish was included in the family pot, the protein servings were very, very scant in the young child's portion if present at all. The same was true with vegetables. In general, the amounts that young children ate during our observations were also lower than recommendations given by NNP.

Concern about what small children are able to eat

Perhaps more importantly, about half of the caregivers stated that they had to alter what they served to young children because their children could not eat all foods served to the family. Chief among these concerns was that they would choke on elements of the family meal. This is why liquid forms of meals are the preferred food for young children, such as soups and thin porridges as a first complementary food.

> *"With samlow, they can sip and it will not gag or choke them. With samlow, it's easy to swallow rice."*

> *"At the beginning we made our white porridge with rice and salt. We made it thin and put into a bottle with cap for him to suck. I crushed the borbor to feed him. I started doing this since he was 6 months old."*

Choking continues to be a concern for caregivers even as their children become older infants and toddlers. In fact, the vast majority of cases where caretakers mentioned choking as a concern were for children who were 12-24 months of age. According to the HARVEST recommendations, by this age children should be able to eat softened vegetables and sliced or diced pieces of meat or protein (HARVEST 2012). Yet, among these caretakers, about 76% said they withheld specific ingredients from a family dish because they feared that the young child would gag or choke on specific food items. Invariably, these items were foods that would provide diversity to the child's meal. Most common among these practices was to withhold fish, "hard vegetables" from soups or stir fries, vegetables that are not cut small enough or mashed for the child, and various proteins for health reasons.

> *"Sometimes if the soup has vegetables I let him eat vegetables such as ivy gourd. The vegetables that are in big pieces are not given to him. I am afraid he could choke."*

> *"If I eat grilled fish or fried fish I will give my child only porridge, but not fish because I am afraid he will choke."*

Although most of these cases were for children of toddler age (12-24 months), the patterns cited were not any different from caregivers of older infants (6-11 months). Surprisingly, caretakers of younger children had reservations about the same types of foods mentioned for toddlers. This finding suggests that caregivers do not differentiate among the age-specific messages provided by HARVEST about the introduction of family foods. In practice this means that they do not adjust their approach much as their child moves from older infancy to the toddler stage.

Caregivers show limited willingness to make special preparations of young children's foods

As discussed in the previous section, withholding ingredients from the family dish is a common practice that appears to contribute to decreasing food diversity in young child servings. Yet, simple practices stressed in the nutrition education, such as mashing and further chopping vegetables would allow parents to serve children more vegetables from the family pot. The HARVEST recommendations are clear about how to deal with issues of bones and "hard vegetables." Vegetables should be boiled until soft and then mashed into the child's softened rice. Bones should be removed from fish and other forms of protein (pork, frogs) before mashing or mixing into the child's softened rice. Why are caretakers not taking steps to boil "hard vegetables" longer or to chop them? Or pick out fish flesh for their children?

In-depth interviews with caretakers indicate there is good awareness among caregivers about the desirability of these practices. However, when speaking with caregivers about specific meals in which they decline to chop vegetables or boil the 'hard parts' further for the young child's portion, the caregivers admitted that there were limits to what they were willing to do to create meals for their young children.

> *"I was taught to chop the vegetables into small pieces, but I rarely do it because the food is not just for my children, but also for me and older people. So the vegetables are normally kept in big pieces when we cook, except for some certain dishes that we had to chop vegetables for like omelet with acacia leaves."*

> *"It's difficult for us to just cook for our kids because we also have to think about ourselves. The small kids can only eat soft vegetables or the soft parts of vegetables like the leaves. Yet we can't eat just soft vegetables. It can't make us feel full. Also,*

the seller won't just sell the soft parts to us. We have to buy the whole part and can't afford to buy much. After I cook it I can just feed my daughter the soft part and I eat the solid part."

"Sometimes, I am lazy to mash it. When I'm in a hurry, I don't have enough time to mash it. Furthermore, my daughter is so hungry that she needs to be served immediately."

Caregivers gave ample examples of how young children were forced to have meals with poor diversity because the meal prepared for the family was not appropriate for the young child. One caretaker talked of when they made salads with raw vegetables that the youngest child could not chew. "If we make a salad or a stir-fry dish he will get sauce with no vegetables," she said. Rather than boiling the vegetables from the salad for the child, the child was served rice with sauce from the dish only.

Another mother, when asked to identify the importance of the three food groups, stated: "Children can't eat as much as the adults so high vitamin vegetables should be chosen and cooked for children." But when asked to assess the number of food groups her son is served, she answered, "He is always served the food I eat. Sometimes I am too busy to give him all three food groups. I think it may include all three food groups when he is served soup, but not when he gets rice and fried meat."

When pressed about why they insisted that young children should eat from the same preparations as the adults, respondents gave one of two reasons. First, they often countered that they could not afford to make a second dish for their child. Second, when pressed, they revealed their lack of interest in engaging in extra processes for their small child,

"Mother: The seller won't just sell the soft parts [of the vegetable] to us. We have to buy the whole vegetable and can't afford to buy much. After I cook it I can feed my daughter just the soft part and I eat the harder part.

Interviewer: But your daughter doesn't eat so much; it wouldn't cost you much to buy the ingredients to cook for her separately?

Mother: I feel lazy to cook multiple times."

Others validated the lack of interest in engaging in extra processes for a complementary or transitional food. Time was a frequently mentioned concern, while others also mentioned cooking fuel.

"[My daughter] can share our adult food now, so I don't need to cook a separate dish for her."

"I find it hard to cook again and again as it takes me some time and it also needs firewood. Here firewood is scarce."

"It is not about difficulties, but laziness. I feel lazy to cook food in a pot for my child and then in another pot for me and other people."

"It was difficult as I had to separate out food ingredients such as fish, meat and vegetable into two parts—one part for [my daughter's] porridge and one for us. It was difficult to separate because we have very a small amount of food."

Furthermore, several respondents justified their decisions to withhold nutrient-rich ingredients by making incorrect claims about the nutritive value of soup broth,

"For example, if I buy fish to cook soup, how can I pick the fish meat out to feed him? It's quite small and my eyesight isn't good. That is why I just mix rice with the soup water. I believe the fish protein also exists in the soup water."

"I think that the vitamins from vegetables are already in the soup water after being cooked. For instance, if I cook a mixed vegetable soup (samlow kor ko), I will take only the broth and fish meat and mix them with rice before feeding my daughter. I think the vitamin from those vegetables is in the soup water."

The misinformation about the nutritive value of broth is likely to be related to the nuanced misunderstanding about making soup from enriched porridge. In any case, it suggests that more attention needs to be put on simple, practical messages about the appropriate ways to use family foods, including soup, into complementary and transitional foods. In particular, it would be important to focus on practical concepts related to making family foods into nutrient-rich foods for young children and the dilution effect of excessive broth.

Households do not understand the three food groups

When respondents make inaccurate nutritional claims, it raises the question of how well they actually understand the three food group recommendations. In-depth interviews with caretakers allowed us to explore this understanding. To start, conversations with caretakers revealed that most had only a vague understanding of the three food groups. Many could make a general statement that related the three food groups to the topic of health; for example, they are "good for keeping us and our bodies healthy." And many could list random foods that belonged somewhere in the food groups, for example "water spinach, star gooseberry, meat and fish." But there were very few – 5 out of 44, or 11% – who could identify the three groups themselves and foods that belonged to each.

"The first group consists of vegetable such as carrot… The second group includes meat, while the third group includes dessert and fruits."

We recognize that identifying the name of a food group correctly is not important on its own; what is important is that the caretakers know what to do with this information. Yet, the interview data indicate that very few (7%) mentioned any practical knowledge about the food groups, such as "If a child eats these three food groups per day, he is healthy." Instead, many of the answers included disjointed information that seemed more bent on memorization than on practical application of knowledge.

"[The three food groups] makes people healthy, [with] a strong body and not being sick. Especially vitamins A and B. If you lack vitamins A and B, a person can be handicapped – like blind – and their limbs will have no energy. People will be crippled."

> *"Yes, of course. [The three food groups] means nutrients for children and the elders. I forgot it… It seems to be the food for elders and the food for children is called enriched rice porridge whose ingredients are meat and green vegetables. It has calcium nutrient, zinc nutrient."*

From people's responses, it appears that a lot of basic nutrition information was included in the curriculum to motivate caregivers to care about nutrition. However, it appears to have created overload on the part of some learners, as several stated that they had forgotten everything. With so much detailed information some of the main messages, such as that meals should include foods from each of the three food groups, might have been obscured.

Conclusions

The objective of this study has been to examine the current practices and constraints to adopting two child feeding recommendations promoted by HARVEST. The study took place during the final third of the HARVEST Phase II interventions under the family nutrition program. The goals of the study were 1) to understand to what extent respondents have adopted these practices; and 2) to determine if there are any lessons regarding perceptions and constraints that might inform future USAID programs on child feeding in Cambodia.

Summary of Current Practices

Enriched porridge

If USAID aims to increase the numbers of young children consuming enriched porridge it appears that new approaches are needed to promote the current policy. Cooking demonstrations may serve to get participants excited, but this excitement does not appear to be sustained when caregivers weigh the relative costs and benefits of adopting the practice.

Overall, most caretakers have good awareness about enriched porridge but appear to have already formed opinions about it. Almost all revealed a strong desire to rely on family food preparations as a way to create complementary and transitional foods. In this study we had very few households in the 6-8 month age-range, but their narratives regarding enriched porridge were not different from caregivers of older target children (9-24 months of age). Caregivers chose complementary and transitional foods that did not have to be prepared separately; they looked for ways to save time in feeding their young child.

Most of this sample fell in the 9-24 month age range, and all sampled children were found to consume a modified version of foods that were served to the rest of the family. The majority of these households said they had tried enriched porridge for a short trial (if at all) but did not adopt it. A minority of households said that they had given it regularly to their young child for a period; all had moved on to other complementary and transitional foods that are based on meals prepared for the rest of the family. In many cases this involved soup ladled onto rice. But when the family ate a simpler meal such as rice with dried fish or a stir fried dish that involved a vegetable that the child could not or would not eat, the child often ate a meal of rice and fish that had been wet with a small amount of watery sauce. If the dish included a vegetable that the child could or would eat, the vegetable might be smashed into the rice that had been wet with sauce.

The Three Food Groups

The results from this section indicate that households do not seem to be intentionally applying the three food groups rule. The in-depth interviews with poor caretakers underscored that they did not think it was possible to follow the recommendations due to their lack of resources and

access to good foods. Rather, they cook the food that is available and accessible to them. For households that are not poor, caretakers cook what is accessible and what they prefer. In either case, however, it does not appear as if the young child's needs really come into these decisions. With the exception of soup, decisions about what to feed the young child appear to be affected by what is cooked for the rest of the family.

Analysis of family meals indicates that there are differences in terms of the number of food groups that are served to the family by meal. Meals that include more complex soups such as *samlow prohail* or *saml ka kor* are more likely to provide diverse foods, such as proteins and micronutrient-rich vegetables. These soups are served not because they contain the three food groups but because they are traditional and are considered to be a satisfying meal. For poor families, acquiring the ingredients for a nutrient-rich soup like *samlow prohail* or *saml ka kor* is challenging and is not something that can be done multiple times per day. However, caregiver time allocation is an issue for poor and non-poor alike; in particular time allocation across multiple duties affects the ability of caretakers to collect nutrient-dense ingredients from open spaces and to cook separate dishes for small children. Finally, gathering or searching for food while also caring for small children is a physical challenge for elderly caregivers.

The observation data indicated that even when households are able to acquire the ingredients for a good diverse meal, caretakers can still make decisions that affect the nutrient diversity of the child's dish. In particular, caretakers often feed young children a modified portion that is diluted with broth or that omits nutrient-dense aspects of the original preparation. Interviews with caretakers indicated that they justify these actions based on their beliefs that 1) the young child cannot chew various foods that are in the family pot; and 2) it is too much trouble to modify these foods before feeding to the young child.

In particular, for poor and non-poor households, there seems to be a shared reluctance to serve young children specific foods from the family dish that might cause choking. These foods tend to be vegetables that are not chopped small enough, vegetables that are "hard" or "solid", and pieces of protein that contain bones. In interviews, there did not seem to be any controversy over ingredients that are commonly demonstrated in the HARVEST curriculum, e.g. boiled pumpkin, ivy gourd leaves, or amaranth. These ingredients come up often in interviews and are typically described as being smashed, squeezed, or pressed into the young child's food.

The difficulty arises when respondents mention foods that are not featured in HARVEST lessons or demonstrations. These include the harder portions of a vegetable and caretakers tend to omit these from the child's portion. These vegetables could be further boiled or chopped finely, but caretakers are not apt to do it. Similarly, fish is often avoided, particularly small species from which the bones are hard remove.

Since soup with rice is the most common meal served to young children we have serious concerns regarding the nutrient density of meals provided to young children. Participant observation of these meals indicated that young children are often served a disproportionately high ratio of broth to vegetables or broth to protein. In our observation, almost half of the children served this type of meal had nutrient-dense ingredients omitted from their serving due to reservations that could have been addressed with further action by the caretaker.

Second, when pushed further about why children cannot be served ingredients left only for adults, during interviews caretakers said that it is too much trouble to separately cook or soften some of the high nutrient pieces found in the adult servings for the young children. In addition,

some maintained that the nutrients in the broth are as good as the vegetables or protein pieces that have been withheld. Others similarly gave this as reason for not preparing enriched porridge for their children, saying that it "looks like" enriched porridge or that it was just "as good" as enriched porridge.

An additional problem is that both the serving of rice and the overall quantity of the child serving tended to be much smaller than that given in the HARVEST and NNP guidelines. Although this was a qualitative study, during the participant observation we estimated quantities served and consumed by the small child. These observations are not based on weighed estimates, but on visual estimates of volumes served and consumed using soup spoons and standard *chan chang koeh* bowls. While a careful study that employs weighed and measured servings and consumption needs to be done to confirm these results, we are confident in stating that the quantities that are served child of these ages is much lower than the recommendations given in the HARVEST and NNP guidelines.

Finally, child meals that are based on porridge, fried or dry dishes, purchased snacks and leftovers are worse in terms of food diversity than those that involve more complex meals that include soup. Breakfasts tend to be poor in terms of food diversity, as was any meal that was prepared due to time constraints. For other meals this usually comes about because household resources constraints (lack of money to obtain better ingredients) or because of time constraints. Child caretaking is a significant obstacle for many women as they cannot leave the house for work or to collect nutrient-dense foods from the wild when they have small children.

Recommendations

Enriched Porridge

Our results on the use, constraints, and attitudes toward enriched porridge indicate that there continues to be resistance to adopting enriched porridge. New projects need to partner with the NNP to find novel ways to get caretakers interested in enriched porridge. A significant constraint is that caregivers seem to have already formed an opinion about enriched porridge and are quick to defend their position or misrepresent their efforts for fear of being "blamed" by authority figures (including this research team). Whatever behavior changes are suggested in nutrition education programs will have to take into account caregivers' reservations about enriched porridge and work to find ways that will fit in with caregiver constraints, both real and perceived, about time allocation, household resource constraints, and drudgery regarding cooking and food preparation.

Children 6-8 months. Our sample did not focus on the behaviors and attitudes of caretakers of children aged 6-8 months, so we cannot make any strong recommendations for working with this group. We note that a common strategy among the two caretakers of children 6-8 months in our sample was to save time, and that neither of them had reservations about introducing family foods to children (in modified form) before 6 months. We also found this to be true of some households with older infants and toddlers. Caregivers of these older children said that they introduced modified family foods to children as early as 4-8 months of age, although this information was emergent and was not asked systematically of all caregivers.

Our sense is that it will be difficult to find success with the message recommending the use of enriched porridge as the only complementary food at 6 months since the vast majority of parents of older children in the sample (9-24 months) stated that they could not abide by these

recommendations. This finding is consistent with what was reported by the MOH when it initiated the Campaign to Promote Complementary Feeding in Cambodia: 2011-2013 (MOH 2011). However, a more in-depth study of children 6-8 months of age, including observations, would be better placed to make recommendations about the kind of behavior change communication messages that need to be targeted at caregivers of this age group. Our suggestion would be stratify the sample according to type and age of caregiver, as we believe that older caregivers are more pre-disposed to using the 'old ways' of child feeding, including filling bottles of very thin *borbor* to feed a young child, while younger mothers may be more amenable to purchasing pre-made enriched *borbor* for their children.

Children 9-24 months. All of the target children in this age group were making the transition to eating unmodified adult foods; none of the caretakers were feeding them enriched porridge as suggested by the NNP and taught by HARVEST. It is clear from the interview data that caretakers want to create complementary and transitional foods from family meals as early as possible (and often before the recommended age) and they do not want to make a separate dish for their young child.

Continuing with enriched porridge in this age group may be an uphill battle for educators as caregivers demonstrated that they expect to start modifying family foods for their young children. As such, it seems more promising to focus on messages that give caregivers easy methods to create nutrient-dense complementary and transitional foods from family foods, rather than hoping that they will continue with enriched porridge. The majority of our recommendations for this are covered in the next section.

The Three Food Groups: Nutrient-dense Complementary and Transitional Foods

Developing Fewer, Practical and Actionable Messages. When we asked respondents open-ended questions about the three food groups, we were surprised by the amount of unnecessary and often incorrect information they shared. We are aware that the nutrition education curriculum changed between Phase I and Phase II and that the lessons were streamlined and made more practical. However, given what respondents shared about the three food groups we are convinced that the curriculum still focuses unnecessarily on "nutrition facts" and not enough on creating simple, actionable messages. The most important thing that participants need to know about the three food groups is that there should be one food from each of the three groups in every meal, and there should be local examples of each food group. Beyond this information about specific vitamins and minerals and obscure deficiency diseases seems to be unnecessary.

Addressing Incorrect Messages Regarding Use of Soup. One message that some caregivers were keen to follow was one that emphasized using soup to make enriched porridge. This was not an official HARVEST message but appears to have been delivered in some areas. The recipe for this message appears in the BCFI flip chart (2012) as well as in a video produced by UNICEF (2012) that features Dr. Sophonneary instructing caregivers how to make enriched porridge from family foods. In the former a recipe and instructions for a demonstration show how to make *somlaw prohail* and how to extract cooked vegetables and fish that can be mashed into a child's bowl to make a thick pap that resembles enriched porridge. HARVEST says that some cooking demonstrations availed of this recipe during Phase II operations. On the other hand, the video says that caregivers may take the vegetables or proteins from *samlow, sgnao* or a stir fry *(chaa)* and mash them into softened rice to make enriched porridge. The video was not part of the training given to the FSNGs, but it illustrates that the NNP is supportive of this approach.

Unfortunately, in interviews multiple caretakers cited incorrect facts related to these messages. These statements reinforced some of their current behaviors and did not necessarily improve the nutrient density of their complementary or transitional foods. For example, several caretakers told us that they chose not to make enriched porridge because certain soups (usually *somlaw prohail or somlaw ka kor*) could be served with rice and were just as nutritious as enriched porridge. Others justified withholding nutritious ingredients from children because they thought that the nutrients existed in the soup water itself.

Yet, as described in this report, many of the soup with rice meals that we observed were problematic—they were often diluted and did not include many vegetables or proteins. In our observations, only one household serving soup and rice made a thick, enriched pap as illustrated in the UNICEF (2012) video. In addition, not a single household added the quantity of protein or vegetables illustrated in the video. Rather, households ladled soup over rice, with some watering down the portion further with more broth and/or with holding the nutritious elements from the family preparation.

We are uncertain how this message became incorporated in the informal HARVEST curriculum, but we know that it was delivered by at least one of the contracted NGOs. In a project as large as HARVEST with so many staff, interventions and messages we understand that it is difficult to keep consistency across all the geographic areas. However, given our findings regarding the composition of complementary and transitional foods, this appears to be one area that deserves attention in the future. In particular, it is important to address the issue of how (and how NOT) to use soup to make complementary and transitional foods. More generally, it is important to develop practical and actionable messages that get across the point that the nutrition density of complementary and transitional foods matters. Rice with soup needs to be used in very specific ways to ensure that young children are adequately nourished. Perhaps this should be addressed head on. Perhaps messages should also be developed to deal with how to make complementary foods when the family dish is a stir-fry or involves 'hard vegetables' and fish with small bones. And, perhaps, the appropriate quantities for specific age groups need to be addressed in a practical way.

Addressing the emerging role of purchased non-nutritious snacks. The snacking culture that is emerging in these rural areas is pervasive and alarming. What is most disturbing is how the practice of purchasing and consuming non-nutritious snacks (i.e. junk food) is becoming embedded in the social world of these small children, their families, and their social networks. Caregivers who must be away from their children find it easy to leave snacks for their children instead of food. And tired, stay-at-home parents give in to children's requests multiple times a day. Young children (6-24 months) learn from siblings and friends how to buy treats.

It seems that any behavior change communication campaign to address high quality complementary foods needs to also address its competition. Cheap junk food is present in many villages and presents a 'path of least resistance' alternative to persisting with young children to eat more healthy complementary and transitional foods.

Other Recommendations

Older vs. younger caregivers

Our sample only included 9 alternative caregivers. In most cases, these caregivers were left with their grandchildren when the child's parents migrated from the village to Thailand, Phnom Penh, or other locations to find work. In many cases migration occurred because the parent

was in debt and had to find a livelihood that was higher paying and would allow them to pay off the debt. Alternative caregivers were often grandparents and were often poor. They were also burdened with multiple responsibilities, including staying home to take care of their grandchildren. They had few livelihood options.

In terms of nutrition messaging, we found this group of caregivers to be exceptionally honest in their interviews about the constraints they faced as well as their perceptions of the two key messages explored in this paper.

By contrast, younger parents seemed more motivated to present themselves as 'modern' and often wanted to project an image that they wanted do things differently from their parents' generation. At the same time, we believe that some may be more likely to misrepresent their caretaking actions in favor of "good behavior stories."

What this suggests is that there might be separate messages that are appropriate for caretakers with different histories and experiences. Grandmothers may be more likely to adhere to messages if they can tailor them in ways that incorporate their own experience and knowledge. Young mothers, by contrast, may respond to different messages.

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6. Evaluation of Commercial Horticulture Program

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Executive Summary

Background

Cambodia HARVEST (**H**elping **A**ddress **R**ural **V**ulnerabilities and **E**cosystem **ST**ability) is a five-year integrated food security and climate change program supported by the American people through the United States Feed the Future and Global Climate Change initiatives. The program was launched in December 2010 and concluded in June 2016. The Commercial Horticulture project of Cambodia HARVEST focused on innovative technologies and solutions to increase farm productivity and income. The objectives of this evaluation were to assess the economic impact of project intervention on participant households, and to analyze differential impacts of the project on different treatment groups (demonstration clients and participant farmers) in knowledge, attitude and behavior change regarding commercial horticulture technologies.

Evaluation Design and Methods

This evaluation was designed to assess the major economic impact of the Commercial Horticulture project and recommend future programming that may be applied under HARVEST and/or follow-on designs. This mainly focused on innovative technologies and solutions to increase farm productivity and income relating to the activities under component 1 and component 2 in the HARVEST/Cambodia project. Using the quasi-experimental design for program impact evaluation, we assessed the extent to which the Commercial Horticulture program met its objectives in changing knowledge, attitude and behavior of targeted beneficiaries, and increasing household incomes and generating other economic benefits. The evaluation plan consisted of various stages starting from initial document review and prior study, fieldwork such as key informant interviews, focus group discussions and a household survey. Discussion and consultation were also made with the program management team, beneficiaries and concerned stakeholders to obtain necessary information. Stratified cluster random sampling was used to collect data from 545 demonstration clients and training participants. Descriptive and inferential statistics were used to analyze data using STATA 14 software. This evaluation report presents major findings, conclusions and policy recommendations.

Findings

As commercial vegetable farming in the HARVEST/Cambodia area has just begun, farmers are facing several barriers, such as product market price fluctuation, insects/diseases, seasonal water shortage for farming and climatic disasters. In general, farmers' perceptions of the HARVEST project were positive because, as mentioned by Commercial Horticulture program

clients, the HARVEST project did provide adequate information to start over commercial horticulture production on their farms, and what was provided was practical. Also, they perceived that the instructors were knowledgeable enough for transferring commercial horticulture production technologies.

Although, in general, farmers have a positive attitude towards commercialization, they faced some constraints in commercial horticulture farming. Farmers reported that the farm-firm relationship or farmers-buyers linkage was not strong enough to make a commercial horticulture enterprise profitable. However, to some extent, HARVEST staff provided some market information and linkages with buyers to sell the produce. Farmers with membership in a farmers producer group (FPG) took advantage of selling their produce through the group. However, less than half of the farmers from the demonstration group and less than one-third of the training participants were aware of FPGs, and only 38 percent and 5.6 percent of those from each group, respectively, were members of FPGs. This suggests that there is a need for encouraging growers in group formation and participation in collective actions.

We found a positive impact of the HARVEST program on technology and knowledge transfer. In general, both groups of farmers learned commercial horticulture technologies, but the awareness and adoption of vegetable-related agricultural techniques varied with Commercial Horticulture project participation. Given their access to technical support by the HARVEST program, demo clients were likely to be more interested in the learned commercial horticulture technologies than the other participants. A similar pattern is observed in technology adoption among the demonstration farmers compared with the training participants.

The implementation of the Commercial Horticulture program resulted in significant increases in gross income and cropped area but not in returns to land or economic productivity (gross income per m^2) between 2010 and 2015. In each period, the gross income and vegetable cultivated area varied significantly with Commercial Horticulture participation, with demo clients outperforming the training participants. Improvements in crop marketing were observed between the two periods, suggesting a positive impact of the Commercial Horticulture program in increasing market access.

The commercial vegetable farmers in rural Cambodia are moving toward crop specialization rather than diversification as indicated by the Crop Diversification Index (CDI) and Entropy Index (EI). This suggests that growing one crop commercially is more profitable than growing multiple crops at the same time.

In general, younger farmers were more likely to adopt planting technologies than the training participants. This is possibly because young farmers are more flexible and interested in trying new things, and hence likely to adopt new technologies than older farmers. Technologies that require extra physical labor such as raised seed bed and trellising were not popular among female farmers. The probability of adopting planting technologies increased with household size, suggesting that commercial horticulture technologies tend to be more labor-intensive. Educated farmers were more likely than their less educated or illiterate counterparts to adopt newer commercial horticulture technologies and increase commercial horticulture income. The adoption of soil and water management technologies was also driven by the prevailing production risks. Additionally, results show that high disease infestation increased the likelihood of adoption of drip irrigation and soluble fertilizer among demo clients, and increased the probability of adoption of organic mulch and soluble fertilizer among the training participants. It was also noted that use of plastic sheets for weed control and moisture retention

by demo clients could pose environmental concerns because recycling facilities are not developed within the project areas.

Conclusions and Recommendations

The Commercial Horticulture program under HARVEST/Cambodia placed major emphasis on increased food availability (component 1) and increased food access through rural income diversification (component 2). The program was implemented to reduce the gap between supply and demand of vegetables through local production by focusing on innovative technologies and solutions to increase farm productivity and income.

Although the Commercial Horticulture program met most of its objectives of generating income and improving food security, commercial vegetable farming in the HARVEST area has just begun, and the farmers are facing several barriers, such as produce market price fluctuation, insects/diseases, seasonal water shortage for farming and climatic disasters. Connecting farmers to good buyers and determining product-market combinations can be a reasonable policy option. This would help reduce input price and transaction costs, and increase product price by ensuring market participation of producer farmers.

Farmers indicated that the information supplied by the HARVEST project was adequate and practical to assist them in starting commercial horticulture production. They also perceived that the instructors were knowledgeable enough. Providing training to public extension workers in their respective fields, particularly in commercial horticulture production technologies, to make them more competent might lead to a sustainable solution to this end. Also, promoting the use of information and communication technologies (ICTs) may help increase access to technical and market-related information.

A small proportion of farmers in a farmer producer group have taken advantage of selling their products through the group. We suggest that there is a need for great effort in encouraging group formation for collective actions. Through collective action growers can get higher prices for their produce and lower transaction costs. We found a positive impact of the HARVEST program on technology and knowledge transfer. Demo clients were likely to be more interested in learning commercial horticulture technologies, given the access to technical support by the HARVEST program. A similar pattern is observed in their technology adoption. Our recommendation is that continued support of modern technologies and adoption methods through empowering local farmers would help generate motivation for learning and adopting modern technologies and increase household income.

The implementation of Commercial Horticulture resulted in significant increases in gross commercial horticulture income and cropped area but not in returns to land or economic productivity. In each period, the gross income and vegetable cultivated area varied significantly with Commercial Horticulture program participation, with demo clients outperforming the training participants.

Younger farmers from the demo client group were more likely to adopt planting technologies than the training participant group. This could be attributed to the fact that young farmers from the demo client group are exposed to new ideas with extra support from the project and hence are more likely to adopt new innovations and bear more risk than older farmers. Female farmers from both participant groups were less likely to adopt such technologies in general. Further

studies are needed to determine factors affecting adoption of commercial horticultural practices by female farmers.

Adoption increases with the level of education. This suggests that adoption depends on the decision makers' educational level and access to information. Education is thought to create a favorable mental attitude for the acceptance of new practices and improve ability to allocate available resources. Extension programs need to continually support non-formal education of farmers, particularly female farmers.

Finally, ineffective and weak farmers-buyers linkages pose significant challenges to the whole farming system to develop effective cultivation practices and policies. Facilitating farmers in organizing in producers groups or cooperatives and strengthening farmers-buyers linkages can be a policy instrument to improve production and household income. Linking to markets by integrating farmers with potential buyers should reduce transaction costs. Because Cambodia lacks adequate road networks connecting production pockets to market centers, building agricultural roads may contribute to farmers' access to market, thereby reducing transaction costs and increasing profitability in agriculture.

Introduction

Cambodia HARVEST (**H**elping **A**ddress **R**ural **V**ulnerabilities and **E**cosystem **ST**ability) was a five-year food security program launched in December 2010 as part of the United States Feed the Future (FTF) program and Global Climate Change Initiative (GCCI). The overarching goals of Cambodia HARVEST were to improve food availability, increase food access through rural income diversification, improve natural resource management and resilience to climate change, and strengthen the capacity of the public and private sectors and civil society to address food security and climate change. To achieve its goals, HARVEST implemented multiple agriculture-focused initiatives (projects) in three agricultural sectors: horticulture, rice and aquaculture.

Cambodia HARVEST officially concluded in June 2016. Just prior to the end of the program, in March 2016, an evaluation of the Commercial Horticulture project was conducted to capture the level of outreach as well as the impact of the project on project beneficiaries. This evaluation was designed to assess:

- The effectiveness of program interventions in changing knowledge, attitude and behavior regarding commercial horticulture farming among demonstration clients and participant farmers who directly participated in program interventions.
- The effectiveness of program interventions for increasing household incomes and generating other economic benefits.

A six-person research team led by Prof. Murari Suvedi from the Department of Community Sustainability at Michigan State University planned and conducted the fieldwork for this case study. The field data collection team consisted of one field research staff member and four mid-career Cambodian agriculture development professionals as field supervisors. Ten specially trained enumerators were senior undergraduate students from the Royal University of Agriculture (RUA) [eight enumerators] and Prek Leap National School of Agriculture (PNSA) [two enumerators]. The Cambodia HARVEST project staff provided valuable assistance in developing the sampling frame. Two postdoctoral fellows joined the research team during data cleaning, data analysis and interpretation of results.

This evaluation report consists of five sections. The introduction section outlines the objectives of this evaluation. The second section describes the background of the Commercial Horticulture program under the Cambodia HARVEST project. The third section describes the details of evaluation methods used for this evaluation, and the fourth section presents the findings. The fifth section provides a summary and discussion of the findings, policy implications and recommendations.

Background: Cambodia HARVEST Program

Cambodia is a predominantly agricultural country -- 70 percent of its population relies on agriculture, fisheries and forestry for their livelihoods. Despite improvements in food availability and health indicators, the country faces serious poverty and food insecurity challenges. The Cambodia HARVEST project was planned as part of a response to U.S. foreign assistance goals under the Feed the Future (FTF) program and the USAID strategy for the Global Climate Change Initiative. The Cambodia HARVEST scope of work describes its program objective as "improving food security through enhanced agricultural development and rational management of natural resources."

The HARVEST program aimed to increase food availability and food access through diversifying rural incomes, improving natural resource management and resilience to climate change, and strengthening the capacity of the public and private sectors and civil society to address food security and climate change. The HARVEST program sought to reduce poverty and malnutrition by diversifying and increasing food production and income for up to 120,000 rural Cambodian households. The program served over 94,000 clients in approximately 1,500 villages throughout Battambang, Kampong Thom, Pursat and Siem Reap provinces.

Specific objectives of the HARVEST program were:

- Increasing incomes for 100,000 rural households.
- Accruing economic benefits to 283,500 people.
- Developing income-generating activities for 8,500 extremely poor households.
- Diversifying cropping systems for 56,000 households.
- Generating $40 million in incremental new agricultural sales.

HARVEST activities aimed to improve the business-enabling environment for catalyzing agribusiness-led growth, and reduce poverty and hunger. In the face of threats to biodiversity and climate change, HARVEST aimed to increase the resiliency of Cambodian livelihoods by increasing efficiencies across agricultural supply chains, diversifying livelihoods, creating wealth from practicing responsible stewardship of globally unique natural resources, and increasing Cambodia's ability to adapt to climate shocks and severe weather events.

To achieve the overall program objective of HARVEST, the program focused on four components with a total of 15 elements. They are enumerated below.

2.1 HARVEST Results Framework

Program objective: Improving food security through enhanced agricultural development and rational management of natural resources.

COMPONENT 1: Increased food availability

- Element 1.1: Enhanced agricultural input and production systems
- Element 1.2: Adoption of improved varieties and cultivation techniques
- Element 1.3: Diversification of rural production systems
- Element 1.4: Enhanced agricultural policy framework

COMPONENT 2: Increased food access through rural income diversification

- Element 2.1: Strengthened postharvest systems
- Element 2.2: Improved market access and linkages to smallholders
- Element 2.3: Expanded rural employment generation
- Element 2.4: Increased investments in marketing infrastructure

COMPONENT 3: Improved natural resource management and resilience to climate change

- Element 3.1: Accurately inventoried and valued key natural assets
- Element 3.2: Enhanced enabling environment for resource management
- Element 3.3: Improved environmental monitoring and management
- Element 3.4: Increased economic benefit from sustainable management and conservation

COMPONENT 4: Increased capacity of public and private sectors and civil society to address food security and climate change

- Element 4.1 Increased capacity of producer groups and private sector networks
- Element 4.2 Enhanced capacity for adaptive research and extension
- Element 4.3 Improved capacity for climate change mitigation and monitoring

This case study report provides results of an evaluation assessment of the Cambodia HARVEST priority program area focused on commercial horticulture.

Commercial Horticulture Program Area

Vegetables are the major dietary food intake of the Cambodian people. Domestic production of vegetables was estimated at 619,068 metric tons in 2013, which met about 40 to 50 percent of the domestic demand. Cambodia imported some 114,000 tons of vegetables from neighboring countries such as Vietnam and Thailand (USAID, 2014). This gap in domestic vegetable supply has been attributed to poor productivity, postharvest losses, farmers' lack of access to markets, environmental degradation and climate change effects (USAID, 2015).

To reduce the gap between supply and demand of vegetables through local production, commercial horticulture was a priority program under Cambodia HARVEST. The Commercial Horticulture program targeted all four provinces where a majority of small-scale farmers predominantly grow vegetables for their livelihood (Olaf *et. al*, 2015). This evaluation aimed to assess achievements and impacts of HARVEST program goals relative to its commercial horticulture activities for the eight elements listed under Component 1 and Component 2 in the preceding section.

Specific activities of the Cambodia HARVEST's commercial horticulture undertaking included:

- Disseminating modern horticultural technologies and management practices tailored to the growing conditions of Cambodia.

- Increasing crop diversification to provide more stable income streams and increased resilience to climate change.
- Promoting efficiency across value chains and vertically integrating smallholder producers.
- Improving market awareness and linking farmers with markets.
- Increasing access to credit to support producer and agribusiness investment in modern production techniques.
- Introducing value-adding enterprises for primary production, such as processing, cold storage, packaging and reliable transportation, which will increase income and employment.
- Establishing new models for agricultural extension services to help farmers with technology adoption.
- Improving basic knowledge about alternative crops and farming practices, which will increase farmers' interest and ability to shift production to crops other than rice.

The commercial horticulture component of the project worked with farmers having relatively large land holdings who can afford to practice commercial farming.

The project worked with two types of beneficiaries:

- **Demonstration clients** were farmers who received support and demonstrated program techniques and technologies to nearby farmers under a co-investment agreement.
- **Training participants** consisted of farmers or individuals who attended training programs conducted by the Cambodia HARVEST program staff.

Demonstration farmers as well as general farmers received trainings and formed village producer groups for growing larger volumes of selected crops on the basis of buyer requests and/or market demand. The trainings and demonstrations were expected to increase vegetable production and their availability, leading to increased household incomes.

Evaluation Design and Methods

Evaluation Design

"Evaluation design" refers to the conceptual framework within which an evaluation will be conducted. This evaluation of the HARVEST Commercial Horticulture program was designed to assess program impact on participating farmers. For this particular study, a randomized control trial (RCT) design is not suitable because the project activities were already started in 2012 in selected districts within the four target provinces, so it was not possible for the evaluators -- who joined the effort after it had already begun -- to establish a randomized control trial. This poses some threats to the internal validity of the evaluation design. Further, it is difficult to control experimental treatments uniformly in large-scale development projects that involve multiple strategies, approaches and actors operating in the same space during project implementation. With unprecedented advancement in communication technology significantly affecting communication behavior, it is difficult to control for spillover effect. Therefore, impact evaluation following a RCT design was not feasible in this case.

Given the large number of households and multiyear implementation of Commercial Horticulture project activities, impact evaluation of the commercial horticulture project required an evaluation design that can provide as much control as possible under the existing

situation. A quasi-experimental design that does not include complete random assignments can be used in this context where true experimental design is not feasible. Therefore, we used the quasi-experimental design for impact evaluation of the Commercial Horticulture program to reach conclusions that would be reasonable under the circumstances.

The validity of such an evaluation design is based on the assumption that factors such as the vegetable production environment, market prices, farmers' access to markets, and agricultural policies for training participants and demo clients are the same across program beneficiaries. This impact evaluation randomly selected clusters of training participants and demonstration farmers living in the same HARVEST project villages as potential participants in this impact evaluation.

Hypothesis Testing

The Commercial Horticulture impact evaluation study was designed to test the hypothesis associated with the goals and strategies of the Commercial Horticulture project. The hypothesis for this project can be better understood using the program logic model (Figure. 1).

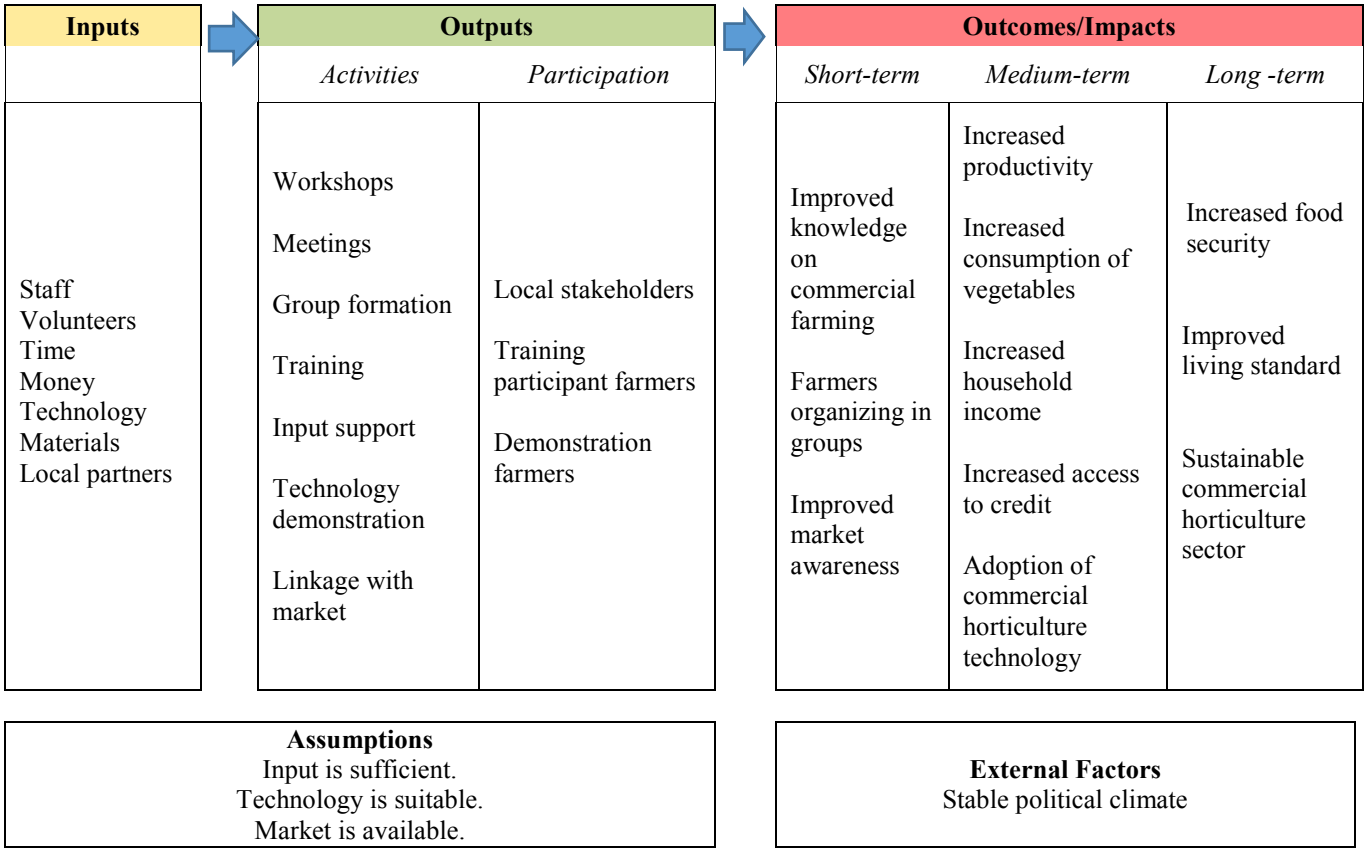

Figure 1. Program logic model for evaluation of Commercial Horticulture program.

The development hypothesis is that, if farmers receive a set of services -- such as appropriate horticulture technology, input support, best management practice demonstration, postharvest trainings, and credit and market information/assistance -- their productivity will increase in the medium term, leading to improved food security and living standard along with a sustainable commercial horticulture sector in the long term. Participating farmers' and demonstration

clients' knowledge, attitude and behavior would then be assessed to evaluate the impact of the project.

Sampling Method

The sampling frame for this evaluation was the training participants and demonstration clients in the four provinces where the Cambodia HARVEST project was implemented. A list of training participants and demonstration clients in the target provinces was used to select a stratified random sample of households participating in the project for the evaluation study.

The population for this evaluative study consisted of 9,114 farm households (3,511 demonstration clients and 5,603 training participants) living in 582 villages from 174 communes of 34 districts in four provinces -- Pursat, Battambang, Siem Reap and Kampong Thom (Table 1).

Based on a 95 percent confidence level, a design effect of 1.5 and a 5 percent margin of error, a minimum sample size of 560 demonstration clients and training participants was determined. The sampling design was based on the stratified cluster sampling method. The two types of beneficiary groups – demonstration clients and training participants -- are defined as strata. Number of samples allocated in each stratum (i.e., 280 households) is then allocated to the four provinces using proportional to population size selection method. Fifty-six clusters were proposed, and to arrive at 560 samples, 10 households per cluster were selected to result in a minimum detectable effect size (MDES) of at least 0.35.

Table 1. Commercial Horticulture clients by province.

Beneficiary	Provinces	Districts	Communes	Villages	Total population
Training participants	Battambang	12	55	166	1,447
	Kampong Thom	7	39	136	1,248
	Pursat	5	37	153	1,439
	Siem Reap	10	43	127	1,469
	Subtotal	***34***	***174***	***582***	***5,603***
Demo clients	Battambang	11	59	196	1,382
	Kampong Thom	8	37	118	633
	Pursat	5	32	117	871
	Siem Reap	10	42	124	625
	Subtotal	***34***	***170***	***555***	***3,511***
	Grand total				**9,114**

The lists of demo clients and training participants were prepared separately, and the allocation of samples and clusters made individually. The first stage of sample selection was based on random selection of 50 percent of districts in each province. The second stage involved selection of village clusters within communes. A village represented one cluster, and nearby households were collapsed into those villages where the numbers of nearby beneficiaries were insufficient to form a cluster. Similarly, in the case of the larger clusters (with more than 20

beneficiaries), these were divided into segments, and only one segment was selected as a cluster. The third and final stage involved the selection of sample beneficiary households from among demonstration clients and training participants (Table 1). Beneficiaries from the two strata in selected districts and clusters were listed, and individual beneficiaries were given a random number (using randomize.com) to ensure that they had an equal chance of being selected. The top 10 random numbers in every cluster were chosen as the sample; the next top five random numbers made a reserve sample list.

Replacement of Sample Clients

A reserve sample list was prepared using the same method as the selection of sample clients. Having a reserve list increased the efficiency in field data collection. For example, if there was no successful second visit to a sample member because the target head of household was absent during the data collection visit, a household from the reserve list could be substituted for the missing interview. The same method was used for those households that did not wish to participate in the survey for various reasons.

Table 2 shows the breakdown of the number of samples in relation to the number of commercial vegetable households by province.

Table 2. Sample size and selection.

Provinces	Demo clients			Training participants		
	Population	Cluster	Sample	Population	Cluster	Sample
Battambang	1,382	11	113	1,447	7	49
Kampong Thom	633	5	50	1,248	7	72
Pursat	871	7	75	1,439	7	62
Siem Reap	625	5	49	1,469	7	75
Total	3,511	28	287	5,603	28	258

To make the data representative of the horticulture program participants of the HARVEST project, the sample was weighted based on the product of the inverse of each sampled farmer's probability of being selected for the survey. Given that a two-stage sampling method was used, the sample weights were estimated by multiplying the inverse probability of selecting the clusters (stage 1) by the inverse of probability of selecting the farmer within a cluster (stage 2).

Data Collection, Enumerator Training and Pretesting

Ten enumerators were recruited from the Royal University of Agriculture (RUA) and Prek Leap National School of Agriculture (PNSA) to assist in survey data collection. The enumerators received two days of training in Phnom Penh on data collection. The training provided an overview of the Commercial Horticulture program under Cambodia HARVEST and introduced the survey instrument, including protocol for how to approach a respondent, dealing with refusal, ethical issues and the requirement to follow informed consent protocol.

The enumerators' training included a full day of pretesting the questionnaire in Pursat province in two villages that were not included in the sample list. Enumerators practiced the administration of face-to-face interviews in a real-life situation. Each enumerator completed two face-to-face interviews involving 20 respondents in total. The team leader and field supervisors monitored and coordinated the process. A briefing and feedback session was

conducted on the same day of pretesting. Clarification of doubts and minor revisions in the survey instrument were made following the feedback from the pretest.

The survey data collection team was organized in four levels: technical advisor, data collection team leader, field supervisors and enumerators. The team leader was in charge of overall coordination, monitoring the quality and supervising the field work. Field supervisors took care that the agreed upon protocols were followed in the field.

Data collection began in Pursat, followed by Battambang, Siem Reap and Kampong Thom provinces. The survey team was divided into two small teams with five enumerators each and one supervisor. The two teams worked together to collect data in various villages and gathered in the evening on a daily basis to keep all members aware of the progress and update day-to-day planning. With an expected five interviews per day per enumerator, the field data collection was completed in 15 days (included the one day of pretesting).

Data Analysis

Descriptive and inferential statistics were used for quantitative data analysis. Descriptive statistics in the form of frequency count, percentage, mean and standard deviation were used to describe demographic characteristics, technologies used and vegetables grown. Inferential statistics such as *t*-test and analysis of variance (ANOVA) were used to compare the impact of the project on demo clients and training participants (Jonh, 2008).

Specifically, data analysis aimed to address the following evaluation objectives:

Objective 1: to assess the effectiveness of program intervention in changing knowledge, attitude and behavior regarding commercial horticulture farming among demo clients and participant farmers.

This objective was addressed using information collected in modules C4, C6, E1 and H in the survey instrument. These modules aimed at understanding if farmers gained knowledge about various commercial horticulture technologies. Attitude and behavior were also captured in these modules.

Objective 2: to assess the effectiveness of program interventions in increasing incomes and economic benefits.

Information generated from modules C1 and C2 in the survey instrument was used to address this objective.

Various methods were used to assess the effectiveness of the program intervention on increasing incomes and other economic benefits. The ANOVA test to see if there is significant difference in income between the groups, the t-test to compare the mean values on economic benefits between demo farmers and training participants, and the regression analysis to evaluate the factors affecting variation in household incomes and technology adoption.

Based on an ordinary least square (OLS) regression, a household income model was developed to assess the effect of the HARVEST program on household and commercial horticulture income. Six models are estimated (three for each participant group), where the dependent variables are the natural log of income of the total household, log of net commercial horticulture

income and log of net commercial horticulture income per unit of area. The total net commercial horticulture income was calculated using the full income approach, consisting of: valuing all commercial vegetable production, regardless of whether it was for home consumption or sales, and deducting cash inputs (hired labor, purchased seed, fertilizers, etc.) from the production. The total household income was estimated by summing up all agricultural income to the value of non-agricultural income from various sources (salaries and wages, non-farm self-employment and others). Then, adapting from poverty literature (Mukherjee and Benson, 2003; Nargis and Hossain, 2006), the effect of the HARVEST program on income was estimated using the following expression:

$$\ln Y_i = \beta_0 + \beta_1 CH_i + \beta_2 X_i + \varepsilon_i \quad (1)$$

where *i=1, 2,.., N* are households; $\ln Y_i$ is the log of income of household *i*. *X* is a vector of exogenous household-specific characteristics such as demographics, natural and physical endowments, human capital, technology, infrastructure and village fixed effect. CH_i is a vector of variable indicators of participation in the HARVEST program. The coefficient β measures the return to a particular household's resources on the percentage change in the income across households, and the coefficient of interest is β_1. The ε_i is the error term assumed to be normal, independent and identically distributed with mean zero and constant variance. Robust standard errors were used to estimate the *t*-values.

Crop diversification has been an important livelihood strategy because it plays a significant role in sustainable income and employment in poor rural contexts. Following Anchirinah et al. (2011), Sichoongwe et al. (2014) and Dube and Guveya (2016), we used three commonly used diversification measures: Herfindahl Index (HI); Crop Diversification Index (CDI), also known as Simpson Index of Diversification; and the Entropy Index (EI) to study the impact of the Commercial Horticulture program on crop diversification. These measures are computed based on the proportion of the cultivated area of each crop over the total area. The CDI is derived by subtracting HI from 1. Given that the HI is a measure of concentration, a higher value of HI is an indication of specialization, which corresponds to a lower CDI value. Entropy Index is a measure of inequality derived as the sum of the product of crop area share and logarithm to crop area share. Given that the crop area share varies between zero and 1, crop shares approaching 1 have lower EI (high negative value) and those approaching zero have high EI (low negative value), suggesting strong diversification. These indicators are estimated as follows:

$$CDI = 1 - HI \text{ where } HI = \sum_{i=1}^{n} P_i^2 \text{ and } P_i = \frac{A_i}{\sum_{i=1}^{n} A_i} \quad (2)$$

where n is the number of crops, Ai is the area under the ith crop, Pi the proportion of ith crop. Adapting from Acharya *et al.* (2011), the Entropy Index was estimated by the following expression:

$$EI = \left[\sum_{i=1}^{n} P_i * \log_n P_i \right] * \left\{ 1 - (\frac{1}{n}) \right\} \quad (3)$$

Drawing on insights from Mwangi et al. (2015) to measure the household market access, the household commercialization index is estimated as the proportion of harvest production that is commercialized. The estimate takes a value of 1 for complete access to market; no access to output market takes a value of 0. The access to market was estimated as follows:

$$CI = \frac{1}{n}\sum_{i=1}^{n}\frac{Qs_i}{Qh_i} \quad ; i = 1,2,..., N \tag{4}$$

where n is the number of crops, Qsi is the amount of output of ith crop marketed and Qhi is the amount of output of ith crop harvested.

Finally, the probit model was estimated, which is associated with technology choices -- i.e., farmers' decisions to adopt technology. The probit model is the most suitable tool to predict the probability of whether a farmer adopts the technology because of our discrete dependent variable with binary outcomes (Wooldridge, 2012). In this study, technology adoption might have been influenced by farmers' participation in the Cambodia HARVEST program. The aim in this study was to examine which factors explain the adoption decisions of both groups of farmers. Most importantly, how much an individual factor influences the farmers' decision can be examined. The influence of each independent variable on the household's adoption decision can be assessed by estimating the marginal effect of independent variables in the probit model (Greene, 2012) . Thus, the adoption decision of any technology can be expressed as follows:

$$Y^* = X\beta + \mu \quad where \quad Y = \begin{cases} 1(adopter) & if\ Y^* > 0 \\ 0 & if\ Y^* \leq 0 \end{cases} \tag{5}$$

where Y is a binary adoption decision variable taking a value of 1 if a farmer adopts commercial horticulture technology and zero if a farmer does not adopt such technologies. The probability for a farmer to adopt the technology provided by the HARVEST program is presented as: P = P [Y_i=1]; the probability of a farmer not adopting is 1-P=P [Y_i=0]. The binary choice adoption consists of a form created by the probability function form $f(y) = P^y (-P)^{1-y}$, where the variable Y is 0 and 1. The new technologies provided by the Commercial Horticulture program were weighed. For instance, $U^*_i(\pi) > U^*_N(\pi)$, where π represents net income. This shows that the technology adoption by the demo farmers happens when its expected utility is considered greater than that of non-adoption. Usually, the parameters associated with farmers' decisions cannot be observable, but a latent variable U^*_i can be expressed in terms of socioeconomic variables (X_i):

$$U_i^* = X_i\beta + e_i \ (i=1,2,3,...,N) \tag{6}$$

where β represents a vector related to adoption parameters and e_i represents a random error term. After getting the choice of farmers' adoption, the dummy variable (Y_i) is denoted as:

$$Y_i = 1 \quad if\ U_A^*(\pi) > U^*_N(\pi),\ 0 \quad \text{otherwise.}$$

Results and Discussion

Socioeconomic Characteristics of Commercial Horticulture Program Participants

Table 3 shows the poverty status of Commercial Horticulture clients and sources of household income in the previous 12 months. The result shows that demo clients of the Commercial Horticulture program are less poor than the training participants -- poor households account for about 16 percent of demo clients and 32 percent of training participants. This indicates that the demonstration farmers are generally better off than the training participants.

Results in Table 3 also show a higher proportion of poor households and female farmers are among the training participants, and a larger percentage of non-poor households are among the

demo clients. About 47 percent of demo clients and 70 percent of training participants are female farmers engaged in commercial horticulture. The higher proportion of female farmers, especially among the training participants, shows how vegetable farming is highly skewed towards female farmers, and perhaps this affects the adoption of commercial horticulture technologies. It also indicates that horticultural production is an important occupation and income source for women.

Income from rice production, horticulture and permanent work appears to be significantly different between two groups -- demo clients have a significantly higher proportion of households generating income from those three sources. Horticulture is the primary income source in the study area, especially for demo clients, and the second largest income source is rice production.

Table 3. Descriptive statistics of poverty status and income sources.

Characteristics	Demo clients (N=287)	Training participants (N=258)	Total (N=545)	Chi^2-value	*p*-value
	---Percent reporting---				
A. Poverty status and gender					
ID Poor 1	5.7	9.7	8.2	5.61	0.018
ID Poor 2	7.9	22.1	16.6	14.89	0.000
Non-poor	86.4	68.1	75.2	22.89	0.000
Female farmers	46.8	70.0	61.0	19.60	0.000
Borrowed money	26.8	22.2	25.1	22.90	0.000
B. Household income sources in the past 12 months					
Rice production	57.2	36.6	44.6	25.87	0.000
Horticulture	79.8	22.1	52.5	181.36	0.000
Fishing	8.0	5.5	6.5	2.37	0.124
Livestock raising	41.2	34.8	37.3	1.59	0.207
Self-employment	22.3	28.5	26.1	2.32	0.128
Permanent work	21.6	38.2	31.8	12.54	0.000
Other sources*	17.5	15.3	16.1	1.23	0.267

* Other sources include seasonal work, government transfer, kind transfer, gifts, etc.

Table 4 shows the characteristics of the Commercial Horticulture clients by participation status. The study observed significant statistical differences in household characteristics between demo clients and training participants -- specifically, differences in farmers' educational level, number of household members engaged in commercial horticulture and number of income earners in the household.

As shown in Table 4, participation in commercial horticultural production in rural Cambodia varies with farmers' education levels and number of persons engaged in vegetable production but not with household size and farmer's age. Results show that the demo clients have about five and a half years of education and three people in each household engaged in vegetable production. Because vegetable production is labor-intensive, availability of household labor could influence horticultural productivity.

Table 4. Household characteristics.

Characteristics	Demo clients (N=287)	Training participants (N=258)	Total (N=545)	Difference	
	Mean (SD)	Mean (SD)	Mean (SD)	*t*-value	*p*-value
Respondent age (years)	45.0 (11.5)	46.2 (14.9)	45.7 (13.7)	0.38	0.710
Farmer's education (years of schooling)	5.4 (3.3)	4.8 (3.5)	5.0 (3.5)	2.07	0.040
Persons in the HH engaged in vegetable /CH production	2.7 (1.4)	0.8 (1.4)	1.5 (1.7)	15.87	0.000
Income earners in the HH (# of people)	2.7 (1.1)	2.3 (1.3)	2.4 (1.2)	4.08	0.000
HH size (# of people)	5.3 (2.1)	5.1 (2.0)	5.2 (2.0)	1.34	0.180

CH= Commercial Horticulture, HH= Household

Commercial Horticulture Program and Knowledge, Attitude and Behavior Change

This section discusses the effects of the Commercial Horticulture program on changes in attitude, knowledge and behavior concerning commercial horticulture farming by assessing the farmers' opinions on major areas of concerns: the barriers to entering commercial horticulture farming, farmers' perceptions toward the Commercial Horticulture program, their membership in and the usefulness of farmer producer groups, other HARVEST assistance programs, and the sources and frequency of technical assistance.

Barriers to entering commercial horticulture farming

Horticulture is an important source of income for the smallholder farmers in rural Cambodia. Therefore, helping farmers overcome the institutional and non-institutional barriers to entry into horticulture is likely to increase farmers' participation and lead to increased income and improved food security. In the study area, survey findings indicated that horticulture is mainly used for income generation and/or food consumption at home -- very few farmers perceive it as a commercial activity. Instead, they view it as providing self-employment or employment at home.

The survey asked growers about the major barriers to commercial horticulture farming. Findings in Table 5 revealed several hurdles. The five most important barriers by order of importance were: product market price fluctuation, diseases, insects, lack of water leading to seasonal farming, and climate disasters such as floods and droughts. All of these barriers apply equally to both types of participants except market price fluctuation, which was reported by a higher proportion of demo clients than training participants.

Table 5. Barriers to commercial horticulture production experienced by vegetable producers.

Characteristics	Demo clients (N=265)	Training participants (N=77)	Total (N=342)	Chi^2 - value	*p*-value
		[Percent reporting]			
Disease was major problem	48.6	34.5	43.5	2.44	0.118
Insects were major problem	39.0	39.2	39.1	0.84	0.360
Credit was major problem	11.0	7.2	9.6	0.22	0.641
Input prices were major problem	13.3	11.2	12.5	1.01	0.316
Farm inputs difficult to find	3.6	4.0	3.7	0.24	0.621
Market price fluctuation	58.3	46.6	54.1	3.33	0.068
Seasonal farming due to lack of water	34.2	26.4	31.4	0.09	0.760
Lack of labor was major problem	6.4	2.9	5.1	0.15	0.695
Lack of land for expansion was major problem	12.7	17.6	14.5	0.18	0.672
Difficulty to find good buyer was major problem	25.2	8.9	19.3	8.37	0.004
Theft of vegetables was major problem	0.9	3.4	1.8	0.01	0.905
Droughts/floods were major problem	33.7	24.6	30.4	0.45	0.502

On the lower end of the spectrum of importance, farmers (mostly among the demo clients) said that it was hard to find a good buyer for their produce, and about 13 percent of farmers saw high input prices as a major problem. This indicates that the most important entry barrier has to do with market participation, and that efforts based on reforms to improve market participation -- including reduction of transaction costs and price risk, market intermediation, institutions and infrastructure -- were seen as more promising than those based exclusively on price and trade policies. If, however, Cambodia can import from the neighboring countries such as Vietnam and Thailand to tackle its food deficit, it can also tailor a trade policy that can work in regions well integrated with the international market that would allow growers to market and increase demand for the local products.

Farmers' perceptions of Commercial Horticulture program

Tables 6 and 7 report farmers' perceptions of the Commercial Horticulture program under Cambodia HARVEST. Statements about adequacy of information provided to start commercial vegetable farming; whether the training was practical and provided hands-on-learning experience; adequacy of the level of knowledge of instructors to provide information on horticulture; and whether the project provided market information were read to capture farmers' opinions. The responses were recorded on a 1 to 5 scale with 1 indicating that farmers strongly disagreed and 5 indicating that they strongly agreed. In general, farmers had a positive attitude toward the HARVEST project, as indicated by the majority of responses having an average score above 3.0.

According to the commercial horticulture farmers, the HARVEST program training provided adequate information to start commercial horticulture production on their farms, and the training was practical or did provide hands-on learning (learning by doing). Also, they perceived that the instructors were knowledgeable about vegetable growing or commercial

horticulture, and the technologies promoted by the program were appropriate for their farms. Respondents also had a positive perception that farmers had fully adopted the commercial horticulture technologies promoted by the HARVEST program, and that the inputs required to adopt new technology were readily available in the local markets. However, they had a neutral opinion about marketing of produce -- i.e., they felt difficulty in marketing their produce (Table 6). It is noteworthy that the perception varied with Commercial Horticulture program participation -- demo clients were more favorable than the training participants to the above statements.

Table 6. Farmers' perceptions of the Commercial Horticulture program.

Statements	Demo clients (N=287)	Training participants (N=258)	Total (N=545)	*t*-value	*p*-value
	Mean (SD)	Mean (SD)	Mean (SD)		
	[Responses in scale 1-5]				
HARVEST training provided adequate information to start commercial horticultural production in my farm.	4.5 (0.64)	4.2 (0.81)	4.3 (0.76)	5.08	0.000
Training was practical / provided hands-on learning [learning by doing].	4.4 (0.66)	4.1 (0.85)	4.2 (0.79)	4.75	0.000
Instructors were knowledgeable about vegetable growing /commercial horticulture.	4.5 (0.64)	4.3 (0.72)	4.4 (0.69)	3.15	0.002
Technology promoted by the program was appropriate for my farm.	4.3 (0.72)	3.6 (0.94)	3.9 (0.93)	9.11	0.000
Inputs required to adopt new technology were eventually readily available in the local markets / dealers.	4.2 (0.89)	3.8 (0.85)	4.0 (0.88)	4.66	0.000
HARVEST staff provided market/buyer linkages to sell my produce.	2.7 (1.25)	2.7 (1.02)	2.7 (1.11)	1.06	0.291
I had no difficulty in marketing my farm produce.	3.2 (1.23)	2.9 (1.11)	3.0 (1.16)	2.47	0.014
I have fully adopted the commercial horticulture technologies promoted by HARVEST program.	4.2 (0.83)	2.9 (1.20)	3.4 (1.26)	16.46	0.000

Scale: 1=Strongly disagree, 2=Disagree, 3=Neutral, 4=Agree and 5=Strongly agree.

On the other hand, although the vegetable farmers reported market price fluctuation as a main concern in commercial horticultural production, they indicated that the HARVEST staff did provide market/buyer linkages to sell their produce. However, strategies to cope with price fluctuations are recommended. Promotion of agro processing technologies at the local level could be a reasonable solution to reduce the price shocks.

As shown in Table 7, we further disaggregated the individual statements by farmers' opinions. For each statement, a higher percentage of demo clients responded positively compared with training participants. Details of the responses to each statement on a 1 to 5 scale, with 1 being strongly disagree and 5 being strongly agree, are reported.

Table 7. Farmers' opinions on the Commercial Horticulture program in detail.

Statements and opinions	Demo clients (N=287)	Training participants (N=258)	Chi^2	*p*-value	Demo clients (N=287)	Training participants (N=258)	Chi^2	*p*-value
	---Percent reporting---							
	HARVEST training provided adequate information to start commercial horticultural production in my farm				*Inputs required to adopt new technology were eventually readily available in the local markets / dealers*			
Strongly disagree	0.8	0.0			0.5	1.3		
Disagree	0.5	3.1			9.6	6.4		
Neutral	1.7	14.3	25.13	0.000	1.1	17.9	14.58	0.006
Agree	41.1	38.3			49.7	55.5		
Strongly agree	56.0	44.3			39.2	19.0		
	Training was practical / provided hands-on learning [learning by doing]				*HARVEST staff provided market/buyer linkages to sell my produce*			
Strongly disagree	0.3	0.4			18.4	20.0		
Disagree	2.0	5.8			35.7	14.0		
Neutral	2.3	11.9	26.92	0.000	9.7	47.7	29.59	0.000
Agree	52.1	47.9			30.0	17.2		
Strongly agree	43.3	34.0			6.2	1.1		
	Instructors were knowledgeable about vegetable growing /commercial horticulture				*I had no difficulty in marketing my farm produce*			
Strongly disagree	0.0	0.0			10.4	17.1		
Disagree	1.8	1.3			25.0	9.2		
Neutral	2.8	11.7	8.58	0.035	7.9	41.0	16.13	0.003
Agree	42.9	44.0			46.1	28.9		
Strongly agree	52.6	43.0			10.6	4.0		
	Technology promoted by the program was appropriate for my farm				*I have fully adopted the commercial horticulture technologies promoted by HARVEST program*			
Strongly disagree	0.6	1.2			0.5	18.1		
Disagree	2.6	12.3			5.9	17.9		
Neutral	3.2	25.0	27.82	0.000	5.4	31.8	60.96	0.000
Agree	49.3	44.4			48.3	24.2		
Strongly agree	44.4	17.1			39.9	8.0		

Farmer producer groups and other HARVEST assistance programs

Farmers' participation in farmer producer groups and other HARVEST assistance programs is reported in Table 8. The results show that the awareness of and participation in farmer producer groups (FPGs) and the commercialization of horticultural products through the FPGs varied with participant group, with a significantly larger proportion of demo clients than training participants participating. For instance, although about 29 percent of training participants were aware of FPGs, only about 6 percent of them were members, compared with about 38 percent of demo clients.

The limited FPG membership among the training participants deserves attention because those who are members have taken advantage of the opportunity to sell their produce through the group. However, overall 17 percent of the training participants reported that HARVEST staff members helped provide market/buyer linkage to sell their produce. It appears that promoting FPG membership among training participants would have beneficial impact. The higher

membership rate of demo clients could be associated with the technical support and training they received from the program.

Table 8. Participation in farmer producer groups and other HARVEST assistance programs.

Characteristics	Demo clients (N=265)	Training participants (N=77)	Total (N=342)	Chi^2 - value	*p*-value
	[Percent reporting]				
A. Farmer producer group:					
The farmer is aware of farmer producer group	43.9	28.8	38.4	62.54	0.000
The farmer is a member of farmer producer group	37.7	5.6	26.1	87.60	0.000
The farmer sold vegetables via farmer producer group	100.0	94.3	97.9	234.13	0.000
B. Other HARVEST assistance:					
The household also participated in HARVEST horticulture (home garden) program	3.6	6.5	5.4	2.21	0.137
The household also participated in HARVEST aquaculture program	4.6	7.4	6.3	0.77	0.380
The household also participated in HARVEST rice production program	6.6	10.9	9.2	1.34	0.246
The household also participated in nutrition/child feeding program	47.0	54.6	51.7	1.70	0.192
The household also participated in HARVEST input supplier program	2.3	0.7	1.3	3.11	0.078

On the participation in other HARVEST assistance programs, results show that in general, a small proportion of commercial horticulture farmers participated in other HARVEST assistance programs. An exception was the nutrition/child feeding program, in which a little more than half of commercial horticulture farm households participated. The participation in these programs does not vary with Commercial Horticulture program participation except for the input supplier program, in which a significantly higher proportion of demo clients than training participants took part.

Sources and frequency of technical assistance

Literature recognizes that one of the most significant constraints on productivity growth in agriculture is failure in delivering information on agricultural technologies (Dube and Guveya, 2016). Therefore, technology and knowledge transfer from researchers to farmers or between peer farmers in a form of extension services is crucial. In Table 9 and Table 10, we analyze the sources and frequency at which commercial horticulture farmers access extension services in rural Cambodia.

With responses on a 1 to 5 scale with 1 indicating that farmers never received extension services and 5 indicating that they received services very frequently, a lower average value in Table 9,

except for the HARVEST program, reflects lack of or no access to extension, while a higher value close to 5 indicates frequent access to extension. With various sources of extension services available for farmers in rural Cambodia, the HARVEST program was rated highly for information source by farmers compared with the others.

Table 9. Sources of technical assistance or extension services received in the past 12 months.

Source of information	Demo clients (N=265)	Training participants (N=77)	Total (N=342)	*t*-value	*p*-value
	Mean (SD)	Mean (SD)	Mean (SD)		
Commercial Horticulture demo client	2.6 (1.21)	2.7 (1.26)	2.7 (1.23)	1.63	0.103
HARVEST program /HARVEST technicians	4.1 (0.71)	3.3 (1.35)	3.8 (1.06)	8.12	0.000
Other NGOs besides HARVEST and partners	1.8 (1.02)	1.5 (0.92)	1.7 (1.0)	2.17	0.031
Provincial/District Department of Agriculture	1.5 (0.83)	1.4 (0.78)	1.5 (0.81)	0.95	0.344
Neighbors /relatives	2.2 (1.2)	2.0 (1.04)	2.2 (1.15)	0.66	0.509
Television program	2.5 (1.18)	2.1 (1.12)	2.4 (1.17)	2.10	0.036
Radio program	2.0 (1.18)	1.9 (1.08)	2.0 (1.14)	0.30	0.767
Others[b]	3.5 (1.05)	2.3 (1.45)	2.6 (1.42)	2.05	0.063

Note: Likert-type scale on frequency of source of information where 1=Never, 2=Seldom, 3=Sometimes, 4=Frequently and 5=Very frequently.
[b] ADDA organization; IDE; input supplier company; seed and pesticide promoter; self experience; village chief; Trapaing Russey vocational training center, Youtube and Facebook.

In general, farmers had limited access to extension services, as indicated by an average value of responses below 3 for most sources except the HARVEST project, from which the majority of respondents (90 percent of demo clients and 50 percent of training participants) received extension services frequently, with an average response of 3.8. Access to extension does not vary with type of participant except for that provided by the HARVEST staff, other NGOs besides HARVEST and partners, television programs and others where the demo clients benefited more, as indicated by the percentage of farmers accessing extension services from any source.

Table 10. Sources of technical assistance received in the past 12 months in detail.

Extension access frequency	Demo clients (N=267)	Training participants (N=77)	Chi^2	*p*-value	Demo clients (N=267)	Training participants (N=77)	Chi^2	*p*-value
				---Percent reporting---				
Commercial Horticulture demo client					*Neighbors /relatives*			
Never	28.2	27.2			40.0	42.3		
Seldom	12.2	9.0			18.5	20.7		
Sometimes	30.9	37.7	7.46	0.113	22.0	27.7	4.11	0.392
Frequently	26.7	18.6			17.6	9.3		
Very frequently	2.0	7.5			1.9	0.0		
HARVEST program /HARVEST technicians					*Television program*			
Never	1.2	15.6			30.8	44.2		
Seldom	2.3	10.6			13.3	12.5		
Sometimes	6.4	23.4	84.73	0.000	34.1	34.2	5.76	0.218
Frequently	66.3	28.0			19.5	7.2		
Very frequently	23.7	22.4			2.3	2.0		
Other NGOs besides HARVEST and partners					*Radio program*			
Never	54.9	74.2			50.6	49.3		
Seldom	18.5	11.0			12.8	15.7		
Sometimes	18.5	8.7	11.23	0.024	24.7	28.4	2.08	0.720
Frequently	7.7	5.4			9.0	4.2		
Very frequently	0.5	0.8			3.0	2.3		
PDA, DDA					*Others*			
Never	64.0	69.5			0.0	48.5		
Seldom	20.0	19.6			15.6	7.3		
Sometimes	13.3	7.4	6.80	0.079	34.2	14.4	4.00	0.407
Frequently	2.7	3.4			30.2	29.9		
Very frequently	0.0	0.0			20.0	0.0		

Learning and adoption of commercial horticulture technologies in rural Cambodia

In general, both groups of farmers learned commercial horticulture technologies in rural Cambodia. The awareness and adoption of vegetable-related agricultural techniques varied with participation in the Commercial Horticulture program. Results in Table 11 show that a higher proportion of demo clients learned and adopted production techniques, given their greater access to technical support by the HARVEST program. Study results show that seedling (nursery) production (91.7 percent), use of raised beds (90.7 percent), fertilizer starter solution (87.9 percent), trellising (87.5 percent) and plastic mulch (87.2 percent) are the five most learned techniques by commercial horticulture farmers. The adoption of hybrid seeds/open-pollinated varieties is the least learned technology by vegetable farmers in rural Cambodia.

Table 11. Learning and adoption of commercial horticulture technologies.

Technologies	Demo clients		Training participants		Total		Difference	
	N	Mean	N	Mean	N	Mean	Chi^2-value	*p*-value
Percentage of farmers that learned technologies in the past 12 months								
Raised beds	265	98.8	77	76.5	342	90.7	51.43	0.000
Hybrid seeds/ open-pollinated seeds	265	48.5	77	19.8	342	38.1	14.62	0.000
Trellising	265	95.2	77	74.0	342	87.5	41.71	0.000
Seedling (nursery) production	265	97.9	77	80.7	342	91.7	43.92	0.000
Organic (rice straw) mulch	265	86.6	77	63.3	342	78.2	28.04	0.000
Plastic mulch	265	98.9	77	66.5	342	87.2	77.58	0.000
Drip irrigation	265	97.6	77	66.2	342	86.3	77.18	0.000
Soluble fertilizer injected through drip irrigation	265	98.4	77	61.6	342	85.1	105.72	0.000
Fertilizer starter solution	265	96.5	77	72.6	342	87.9	52.19	0.000
Crop rotation	265	89.1	77	59.0	342	78.3	45.56	0.000
Cultural practices (a)	265	95.4	77	73.2	342	87.4	44.96	0.000
Weed control	265	92.7	77	66.1	342	83.1	45.29	0.000
Postharvest management	265	85.4	77	53.2	342	73.7	51.43	0.000
Live barriers	265	97.2	77	62.6	342	84.7	81.57	0.000
Pest and disease control practices (chemical recommendations)	265	95.2	77	70.1	342	86.1	39.48	0.000
Integrated pest management	265	70.8	77	35.6	342	58.1	39.09	0.000
Composting	265	71.9	77	62.3	342	68.4	6.20	0.013
Botanical pesticides	262	56.5	76	28.8	338	46.5	16.42	0.000
If learned, percentage of farmers that applied the techniques in the past 12 months								
Raised beds	262	96.9	57	65.0	319	87.2	42.11	0.000
Hybrid seeds/ open-pollinated seeds	123	81.5	17	59.0	140	77.3	4.48	0.034
Trellising	253	88.3	54	39.8	307	73.5	40.73	0.000
Seedling (nursery) production	260	95.3	59	50.3	319	81.0	59.70	0.000
Organic (rice straw) mulch	230	74.7	46	35.2	276	63.2	12.35	0.000
Plastic mulch	261	90.7	51	20.2	312	71.3	103.54	0.000
Drip irrigation	258	93.5	49	23.2	307	74.0	114.78	0.000
Soluble fertilizer injected through drip irrigation	261	91.3	44	15.4	305	71.5	104.06	0.000
Fertilizer starter solution	257	94.3	54	60.7	311	84.3	16.81	0.000
Crop rotation	231	78.0	40	35.6	271	66.5	12.01	0.001
Cultural practices (a)	253	93.0	53	56.7	306	82.0	28.53	0.000
Weed control	244	93.8	47	55.0	291	82.7	26.62	0.000
Postharvest management	217	87.1	35	44.0	252	75.8	13.00	0.000
Live barriers	258	81.1	48	26.4	342	61.4	30.32	0.000
Pest and disease control practices (chemical recommendations)	252	88.4	54	37.7	342	70.1	36.50	0.000
Integrated pest management (b)	188	39.6	27	20.9	342	32.8	0.12	0.728
Composting	191	46.4	48	22.7	342	37.9	5.31	0.021
Botanical pesticides	148	22.0	22	8.5	342	17.1	0.26	0.613

(a) Pruning, thinning, stacking, etc.
(b) Yellow traps, pest and disease identification, etc.

A similar pattern is observed in technology adoption, except that the fertilizer starter solution is the third most adopted technology instead of plastic mulch. Again, higher rates of technology adoption were observed among the demonstration farmers than among training participants.

It is noteworthy that modern technologies such as drip irrigation, soluble fertilizer injected through drip irrigation and fertilizer starter solution have high learning and adoption rates compared with traditional techniques such as organic (rice straw) mulch and weed control, suggesting that although these modern technologies require additional investments in time and resources, farmers are willing to adopt them if they can increase production. This indicates that the availability of appropriate technology increases horticultural production and farm income.

The limited adoption of hybrid or open-pollinated seeds is possibly because of the limited knowledge about hybrid seeds and their production technique. However, those who learned about this technology have a high adoption rate (77.3 percent). Also, farmers in the study area may have never attended technical school to learn about breeding techniques. Therefore, farmers may be hesitant to use such technologies. A technology with high risk and uncertainty such as a new seed variety will have a stepwise learning and adoption process as farmers tend to learn from their own experience and/or or from others to reduce risk and uncertainty.

The effect of Commercial Horticulture Program Interventions on Household Incomes

Program effects on household income, cultivated area and crop commercialization

Table 12 presents a statistical analysis of the overall household and commercial horticulture income. As observed, horticulture is a source of income of rural households in Cambodia, practiced by about 80 percent of households. Results show that total household income (including commercial horticulture income), net commercial horticulture income and the commercial horticulture cultivated area varied with Commercial Horticulture program participation, with demo clients earning significantly higher incomes than training participants. Specifically, net commercial horticulture income and average commercial horticulture area significantly increased (at 1 percent level of significance) among demo clients (Table 12). The difference in overall household income between the two groups is smaller, although it is significant at 10 percent level of significance ($p < 0.1$).

Table 12. Commercial Horticulture (CH) program participation and household income (US$).

Characteristics	Demo clients		Training participants		Total		Difference	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	*t*-value	*p*-value
Overall HH income in 2015 (including net CH income in '000 of US$)	287	3.81 (4.42)	258	3.49 (6.20)	545	3.62 (5.58)	1.83	0.070
Net CH income in 2015 ('000 of US$)	263	1.19 (2.07)	73	0.31 (0.60)	336	0.87 (1.75)	3.20	0.000
Average CH area ('000 of m^2)	265	4.18 (5.39)	77	1.74 (3.31)	342	3.30 (4.89)	2.65	0.008

We evaluated the impact of the Commercial Horticulture program on income using before and after treatment recall data with respect to cultivated area increase, crop yield gain, marketability growth and income gain (Table 13 and Table 14).

Results from Table 13 show that gross commercial horticulture income and cropped area significantly increased among demo clients ($p < 0.01$). The demonstration group achieved increases from UD$ 1065 to US$ 1613 and 2628 m^2 to 4177 m^2 in CH income and vegetable area, respectively. There was a little increase in vegetable area among training participants

(1269 m^2 to 1737 m^2), which was significant at 10 percent level of significance. However, returns to land or economic productivity (gross income per m^2) between 2010 and 2015 were not significantly different between both groups.

The Commercialization Index improved over time (from 0.87 in 2010 to 0.90 in 2015), with significant difference among demo clients only. This reflects improvements in crop marketing between the two periods, suggesting a positive impact of the Commercial Horticulture program in increasing market access. Results show that, after the Commercial Horticulture program, vegetable marketing varied with Commercial Horticulture program participation, with demo clients outperforming the training participants.

Did the HARVEST project encourage crop change over time among the CH participants?

To address this question, a disaggregated analysis is presented in Table 14 that focuses on the top five vegetable crops in rural Cambodia: bitter gourd, cucumber, yard-long bean, Chinese kale leaf and green onion. As reported in Table 14, for demo clients, the largest cultivated area was dedicated to Chinese kale before and after HARVEST; for the training participants, cucumber occupied the largest cultivated area before HARVEST. Green onion took over in 2015-2016, generating the highest income. This is probably because green onion fetches high market value to meet the demand for fresh green onion leaves in the market. Although cucumber was the vegetable most widely grown among the training participants in 2010, the highest income was earned from green onion.

Table 13. The impact of the Commercial Horticulture program on cultivated area and land productivity.

Indicator	Before HARVEST (2010-2011)				After HARVEST (2015-2016)				Mean differences			
	Demo clients		Training participants		Demo clients		Training participants		Demo clients		Training participants	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	[C-A]		[[D-B]	
	[A]		[B]		[C]		[D]		*t*-value	*p*-value	*t*-value	*p*-value
Gross CH income (US$)	215	1065.07 (1841.99)	61	475.13 (656.0)	263	1613.28 (2379.62)	74	492.09 (918.36)	3.61	0.000	1.00	0.32
Area (m^2)	265	2627.7 (3799.7)	77	1268.6 (2752.8)	265	4177.1 (5394.5)	77	1737.3 (3314.2)	4.05	0.000	1.91	0.06
Gross CH income per m^2 (US$/$m^2$)	212	0.93 (6.09)	61	0.56 (0.55)	261	0.46 (0.48)	73	0.50 (0.56)	1.13	0.26	0.03	0.98
Commercialization Index[a]	213	0.87 (0.19)	61	0.84 (0.23)	261	0.90 (0.12)	73	0.85 (0.26)	1.91	0.06	0.19	0.85

[a] Estimated as a percentage of production that was sold.

Table 14. Selected performance indicators of the Commercial Horticulture program in rural Cambodia.

Vegetables (Top 5)	Before HARVEST (2010)				After HARVEST (2015)				Mean differences			
	Demo clients		Training participants		Demo clients		Training participants		Demo clients		Training participants	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	[C-A]		[D-B]	
	[A]		[B]		[C]		[D]		*t*-value	*p*-value	*t*-value	*p*-value
Cultivated area (m^2)												
Bitter gourd	13	596.7 (744.1)	2	207.6 (127.2)	50	1390.0 (1885.3)	7	875.2 (1469.4)	0.08	0.426	1.00	0.500
Cucumber	96	1113.4 (1063.6)	26	867.7 (1184.4)	167	1715.3 (2294.2)	24	1338.3 (1293.1)	2.09	0.039	0.89	0.386
Yard-long bean	46	654.5 (645.5)	18	362.6 (464.9)	93	842.0 (1102.6)	22	487.6 (516.8)	1.58	0.124	0.45	0.655
Chinese kale leaf	8	2240.2 (2938.9)	3	330.0 (453.6)	5	5957.7 (9049.3)	3	64.9 (40.6)	0.72	0.602	0.93	0.521
Green onion	29	1090.8 (1789.4)	2	189.6 (129.1)	22	1741.0 (2748.8)	7	2969.5 (6318.3)	0.84	0.417	N/A	N/A
Crop yield (Kg/ m^2)												
Bitter gourd	13	1.96 (1.77)	2	0.31 (0.28)	50	2.33 (2.68)	7	1.37 (1.40)	1.01	0.348	1.00	0.500
Cucumber	93	1.99 (2.26)	26	1.83 (2.60)	163	2.33 (2.68)	22	1.37 (1.40)	1.45	0.150	0.41	0.687
Yard-long bean	46	1.38 (1.16)	18	1.57 (1.38)	87	1.40 (1.47)	20	1.37 (1.33)	0.93	0.357	0.39	0.702
Chinese kale leaf	8	2.25 (1.27)	2	0.74 (0.44)	5	1.62 (0.80)	3	1.69 (0.57)	0.32	0.851	N/A	N/A
Green onion	29	1.51 (1.18)	2	1.34 (1.55)	22	1.70 (1.47)	7	1.24 (1.10)	0.61	0.553	N/A	N/A
Commercialization index (proportion)												
Bitter gourd	13	0.67 (0.43)	2	0.83 (0.24)	50	0.93 (0.11)	7	0.96 (0.07)	0.84	0.429	1.00	0.500
Cucumber	90	0.94 (0.09)	26	0.89 (0.13)	163	0.93 (0.16)	21	0.87 (0.27)	1.15	0.252	0.53	0.601
Yard-long bean	43	0.87 (0.20)	18	0.89 (0.11)	87	0.94 (0.08)	19	0.89 (0.10)	0.47	0.641	0.49	0.635
Chinese kale leaf	8	0.98 (0.03)	1	0.97 (N/A)	5	0.97 (0.04)	3	0.75 (0.50)	N/A	N/A	N/A	N/A
Green onion	28	0.95 (0.07)	2	0.96 (0.00)	21	0.89 (0.16)	7	0.94 (0.14)	1.20	0.255	N/A	N/A
Real income (US$)												
Bitter gourd	13	168.31 (207.5)	2	25.0 (N/A)	50	723.25 (1040.64)	7	299.18 (301.51)	1.01	0.349	1.00	0.500
Cucumber	92	314.94 (364.85)	26	207.38 (205.98)	163	760.51 (1302.39)	22	373.34 (522.41)	2.89	0.005	0.21	0.838
Yard-long bean	44	267.22 (365.03)	18	252.34 (457.26)	87	493.48 (1109.83)	20	121.35 (78.46)	0.61	0.545	0.74	0.475
Chinese kale leaf	8	2019.69 (3605.44)	1	25.00 (N/A)	5	4979.34 (8297.22)	3	53.15 (48.74)	0.81	0.565	N/A	N/A
Green onion	29	849.07 (1558.17)	2	342.77 (709.94)	22	1679.19 (3064.0)	7	685.51 (1367.97)	0.53	0.606	N/A	N/A

N/A: not available.

(a) Calculated by dividing the amount of the produce sold over the amount produced. This indicator measures output market development and access.

Effects of Commercial Horticulture program on crop diversification

Did the HARVEST project lead to commercial horticulture diversification or crop specialization?

Table 15 presents the results of the effects of Commercial Horticulture program on crop diversification. As observed, the average number of vegetable crops grown increased from two to three crops among demo clients only. The Herfindahl Index (HI) and Crop Diversification Index (CDI) appeared to be highly significant at 1 percent level among both demo clients and training participants (Table 15). This indicates that, although the number of vegetable crops increased over time, the commercial vegetable farmers in rural Cambodia are moving toward crop specialization rather than diversification. The increased value of HI from 0.51 to 0.59 among demo clients and 0.53 to 0.63 among training participants confirms the crop specialization. Similarly, the decrease in CDI value from 0.49 to 0.41 among demo clients and 0.47 to 0.37 among training participants further highlights the crop specialization during the HARVEST period.

Furthermore, we reach the same conclusion using the alternative diversification measure -- the Entropy Index. This measures inequality, derived as the sum of the product of crop area share and logarithm to crop area share, which yields values ranging from zero to 1. Crop shares approaching 1 lead to a lower EI (high negative value), and those approaching zero lead to a high EI (low negative value) suggesting strong diversification. Result in Table 15 shows a decrease in EI value from -0.48 to -0.64 among demo clients only, indicating that the Commercial Horticulture program has more effects among demo clients leading to crop specialization rather than crop diversification since the HARVEST project interventions.

Table 15. The impact of the Commercial Horticulture program on crop diversification.

Indicators	**Before HARVEST (2010-2011)**				**After HARVEST (2015-2016)**				**Mean differences**			
	Demo clients		Training participants		Demo clients		Training participants		Demo clients		Training participants	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	[C-A]		[D-B]	
	[A]		[B]		[C]		[D]		*t*-value	*p*-value	*t*-value	*p*-value
Number of vegetable crops grown	265	2.10 (1.96)	77	2.40 (2.10)	265	2.52 (1.34)	77	2.30 (1.30)	2.68	0.007	0.49	0.618
Diversified crops (%)	215	70.60 (45.70)	61	62.10 (48.90)	264	78.3 (41.3)	77	65.6 (47.8)	1.73	0.084	0.65	0.517
Herfindahl Index	264	0.51 (0.36)	77	0.53 (0.37)	263	0.59 (0.27)	77	0.63 (0.30)	3.37	0.000	2.71	0.008
Crop Diversification Index (Simpson)	264	0.49 (0.36)	77	0.47 (0.37)	263	0.41 (0.27)	77	0.37 (0.30)	3.37	0.000	2.71	0.008
Entropy Index	264	-0.48 (0.51)	77	-0.53 (0.57)	263	-0.64 (0.46)	77	-0.55 (0.48)	3.91	0.000	1.01	0.313

Determinants of household and commercial horticulture income

In this section, we used the ordinary least square (OLS) method to answer the question "What factors determine the household and commercial horticulture income?" In Table 16, we present the parameter estimates for the marginal value of the overall household and net commercial horticulture incomes in the overall sample; in Table 17, we disaggregated our analysis into two groups by Commercial Horticulture participation status -- demo clients and training participants. In both analyses, we transformed the dependent variable -- income -- into the natural log form, so the estimated regression coefficients measure the percentage change in incomes for a unit change in the explanatory variables. The explanatory variables include household demographic characteristics, Commercial Horticulture program participation, cultivated land area and farmers' perceptions about the HARVEST project.

The estimates of the overall sample (Table 16) are presented as follows:

Engaging in the Commercial Horticulture program had a significant and positive effect on overall household and net commercial horticulture incomes. The average increase in household income for each demo client household was 29 percent.

Younger farmers had significantly higher household incomes than did older participants. This means that overall household income decreases as the farmer's age increases. Results in Table 16 show that the overall household income declines by 1.7 percent for every additional year of age. This indicates that older farmers are less likely than younger farmers to adopt new technology. This is true possibly because young farmers in general are more flexible, exposed to new ideas, and likely to adopt innovations and bear more risk than their older counterparts.

The effect of family labor on income is positive and significant. An additional household member working in horticulture increases net commercial horticulture income by about 10.5 percent and overall household income by 6.5 percent. This incremental effect can happen because every additional household member can fulfill the seasonal demand for labor during planting, irrigating and other cultivation practices, leading to higher production and income.

Permanent work, self-employment, rice production and aquaculture have shown positive and significant effects on overall household income. As observed in Table 16, households participating in permanent work have overall household incomes 91 percent higher than those who were not involved in this kind of employment. Those with self-employment, rice production and fishing had about 73 percent, 65 percent and 44 percent higher incomes, respectively, compared with households with no access to those income sources.

There is a visible effect of climate change on commercial horticulture production in Cambodia as evidenced by the fact that farmers saw droughts and floods as a major problem. Commercial Horticulture participants who perceived droughts/floods as a major problem had 42 percent and 50 percent less overall income and commercial horticulture income than those considering droughts/floods as a minor problem. Awareness programs about climate change and its effects and adaptation strategies could help reduce the effects of droughts/floods as well as insects/disease problems among farming communities in rural Cambodia.

Table 16. OLS estimates of the determinants of household and commercial horticulture incomes.

Variables	Log of overall HH income	Log of net CH income	Log of net CH income per m^2
Demo client (1=Yes)	0.289*	1.021**	0.063
	(0.14)	(0.20)	(0.04)
Respondent age (years)	-0.017**	-0.007	-0.002
	(0.00)	(0.01)	(0.00)
Engaged in CH production (number of people)	0.169**		-0.027*
	(0.04)		(0.01)
HH size (number of people)	0.065*	0.105**	0.015
	(0.03)	(0.03)	(0.01)
Rice production (1=Yes)	0.647**		
	(0.11)		
Fishing (1=Yes)	0.438*		0.060
	(0.18)		(0.03)
Self-employed (1=Yes)	0.734**	-0.265	
	(0.12)	(0.15)	
Livestock raising (1=Yes)		-0.377*	-0.039
		(0.15)	(0.03)
Permanent worker (1=Yes)	0.910**	-0.241	-0.073*
	(0.13)	(0.17)	(0.03)
Other sources (1=Yes)	0.726**		0.093*
	(0.14)		(0.05)
Unprofitable CH enterprise (1=Yes)	-0.183	-0.372*	-0.069*
	(0.13)	(0.15)	(0.03)
Theft of vegetables (1=Yes)	0.560		0.399**
	(0.29)		(0.12)
Lack of technical assistance (1=Yes)	-0.406*	-0.535*	-0.069*
	(0.18)	(0.24)	(0.03)
Lack of land for expansion (1=Yes)	-0.210		-0.117**
	(0.14)		(0.04)
Droughts/floods as major problem (1=Yes)	-0.420**	-0.501**	
	(0.14)	(0.14)	
Participated in HARVEST rice production (1=Yes)	-0.351	0.641*	0.091
	(0.21)	(0.29)	(0.07)
Participated in nutrition/feeding program (1=Yes)	-0.225*	-0.452**	-0.067*
	(0.11)	(0.14)	(0.03)
Participated in HARVEST input supply program (1=Yes)	0.822**		
	(0.20)		
Participated in HARVEST horticulture program (1=Yes)		0.470*	0.092
		(0.24)	(0.05)
Log of vegetable cultivated area		0.514**	-0.041**
		(0.05)	(0.01)
Credit was major problem (1=Yes)		0.333	
		(0.20)	
Input prices as major problem (1=Yes)		0.441**	
		(0.15)	
Constant	6.970**	2.091**	0.718**
	(0.26)	(0.43)	(0.12)
Observations	540	302	334
Adjusted R-square	0.336	0.664	0.375

Robust standard errors in parentheses; village fixed effects included; * $p < 0.05$, ** $p < 0.01$.
CH= commercial horticulture. HH=Household.
Source: Cambodia Commercial Horticulture Survey, 2016.

The area under commercial horticulture crops is positively and significantly associated with commercial horticulture income but negatively correlated with land productivity. Results show that each additional hectare increase in vegetable area could lead to about a 51 percent increase

in commercial horticulture income but a 4 percent decrease in net commercial horticulture income per square meter. This finding supports the inverse productivity relationship consistent with production economics literature, which posits that smaller farms are more productive than large farms (Barrett *et al*., 2010). Generally, measurement error may introduce a spurious inverse relationship between size and productivity. For example, if farmers with smaller plots and farms systematically over-report the size of their farms or plots -- perhaps because land is a measure of prestige -- one is likely to find a spurious inverse relationship between size and productivity.

Farmers' participation in HARVEST rice production and HARVEST horticulture (home garden) programs showed positive effects on commercial horticulture incomes, with incomes of participants 64 percent and 47 percent higher, respectively, than those of farmers who did not participate in such programs.

In addition, participation in the HARVEST input supply program and the nutrition/feeding program showed opposite effects on income. A significant and positive effect was observed from participation in the HARVEST input supply program -- 82 percent higher income -- and a negative effect from participation in the nutrition/feeding program -- 23 percent and 45 percent decreases in overall household income and CH income, respectively.

In Table 17, we present the disaggregated analysis of income by demo clients and training participants. Both the overall household income and commercial horticulture income vary with Commercial Horticulture program participation status, with the net commercial horticulture income of training participants significantly lower than that of demo clients. For example, as reported in Table 17, household size and income earners (number of working people) have positive and statistically significant effects on CH income among demo clients, with 12 percent and 18 percent higher incomes, respectively. In contrast, household size and income earners had negative and significant effects on CH income among training participants, with 16 percent and 46 percent lower incomes.

Household size had a positive effect on net CH income and income productivity (income per m^2) among demo clients. As shown in Table 17, for every additional member in a household, the net CH income and income per unit of land would increase by 12 percent and 3.5 percent, respectively.

The effects of self-employment and livestock raising on overall income appeared to be positive in both groups, with 0.7 percent and 0.3 percent higher incomes among demo clients, respectively.

The effect of rice production, fishing and other income sources is positive and higher within the demo clients compared with the training participants. The opposite is true for permanent work, suggesting that promoting permanent work to training participants is likely to generate high income gain. Note that the training participants had significantly higher participation in permanent work, particularly in salary-based employment, than the demo clients.

The vegetable area had a positive and significant effect on net commercial horticulture income, with the higher effect among training participants -- 40 percent for demo clients and 81 percent for training participants. This finding supports the inverse productivity relationship consistent with production economics literature, which posits that smaller farms are more productive than large farms. Demo clients cultivated larger areas (0.42 ha on average) than the training

participants (0.17 ha).

Table 17. OLS estimates of household and commercial horticulture incomes by Commercial Horticulture program participation.

Variables	Demo clients			Training participants		
	Overall HH income	Net CH income	Net CH income per m^2	Overall HH income	Net CH income	Net CH income per m^2
Respondent age (years)	-0.007		-0.003*	-0.020**	0.024**	-0.003*
	(0.01)		(0.00)	(0.00)	(0.01)	(0.00)
Engaged in CH production (# of people)	0.172**		-0.022	0.124*	0.548**	-0.022
	(0.06)		(0.01)	(0.05)	(0.06)	(0.01)
HH size (number of people)	0.061	0.122**	0.035**	0.056	-0.163*	0.035**
	(0.04)	(0.04)	(0.01)	(0.04)	(0.06)	(0.01)
Income earners in the HH (# of people)	0.107	0.179*			-0.460**	
	(0.06)	(0.07)			(0.07)	
Rice production (1=Yes)	0.006**	0.002	0.000	0.008**	0.003	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Fishing (1=Yes)	0.008**	0.004	0.001**		0.012**	0.001**
	(0.00)	(0.00)	(0.00)		(0.00)	(0.00)
Self-employed (1=Yes)	0.007**	-0.004**	-0.001	0.007**	0.006**	-0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Livestock raising (1=Yes)	0.003*			0.003*		
	(0.00)			(0.00)		
Permanent worker (1=Yes)	0.005**	-0.004*	-0.001*	0.012**	0.018**	-0.001*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Other sources (1=Yes)	0.008**		0.001	0.006**	0.011**	0.001
	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Unprofitable CH enterprise (1=Yes)		-0.004*	-0.001		-0.009**	-0.001
		(0.00)	(0.00)		(0.00)	(0.00)
Theft of vegetables (1=Yes)	0.008**		0.003**		0.015*	0.003**
	(0.00)		(0.00)		(0.01)	(0.00)
Lack of technical assistance (1=Yes)			-0.001	-0.010**	-0.033**	-0.001
			(0.00)	(0.00)	(0.00)	(0.00)
Lack of land for expansion (1=Yes)	-0.002	-0.005**	-0.001*		0.010**	-0.001*
	(0.00)	(0.00)	(0.00)		(0.00)	(0.00)
Droughts/floods as major problem (1=Yes)	-0.003*	-0.005**	-0.001		-0.004*	-0.001
	(0.00)	(0.00)	(0.00)		(0.00)	(0.00)
Participated in HARVEST rice production (1=Yes)				-0.005	-0.007	
				(0.00)	(0.00)	
Participated in nutrition/feeding program (1=Yes)	-0.004**	-0.004*	-0.001*	-0.002	-0.028**	-0.001*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Participated in HARVEST input supply program (1=Yes)	0.004					
	(0.00)					
Participated in HARVEST aquaculture program (1=Yes)				-0.003	0.021**	
				(0.00)	(0.00)	

Table 17. Continued…

Variables	Demo clients			Training participants		
	Overall HH income	Net CH income	Net CH income per m^2	Overall HH income	Net CH income	Net CH income per m^2
Participated in HARVEST horticulture program (1=Yes)					0.037**	
					(0.00)	
Log of vegetable cultivated area		0.400**	-0.041		0.811**	-0.041
		(0.08)	(0.02)		(0.03)	(0.02)
Credit was major problem (1=Yes)	0.003	0.004				
	(0.00)	(0.00)				
Borrowed money (1=Yes)				-0.005*	-0.006*	
				(0.00)	(0.00)	
Input prices as major problem (1=Yes)		0.006**			-0.020**	
		(0.00)			(0.00)	
Disease was major problem (1=Yes)				0.008**	0.014**	
Insects were major problem (1=Yes)				-0.007**	-0.002	
				(0.00)	(0.00)	
Lack of labor as major problem (1=Yes)					-0.020*	
					(0.01)	
Market price fluctuation (1=Yes)					0.020**	
					(0.00)	
Farm inputs difficult to find (1=Yes)				0.036**		
				(0.01)		
Difficult to find good buyer (1=Yes)					0.003	
					(0.00)	
Seasonal farmer due to lack of water (1=Yes)					0.006**	
					(0.00)	
Member of farmer producer group (1=Yes)					0.017**	
					(0.00)	
Constant	6.695**	3.219**	0.825**	6.787**	-2.201**	0.825**
	(0.33)	(0.74)	(0.22)	(0.32)	(0.55)	(0.22)
Observations	283	239	262	257	63	262
R^2	0.392	0.623	0.378	0.514	0.996	0.378
Adjusted R-square	0.297	0.535	0.227	0.427	0.981	0.227

Standard errors in parentheses; dependent variables in log; village fixed effects included; * $p < 0.05$, ** $p < 0.01$.
CH= commercial horticulture. HH=Household.
Source: Cambodia Commercial Horticulture Survey, 2016.

As we found in our overall sample in Table 16, a similar pattern appeared with climate change effects on income. Droughts/floods had a negative and significant effect, reducing commercial horticulture income by about 0.5 percent in both participation groups.

Participation in HARVEST horticulture and aquaculture programs was found to have positive and significant effects on CH income among training participants (about 4 percent and 2 percent, respectively), but a negative effect for those who participated in the nutrition/feeding program (3 percent).

Farmers' contact with extension agents is expected to have a positive effect on adoption of modern technology and increase farm income. Results in Table 17 show that lack of technical assistance appeared to be negative and statistically significant among training participants. This indicates that having fewer contacts with extension agents reduces net CH income by 3.3 percent. Availability of technical assistance is, therefore, vital, particularly because it exposes farmers to information and new ideas about methods of cultivation that eventually increase farm productivity and income.

Membership in farmer producer groups plays an important role because members share technical and market information. Membership in FPGs had a positive and significant effect on net CH income among training participants, increasing income by almost 2 percent. Encouraging such membership is particularly important for training participants because very few farmers from this group are involved in FPGs, and they lack technical information and access to market compared with demo clients.

Factors Explaining the Adoption of Commercial Horticulture Technologies

Understanding adoption behavior relies not only on the characteristics of adopters and non-adopters but also on the factors affecting the decision and the intensity of adoption. In this study, we focus on the factors affecting farmers' decisions to adopt certain technologies. We define adoption as the extent to which a new technology is utilized over time.

To estimate the factors explaining the adoption decision, we used a set of stepwise probit models where the dependent variable is whether the farmer adopted or did not adopt certain technology. With the limited dependent variable (adoption), a value of 1 was assigned to those who adopted a technology and zero to those who did not. The regression results are reported in Table 18 for planting techniques, Table 19 for water and soil management techniques, and Table 20 for crop and postharvest management. Marginal effects are interpreted as a unit change in the independent variable resulting in the likelihood of adoption by the value of the particular coefficient.

Planting technologies

Three main planting technologies – raised beds, hybrid seeds and trellising – were selected to analyze the factors of adoption between Commercial Horticulture program participation groups.
Factors explaining the adoption of commercial horticulture planting technologies vary by type of Commercial Horticulture program participation. As indicated in Table 18, the results confirm that the demo clients were more likely to adopt planting technologies than their counterparts, the training participants. For instance, being a demo client increased the probability of adopting raised beds, hybrid seeds and trellising by about 42 percent, 24 percent and 50 percent, respectively, over the training participants.

Given that most of the planting techniques are labor-intensive, the adoption of these technologies is positively associated with the number of household members engaged in commercial horticulture production. Result shows that, for each additional member added in the household, the likelihood of adopting raised beds and trellising technology among demo clients will increase by 11 percent and 13 percent, respectively, while training participants will adopt these technologies by 7 percent. In general, greater adoption occurred among the demo clients in all types of technologies.

Gender differences are apparent in technology adoption in commercial horticulture farming in rural Cambodia. Adoption of raised beds and trellising technology appeared to be significant but negatively associated with female farmers. Result shows that female farmers were 7 and 10 percent less likely to adopt raised beds and trellising technology than male farmers, respectively. This might be the case in rural Cambodia because most of the agricultural technologies are manually operated and require more physical labor than female farmers can provide. The problem of insects and diseases had a significant effect on the adoption of planting

techniques, especially hybrid seeds, raised beds and trellising. Greater insect infestation led to increased adoption of hybrid seeds among demo clients by about 0.2 percent. Plant disease problems increased adoption of raised beds and trellising by 0.2 percent and 0.1 percent, respectively, among demo clients and training participants. Similarly, lack of technical assistance reduced the probability of adopting planting technologies in both participation groups, with greater effect among demo clients.

Table 18. Probit estimates of the factors influencing the adoption of planting technologies for commercial horticulture production.

Variables	Demo clients			Training participants			Overall		
	Raised beds	Hybrid seeds	Trellising	Raised beds	Hybrid seeds	Trellising	Raised beds	Hybrid seeds	Trellising
Demo client (1=Yes)							0.421***	0.238**	0.501***
							(0.06)	(0.08)	(0.06)
Female farmer (1=Yes)	-0.067	-0.038	-0.049	0.022	-0.010	-0.058	-0.073*	-0.037	-0.104***
	(0.04)	(0.06)	(0.05)	(0.04)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)
Respondent age (years)	-0.002								
	(0.00)								
Farmers' education (years of schooling)	-0.009		0.012						
	(0.01)		(0.01)						
Engaged in CH production (number of people)	0.107***		0.126***	0.069***	0.029***	0.069***	0.124***	0.046***	0.107***
	(0.01)		(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
HH size (number of people)						-0.023**			-0.020**
						(0.01)			(0.01)
Self-employed (1=Yes)		-0.001			-0.002***			-0.001*	
		(0.00)			(0.00)			(0.00)	
Fishing (1=Yes)				-0.002*	-0.001***				
				(0.00)	(0.00)				
Permanent worker (1=Yes)	-0.001**	-0.001			-0.000*		-0.001*	-0.001*	-0.000
	(0.00)	(0.00)			(0.00)		(0.00)	(0.00)	(0.00)
Insects were major problem (1=Yes)		0.002***	-0.001*		0.000**			0.001***	
		(0.00)	(0.00)		(0.00)			(0.00)	
Lack of technical assistance (1=Yes)		-0.004**			0.001*			-0.001	
		(0.00)			(0.00)			(0.00)	
Technology promoted not appropriate (1=Yes)			-0.004**			-0.001			-0.003**
			(0.00)			(0.00)			(0.00)
Observations	232	287	258	257	202	215	506	545	535
Pseudo R-square	0.44	0.16	0.29	0.36	0.70	0.44	0.50	0.28	0.46

Marginal effects; standard errors in parentheses; village fixed effects included; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
CH= commercial horticulture. HH=household.
Source: Cambodia Commercial Horticulture Survey, 2016.

Water and soil management technologies

In this section, we considered four technologies -- organic mulch, plastic mulch, drip irrigation and soluble fertilizer – for our analysis. The demographic and Commercial Horticulture program dimensions of the adoption of water and soil management technologies are reported in Table 19. The main findings on the determinants of adopting commercial horticulture technologies for water and soil management are as follows.

Adoption of water and soil management technologies was lower among female farmers. Female farmers are less likely to adopt water and soil management technologies, particularly plastic mulch and soluble fertilizer, by about 7 to 10 percent in the overall sample; a positive effect appeared for soluble fertilizer adoption by 9 percent of training participants. There was no gender difference in the adoption of soil and water management technologies among demo clients, but among training participants, female farmers were less likely to adopt these technologies.

A farmer's age had differential adoption effects, with older demo clients less likely to adopt organic mulch and older training participants more likely to adopt soluble fertilizer technology. Mulching technology demands more labor, which older farmers are unlikely to supply, and soluble fertilizer is easy to use and therefore popular among older farmers.

The number of family members engaged in commercial horticulture farming was positively associated with the adoption of all types of soil and water management technologies in rural Cambodia, irrespective of the participation group. The results show that, on an average, the probability of adopting these technologies will increase by 10 percent if a member of household engaged in commercial horticulture farming

As we expected, the farmer's level of education played a positive role in the adoption of technologies. As reported in Table 19, every additional year of education increased the likelihood of adopting plastic mulch and soluble fertilizer by 3 percent among training participants. This is reasonable because educated people generally can allocate resources properly and enhance farm income sources, and better able to process information faster than less educated ones. The adoption of water and soil management technologies was also driven by the prevailing production risks. Results show that high disease infestation increased the likelihood of adoption of drip irrigation and soluble fertilizer among demo clients and increased the probability of adoption of organic mulch and soluble fertilizer among the training participants.

Table 19 supports the conclusion that promoting socially unacceptable and inappropriate technologies would result in limited technology adoption. For instance, demo clients who perceived that the HARVEST project promoted inappropriate technologies were less likely to adopt plastic mulch than those who did not have such a perception about the HARVEST project.

Contrary to our expectation, training participants were 0.2 percent more likely to adopt soluble fertilizer even though they lacked technical assistance, and demo clients had a 0.2 percent higher likelihood of adopting organic mulch, even though they perceived that commercial horticulture was unprofitable. This can be true for organic mulch, which is less capital-intensive than plastic mulch, and therefore does not severely affect the profitability of a

commercial horticulture enterprise, but the same explanation may not be applicable for soluble fertilizer.

Participation in other income-generating activities such as self-employment and fishing seem to be negatively associated with the adoption of agricultural technologies but in a very minor way. Farmers participating in these activities had a 0.1 percent and 0.2 percent lower probability of adopting soluble fertilizer and organic mulching, respectively.

Table 19. Probit estimates of the factors explaining the adoption of water and soil management technologies for commercial horticulture production.

Variables	Demo clients				Training participants				Overall sample			
	Organic mulch	Plastic mulch	Drip irrigation	Soluble fertilizer	Organic mulch	Plastic mulch	Drip irrigation	Soluble fertilizer	Organic mulch	Plastic mulch	Drip irrigation	Soluble fertilizer
Demo client (1=Yes)									0.265***	0.468***	0.574***	0.543***
									(0.04)	(0.08)	(0.09)	(0.06)
Female farmer (1=Yes)	-0.004	-0.027	-0.043	-0.054	0.016	0.019	0.021	0.088*	-0.036	-0.091**	-0.077*	-0.091**
	(0.06)	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)
Respondent age (years)	-0.006*			-0.002		0.002		0.005**	-0.002*			
	(0.00)			(0.00)		(0.00)		(0.00)	(0.00)			
HH size (number of people)		-0.017	-0.012			-0.017	-0.010			-0.013	-0.015	-0.011
		(0.01)	(0.01)			(0.01)	(0.01)			(0.01)	(0.01)	(0.01)
Engaged in CH production	0.081***	0.098***	0.105***	0.096***	0.035***	0.078***	0.045***	0.037*	0.093***	0.110***	0.109***	0.099***
(number of people)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
Farmer's education (years of		0.013			0.007	0.026***	0.010*	0.028***		0.009	0.007	0.007
schooling)		(0.01)			(0.00)	(0.01)	(0.00)	(0.01)		(0.00)	(0.00)	(0.00)
Fishing (1=Yes)					-0.002**							
					(0.00)							
Self-employed (1=Yes)						-0.001		-0.001*				
						(0.00)		(0.00)				
Lack of technical assistance	-0.002			0.002				0.002**				
(1=Yes)	(0.00)			(0.00)				(0.00)				
Unprofitable CH enterprise	0.002*	0.001										
(1=Yes)	(0.00)	(0.00)										
Technology promoted not		-0.003*	-0.002	-0.002					-0.001	-0.004***	-0.003**	-0.003**
appropriate (1=Yes)		(0.00)	(0.00)	(0.00)					(0.00)	(0.00)	(0.00)	(0.00)
Disease was major problem		0.001	0.001*	0.001*	0.001***		0.001*		0.001*	0.001***	0.001***	0.001***
(1=Yes)		(0.00)	(0.00)	(0.00)	(0.00)		(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Insects were major problem	0.001	-0.001	-0.001	-0.001*		0.001*		0.001**	0.001			
(1=Yes)	(0.00)	(0.00)	(0.00)	(0.00)		(0.00)		(0.00)	(0.00)			
Observations	280	265	255	255	246	126	203	114	545	525	520	520
Pseudo R-square	0.11	0.26	0.26	0.25	0.41	0.55	0.38	0.45	0.34	0.47	0.46	0.43

Marginal effects; standard errors in parentheses; village fixed effects included; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
CH= commercial horticulture. HH=household.
Source: Cambodia Commercial Horticulture Survey, 2016.

Crop and postharvest management technologies

Four crop and postharvest management technologies -- crop rotation, cultural practices, weed control and postharvest technologies -- were analyzed. In Table 20, we report the estimates of the factors affecting adoption decisions on crop and postharvest technologies among the demo clients and training participants in rural Cambodia. These results highlight the following key findings:

In the overall sample, the probability of adopting crop rotation, cultural practices, weed control and postharvest technologies increased with participation as demo clients by 16 percent, 12 percent, 20 percent and 6 percent, respectively. These effects are important and suggest that adoption behavior changes with the availability of technical support and market information. Here, we assume that demo clients were supported by the HARVEST project with demonstration materials and inputs, so their adoption rate was higher than that of training participants.

Female farmers were less likely to adopt cultural practices and postharvest technology by about 7 percent each (Table 20). This is possibly because these technologies need extra time and physical labor, and females probably needed to take care of household chores and may not have been able to devote extra time to follow these technologies, so they perceived that the technologies were not female-friendly.

The number of family members working on the farm had a positive and significant effect on the adoption of crop and postharvest technologies, as did the farmer's education. Farmer's education affected the adoption of postharvest technologies positively, especially among the demo clients, by almost 2 percent.

Results show that disease infestation had a positive influence on the likelihood of adopting crop and postharvest management technologies. These effects appeared to be higher among the training participants in cultural practices (0.2 percent) than among the demo clients, but the effects are very small.

Furthermore, as reported in Table 20, promoting inappropriate technologies did not promote technology adoption. Instead, it had a detrimental effect on adoption.

It is surprising that farmers who perceived a lack of technical assistance were more likely to adopt postharvest technologies among demo clients but it was not significant among training participants.

Farmers participating in off-farm income activities were less likely to adopt farm technologies than those that did not have access to off-farm occupations. For instance, farmers in both groups who earned income as permanent workers had a lower probability of adopting cultural practices and weed control. Similarly, training participants with such occupations were 0.1 percent less likely to adopt weed control techniques.

Table 20. Probit estimates of the factors explaining the adoption of crop and postharvest management technologies for commercial horticulture production.

Variables	Demo clients				Training participants				Overall sample			
	Crop rotation	Cultural practices	Weed control	Post-harvest	Crop rotation	Cultural practices	Weed control	Post-harvest	Crop rotation	Cultural practices	Weed control	Post-harvest
Demo client (1=Yes)									0.165**	0.118**	0.202***	0.062
									(0.06)	(0.04)	(0.03)	(0.07)
Female farmer (1=Yes)	0.063	-0.044	-0.004	-0.053	0.007	0.012	0.006	-0.022	-0.015	-0.073*	-0.048	-0.064*
	(0.05)	(0.05)	(0.05)	(0.05)	(0.03)	(0.04)	(0.04)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)
Farmer's education (years of schooling)	0.018*								0.008			
	(0.01)								(0.00)			
Engaged in CH production (# of people)	0.098***	0.072***	0.084***	0.127***	0.017*	0.045**	0.049**	0.029***	0.095***	0.105***	0.111***	0.105***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
HH size (# of people)								-0.011	-0.016*	-0.014	-0.018	-0.016
								(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Permanent worker (1=Yes)		-0.001*	-0.002**		-0.001		-0.001*	-0.001	-0.001	-0.001	-0.001**	-0.001
		(0.00)	(0.00)		(0.00)		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Fishing (1=Yes)		0.002			-0.001*						-0.001	-0.001
		(0.00)			(0.00)						(0.00)	(0.00)
Disease was major problem (1=Yes)	0.001*	0.001*	0.001**		0.001***	0.002***	0.001**	0.001***	0.002***	0.002***	0.002***	0.001***
	(0.00)	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Insects were major problem (1=Yes)	-0.001											
	(0.00)											
Technology promoted not appropriate (1=Yes)	-0.004*	-0.003*	-0.002*	-0.005***				-0.002*	-0.002	-0.002*	-0.003*	-0.003***
	(0.00)	(0.00)	(0.00)	(0.00)				(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Lack of technical assistance (1=Yes)				0.003*	0.001			0.001				0.001
				(0.00)	(0.00)			(0.00)				(0.00)
Observations	282	259	256	285	246	242	242	233	540	519	519	545
Pseudo R-square	0.16	0.17	0.19	0.18	0.40	0.30	0.32	0.54	0.36	0.37	0.42	0.41

Marginal effects; standard errors in parentheses; village fixed effects included; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
CH= commercial horticulture. HH=household.
Source: Cambodia Commercial Horticulture Survey, 2016.

Conclusions and Policy Recommendations

Horticultural farming is by far the main income source of smallholder farmers in rural Cambodia. As a priority program under Cambodia HARVEST, the Commercial Horticulture program was implemented to reduce the gap between supply and demand of vegetables through local production by focusing on innovative technologies and solutions to increase farm productivity and income. This evaluation aimed at assessing the effectiveness of the Commercial Horticulture program in changing knowledge, attitude and behavior related to commercial horticulture farming among demo clients and training participant farmers, and increasing incomes and economic benefits.

(a) Changing knowledge, attitude and behavior related to commercial horticulture farming

Commercial horticulture farming is an important source of income for smallholder farmers in rural Cambodia. Farmers' likelihood of participating in commercial horticulture activities increases with remediation of institutional and non-institutional hurdles to enter commercial horticulture farming. This ultimately leads to increased household income and improved food security of farming households. In this study, the Commercial Horticulture program met its objectives of generating income (self-employment or employment at home) and improving food security through increased food production and consumption.

As commercial vegetable farming in the HARVEST area has just begun, farmers are facing several barriers such as product market price fluctuation, insects/diseases, seasonal water shortage for farming, and climatic disasters (floods and droughts).

Our policy recommendation would be: connect farmers (mostly among the demo clients) to good buyers for their produce and determine appropriate product-market combinations. This would help reduce input prices and transaction costs, and increase product prices by ensuring market participation of producer farmers.

Farmers' perceptions toward the Commercial Horticulture program under Cambodia HARVEST varied with their participation status in the program. In general, farmers had a positive attitude toward the HARVEST project. As mentioned by the majority of commercial horticulture farmers, the HARVEST project did provide adequate information to start commercial horticulture production on their farms, and whatever was provided was practical or hands-on learning. Also, they perceived that the instructors were knowledgeable enough in commercial horticulture production. To some extent, HARVEST staff members did provide some kind of market information and linkages with buyers to sell their produce. Results also show that weak farm-firm relationships or linkages significantly reduce a commercial horticulture enterprise's profitability.

It is imperative that Cambodia provides technical skills training to extension workers to make them more competent in commercial horticulture technology. It is also imperative to encourage private sector service providers to get involved in disseminating horticulture technology as well as linking farmers to markets. Because fewer farmers indicated that they search information on YouTube, Facebook and other sources, promoting the use of information communication technologies (ICTs) is also suggested.
Study results show that participation in FPGs and commercialization of horticulture products through the FPGs varied with participant group. A significantly larger proportion of demo

clients than training participants belonged to FPGs and took advantage of selling their produce through the groups. Although over two out of five (43.9 percent) farmers from demo group and 28.8 percent from training participants were aware of FPGs, only 37.7 percent and 5.6 percent farmers from each group, respectively, are members of FPGs. This limited participation in groups suggests that there is a need for great effort in encouraging group formations for collective action. Through collective action growers can improve their bargaining power to get higher prices for their produce, lower transaction costs and better deals (increase bargaining power) with the buyers. By working together, farmers can have access to goods and services that improve the performance of their individual farms.

The participation rate of farmers in other HARVEST assistance programs such as the nutrition/child feeding program was satisfactory. Although participation in other programs was low, it did not vary with Commercial Horticulture program participation except for the input supplier program, which had a significantly higher proportion of demo clients than training participants as participants. This finding suggests that ample information about the project before implementation should be provided and farmers encouraged to participate in the program. This helps build a favorable and convincing environment between project people and the real beneficiaries.

We found a positive impact of the HARVEST program on technology and knowledge transfer. The majority of respondents -- 90 percent of demo clients and 50 percent of training participants -- received technical assistance. In general, farmers had limited access to extension services, as indicated by an average value of responses below 3 (out of 1 to 5).

In general, both groups of farmers learned about commercial horticulture technologies in rural Cambodia, but awareness and adoption of vegetable-related agricultural techniques varied with Commercial Horticulture program participation. Our results show that the proportion of demo client farmers learning and adopting production techniques was higher than that of training participants. Demo clients were likely to be more interested in the commercial horticulture technologies they learned about, given their greater access to technical support by the HARVEST program. Results show that seedling (nursery) production (91.7 percent), raised beds (90.7 percent), fertilizer starter solution (87.9 percent), trellising (87.5 percent) and plastic mulch (87.2 percent) were the top five techniques learned by commercial horticulture farmers; the technology of hybrid/open-pollinated seeds was the technology least learned by vegetable farmers in rural Cambodia. A similar pattern is observed on technology adoption, except that the fertilizer starter solution is the third most adopted technology in the place of plastic mulch. Again, higher technology adoption was observed among the demonstration farmers than among the training participants.

It is noteworthy that modern technologies such as drip irrigation, soluble fertilizer injected through drip irrigation and fertilizer starter solutions have high learning and adoption rates compared with traditional techniques such as organic (rice straw) mulch and weed control, suggesting that, although these modern technologies require additional investments in time and resources, farmers are willing to adopt them to achieve higher production and profit.

Our recommendation is that dissemination of modern technologies through on-farm demonstrations and farmer trainings would help generate motivation for learning about and adopting modern technologies and increase household income.

(b) Effects of Commercial Horticulture program interventions on household income and other economic benefits

The implementation of commercial horticulture farming resulted in significant increases in gross commercial horticulture income and cropped area but not in returns to land or economic productivity in general (gross commercial horticulture income per m^2) between 2010 and 2015. In each period, the gross income and vegetable cultivated area varied significantly with Commercial Horticulture program participation, with demo clients outperforming training participants. The returns to land did not vary with Commercial Horticulture program participation nor over time.

Demographic characteristics and asset possession affected households' welfare. Growing commercial horticulture crops, as measured by the number of household members engaged in vegetable farming, had a significant and positive effect on overall household and commercial horticulture incomes, and younger farmers had significantly higher household incomes than their older counterparts.

The area cultivated in commercial horticulture crops was positively and significantly associated with commercial horticulture income but negatively correlated with land productivity. This finding supports the inverse productivity relationship and is consistent with production economics literature, which posits that smaller farms are more productive than large farms.

Improvements in crop marketing were observed between the two periods, suggesting a positive impact of the Commercial Horticulture program in increasing market access irrespective of the participation groups.

Findings show that commercial vegetable farmers in Cambodia are moving toward crop specialization. This was measured through the CDI and Entropy Index, which found that the project participants had the same level of crop diversification as the control group. This suggests that growing one crop commercially is seen as more profitable than growing multiple crops at the same time.

What drives the decision to adopt commercial horticulture technologies?

Factors explaining the adoption of commercial horticulture technologies varied by socioeconomic factors, demographic characteristics, type of participation and type of technology. In general, younger farmers were more likely to adopt planting technologies than older training participants. This is possibly because young farmers have higher levels of education and are more flexible and interested in trying new things, and hence likely to adopt new technologies than older farmers. A gender gap in technology adoption is apparent -- female farmers are less likely to adopt technologies because technologies such as raised seed beds and trellising are labor-intensive.

The adoption of planting technologies (raised beds, hybrid seeds, trellising) varied with the demographic characteristics of the farm households. Results show that the probability of adopting planting technologies increased with the number of household members engaged in commercial horticulture and decreased with the household size, particularly among training participants for trellising technology. This is perhaps because family members from training participant households diverted their family labor to other technologies or non-farm activities. Also, planting technologies tended to be labor-intensive and be adopted more by demo clients than training participants.

As expected, the level of education and the adoption of technology had a positive association, suggesting that the probability of adopting commercial horticulture technologies increases with the level of education because educated farmers are typically assumed to be better able to process information and search for appropriate technologies to relieve their production constraints. The belief is that education gives farmers the ability to perceive, interpret and respond to new information much faster than their counterparts having less education. The result suggests that the educational level of farmers and decision makers influences the adoption of commercial horticulture technology.

The adoption of soil and water management technologies was also driven by the prevailing production risks. Results show that high disease infestation increased the likelihood of adoption of drip irrigation and soluble fertilizer among demo clients, and increased the probability of adoption of organic mulch and soluble fertilizer among the training participants. Also, insect and disease problems significantly affected the adoption of planting techniques, especially hybrid seeds, raised beds and trellising. These results suggest that drought/insect/disease-resistant seed varieties and adaptation strategies should be developed, disseminated and implemented in the affected areas.

Finally, ineffective and weak farmers-buyers linkages pose significant challenges to the whole farming system to develop effective cultivation practices and policies. Facilitating farmers in organizing into producer groups/cooperatives and strengthening farmers-buyers linkages can improve farm household production and income. To reduce transaction costs, farmers need to be linked to markets by integrating farmers with potential buyers or collectors. Because Cambodia lacks adequate road networks and market infrastructures connecting production pockets to market centers, building agricultural roads and market networks may contribute to farmers' access to markets and reduce transaction costs, and increase profitability in agriculture and its subsequent impacts on food security and general livelihoods of rural farmers.

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