FISH ON FARMS

INTEGRATION OF SMALL-SCALE AQUACULTURE WITH HOMESTEAD FOOD PRODUCTION FOR IMPROVED HOUSEHOLD FOOD SECURITY & NUTRITION IN RURAL CAMBODIA

Fish on Farms

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Table of Contents

List of Annexes

1. Monitoring AFS Expected Outcomes.
2. Baseline Survey Report.
3. Endline Survey Report.
4. Monitoring and Evaluation Tools.
5. Dissemination Workshop Report 28-29th Aug 2014.
6. Dissemination Workshop Presentations.
7. Participant List for Fish on Farms Dissemination Workshop.
8. Fish on Farms Nutrition Bulletins.
9. One Pond One Family Policy Brief.
10. Outcome Story for Fish on Farms Project.
11. Case Studies for the Fish on Farms Project.
12. Press Releases Related to the Fish on Farms Project.
13. BCC Materials Produced for the Fish on Farms Project.
14. Environmental Impact Assessments.
15. Cost-Benefit Protocols, Tools & Preliminary Results.
16. Fish Sample Report - Protocol, Tools and Analysis.
17. Training Schedule for Aquaculture, Nutrition and Gender.
18. Research Findings - Presentations and Manuscripts.
19. Gender Analysis Report.
20. Gender Strategy
21. Logic Model.
22. Performance Measurement Framework.

List of Abbreviations

BMC	Biomedical Central
BMI	Body Mass Index
CGIAR	Consultative Group on International Agricultural Research
EIA	Environmental Impact Assessment
FANTA	Food and Nutrition Technical Assistance (III) Project
FiA	Fisheries Administration
FoF	Fish on Farms
HC	Health Center
HFIAS	Household Food Insecurity Access Scale
HFP	Homestead Food Production
HKI	Helen Keller International
IDRC	International Development Research Centre
MDG	Millennium Development Goals
MoH	Ministry of Health
NGO	Non-Governmental Organization
ODOV	Organization to Develop Our Villages
SUN	Scaling-Up Nutrition
UBC	University of British Columbia
VMF	Village Model Farm
WHO	World Health Organisation

1. Executive Summary

The main objective of Fish on Farms (FoF) was "To improve household food security and nutrition outcomes, livelihoods and women's empowerment through an integrated homestead food production (HFP) model using an environmentally sustainable approach." While HFP is not a new approach, there were many unique aspects of this 30-month 'research for development' project, including the addition of household fishponds as part of an innovative model to improve the nutrition and livelihood of women farmers and their families. Fish are culturally acceptable, highly nutritious, and have the potential to generate income for rural subsistence farming households in Cambodia. There are many assumptions made with regard to increasing production of fruits, vegetables, and fish but in actuality, little is known about the impact of household level agricultural interventions on development outcomes, including food security, income, nutritional status, gender empowerment and the environment.

To address this gap in evidence, we designed and rigorously evaluated an integrated model of HFP including fishponds using a three-group randomized control trial design at the household level (300 control, 300 plant-based HFP and 300 HFP + Fish). There were many important research questions asked, most of which we have answered through the final evaluation, some are awaiting the results of further analysis, and others led to more research questions, which is expected from any research study. In less than five months we established 300 fishponds and 600 gardens in targeted households, built around a community support model that included Village Model Farms and a fish hatchery (or fish fingerling nursery in some areas). The establishment of fishponds, with mixed polyculture was in itself an innovative output that had not been attempted before in Cambodia. Small, indigenous, micronutrient-dense fish were raised, frequently harvested and consumed whole, directly providing needed nutrients. Large fish were raised in the same ponds for consumption or sold to generate household income. This design was accomplished with technical input from 3rd party partners, CGIAR's WorldFish and the Fisheries Administration of the Cambodian Ministry of Agriculture, Farm and Fisheries.

Most small scale rural farmers are women who historically practiced basic agricultural techniques with low outputs beyond household needs. Our model for plant-based agriculture introduced new environmentally friendly techniques that increased and diversified production, and in the households with fishponds, made innovative use of the by-products of fish as fertilizer and ponds as a source of irrigation for household gardens. Establishing fish hatcheries through a microcredit scheme proved to be a highly successful component of the project as they became profitable within the time period, and paid back the borrowed funds in full. This has opened the door for expansion and supports the Cambodian government's newly proposed '**Hatchery per Commune'** and **'Pond per Farm'** strategy.

Agricultural productivity was increased in the two HFP intervention groups, leading to a reduction in the percentage of households who reported food shortages the previous month, particularly in the HFP + Fish group where there was an almost 50% reduction in food insecurity. These groups had significantly improved scores on the Household Food Insecurity Access Scale (2.83 vs 4.8) and higher income, with the highest reported mean income in the HFP + Fish group. Of interest was how this extra money was spent as it was used to purchase more animal source foods, oil, eggs, and iodized salt, but also on education expenses. Those in the HFP groups spent less money on vegetables than the control group, as they were able to grow enough in their gardens. Both interventions groups reported consuming more fruits and vegetables and the HFP + Fish households produced and consumed more fish. Collectively, the HFP protocols resulted in improvements in livelihoods for the intervention groups as measured by food production, fruit and

vegetable consumption, food security and income, making households less vulnerable to external shocks.

Our cost-sharing protocol for the establishment of the Village Model Farms and associated hatcheries proved successful which bodes well for future plans for scale-up, incorporating microfinance and enhanced financial and marketing training, particularly for women. Our understanding of gender relations in Cambodia was greatly enhanced through our research, which led to a gender sensitization protocol that had demonstrated impacts on behavior, including successfully increasing men's participation in household and reproductive activities, decreasing women's workload.

We found a high prevalence of anemia at baseline (41%) but further analysis indicated that over half of this was due to hemoglobinopathies limiting the impact a food-based intervention might have. In spite of this, we saw a 10% decrease in the prevalence of anemia in the HFP + Fish group with no change in the control group. In addition there was a decrease by almost 50% in the prevalence of underweight (low BMI) across time among women, with the HFP + Fish group showing the most improvement. We uncovered a startlingly high prevalence of riboflavin and thiamine deficiency among women, with implications for infant mortality where lactating mothers are thiamine deficient. At endline we also found a high prevalence of zinc deficiency (50%) among women of reproductive age, a probable factor in the high prevalence of stunting (30%) among children under five. Collectively, these deficiencies impact not only women but children's health and must be dealt with through interventions and policies if the overall prevalence of undernutrition and its consequences is to be reduced.

There were also challenges to the project and many lessons learned. Randomization itself may have led to some farmers being less committed than if they had chosen the intervention package themselves. When a new factory offered work across the border in Thailand, many women chose to leave their farms and families for cash employment reducing the sample size. We recognize that motivational factors and aspirational beliefs need to be better understood for developmental outcomes to be achieved. With regard to the fishponds themselves, improvements are needed in the design such that they will retain water for a longer period during the dry season. Developing a local, commercial fish feed could lead to improved productivity and increased food security, as currently all is imported other than homemade options the project encouraged.

While the Program Impact Pathway makes assumptions, such that increasing food production will lead to increased intake of nutritious food, both directly and indirectly due to purchases, and that intake will lead to improvements in nutritional status, these are merely assumptions until measurements demonstrate an actual impact. Along the Pathway we were able to measure change at the production, income and food purchase levels as well as encouraging trends in women's nutritional status. The time-frame was not sufficient enough to demonstrate changes from the time of increased production and income to consumption, and the actual measurement of targeted biochemical measures at baseline was too low to show a more significant change in this area, although we did uncover a number of confounding factors such as hemoglobinopathies and other micronutrient deficiencies with implications for programming and policy.

During the 30 months of the program, all project milestones and objectives were met. A highly successful component of the FoF project in terms of sustainability and scalability was the strong involvement of Government Ministries including the Fisheries Administration, which was able to take over from WorldFish by the end of the project. Incorporating successful components of HFP training on agriculture and nutrition into extension worker services, and seeing protocols become policy will ensure the long-term influence of the project on Food Security in Cambodia.

2. The Research Problem

Cambodia has been food secure for nearly a decade, although this is based primarily on rice production and masks great differences at the household level. Household food insecurity and undernutrition stems, in part, from a lack of dietary diversity. Rice, which is low in micronutrients, fat, and limited in protein, accounts for 70% of the daily diet, while animal source foods make up less than 9% of energy intake. As elsewhere in Asia, food insecurity and undernutrition in Cambodia may worsen in the coming years, as food price increases, and population growth, climate change and soil depletion negatively impact the ability of the country to feed its people.

Since 1998, HKI has implemented Homestead Food Production (HFP) programs to increase the availability and consumption of more nutrient-dense food at the household level. HFP enables year round production of micronutrient-rich vegetables and fruit by providing households with training on improved food production techniques and initial farming inputs such as seeds and training. These technical inputs are complemented with behavior change communication and nutrition education with an emphasis on maternal, infant and child nutrition. While plant-based HFP has increased household food production, the impact on nutrition outcomes has been limited without animal source foods. In most areas of Cambodia, fish is a traditional food and plays an important role in the diet and livelihoods of rural households. However, access to fish is limited and may worsen as catch fisheries are declining. The research team hypothesized that improving year round access to fish at the household level through small-scale aquaculture would lead to greater improvements in food security, nutrition and income.

Accordingly, we designed an intervention project, Fish on Farms (FoF), with the overall objective 'To improve household food security and nutrition outcomes, livelihoods and women's empowerment through an integrated homestead food production model using an environmentally sustainable approach'. In our model, small-scale fish polyculture was integrated into the HFP approach, whereby large and small fish are raised together in a household pond. Small fish are micronutrient-dense and can be harvested frequently and consumed whole to provide a direct source of vitamins and minerals, as well as protein and fat. Large fish may also be eaten, but are primarily intended for sale to generate income for other needs, including foodstuffs, healthcare and education. The impact of an HFP approach that includes aquaculture on household food security, nutrition and livelihoods had not been previously studied in Cambodia, or elsewhere in the world. Therefore our project incorporated a rigorous study design, a 'cluster randomized control trial', to test an integrated model of HFP plus small-scale aquaculture, which we call 'Fish on Farms' (FoF). The trial was composed of 90 clusters of 10 women farmers (n=900), randomized to one of three groups: 1) HFP (plants only), 2) HFP + Fish, or 3) a control group. In the two intervention groups, each of the 60 clusters included a Village Model Farm associated with the10 women farmers. The Village Model Farm served as a demonstration farm on improved agriculture practices, nutrition, marketing, and gender, as well as a source of inputs.

Baseline/endline surveys and regular monitoring were conducted to capture information on agricultural production, income, dietary diversity, dietary intake, biochemical status, anthropometry, gender empowerment and the environment. This research has proved both challenging and rewarding, producing results that will help guide the international community for years to come. Within the HFP + Fish clusters, polyculture of fish was found to be technically feasible and sustainable and small fish production and consumption increased at the household level. Our models were modified across the project lifecycle to reflect ongoing learning. From a scientific perspective, we have produced a considerable body of new evidence, including some unexpected findings. In addition to our understanding of the potential impact of HFP at the

household and individual level, we have made significant additions to the development agenda in Cambodia with the integration of HFP into national policy and strategies aimed at improving food security, livelihoods, and nutrition.

The government of Cambodia welcomed the results as they are in line with their vision of a **"Hatchery per Commune"** and **"One Pond, One Family"**. The sustainability of HFP has also been demonstrated during this project by the transfer of aquaculture technical expertise from the CGIAR's WorldFish to Cambodia's Fisheries Administration. The Fisheries Administration is now planning to integrate the fish polyculture model into their five-year national strategy.

3. Progress Towards Milestones

All of the milestones established for the 30-month project period have been achieved. The eight milestones addressed in the reporting period are as follows:

3.1 Endline survey conducted

During the last three months of the project, HKI and UBC conducted an endline survey (Annex 3) to collect information from HFP, HFP + Fish, and control groups. The endline results were compared to the baseline survey (Annex 2) on agricultural production, income, dietary diversity, dietary intake, biochemical status, anthropometry, gender and the environment (Annex 3). The same basic tools were used for both surveys, but additional questions were added to the endline survey, including: (i) attitudes and access to microcredit; (ii) gender; (iii) sanitation/hygiene; (iv) food consumption over the previous year; (v) detailed information on vegetable varieties and quantity consumed; (vi) income generated by sales of each vegetable/fruit variety; (vii) quantity of fish production used for daily household consumption.

Food consumption by women and children was also collected using a separate 24-hour recall tool (Annex 4). This included time of intake, detailed description of each food item, cooking methods, and amount of consumed food. All the data from the baseline, endline and the 24-hour recall survey were entered at the HKI office in Cambodia and sent to UBC for analysis.

Blood samples from a random sample of 450 women participants were collected at the same time as the endline survey. Samples were sent to laboratories in Germany, New Zealand and Canada for analysis. **Table 1** provides information on the sample size and non-respondent rates. The non-response rate was: (i) 16% for household questionnaire; (ii) 12% for blood collection; and (iii) 4% for 24-hour recalls. The main reasons for these non-response rates were seasonal migration and fear of blood draw. Despite the higher than expected non-response rate, the sample size was sufficient to detect statistical differences.

Table 1: Endline sample size information

Items	Planned sample size	Actual sample size	% of non-respondents	Main reason for non-respondent
Main Questionnaire	900	754	16%	Seasonal migration
Blood collection	450	398	12%	Fear of blood draw; distance to HC
24-hour recall	450	434	4%	No time

3.2 Dissemination workshop with all stakeholders organized and report finalized

On August 28th and 29th 2014, HKI and UBC, in collaboration with the Fisheries Administration, hosted a two-day Dissemination Workshop. Day One was a closed session with project partners, including World Fish, local NGO partner Organization to Develop Our Villages (ODOV), and

IDRC representative Dr. Annie Wesley. The workshop provided all partners with a forum in which to discuss the successes, challenges, and lessons learned from the FoF project. In total, 20 participants attended the Day One workshop. Details of the workshop schedule and outputs can be found in Annexes 5 and 6.

The objectives of Day One were: to provide a forum for open discussion among the research team, implementing partners and IDRC project officers; to review outputs and outcomes in relation to project goals and objectives; to share lessons learned, including the strengths and limitations of the current approach; to discuss regional implications of the results of FoF; and to identify ways forward regarding scale-up and sustainability.

On the second day of the workshop, HKI and UBC hosted a public session in collaboration with the project partners. The purpose was to bring together nutrition, aquaculture, and agriculture stakeholders to share key results of the project. Twenty-three organizations including local NGOs; donors; United Nation agencies; national, provincial and district level government departments; and universities were represented by 48 participants (Annex 7). Initial presentations reviewed the design and activities of the project. Project results were then shared as a means of facilitating discussion on implications and future direction for HFP programs.

The key outcome of the workshop was government commitment to incorporate polyculture into national strategy. His Excellency Dr. Nao Thouk, Director General, Ministry of Agriculture Forestry and Fisheries, gave an opening address and discussed the importance of fish in traditional Cambodian cuisine and how he believes aquaculture will play a major role in stimulating the Cambodian economy while also improving food and nutrition security. This is the first time in Cambodia that polyculture of small and large fish has been tested in the same pond and the Fisheries Administration considers this approach as a successful innovation which should be incorporated into their next five year-national strategy.

3.3 Develop a communications strategy to disseminate information gained from research to key stakeholders

The project's communication strategy was developed with consideration to dissemination across the life of the project as well as beyond with international presentations, journal publications, and workshops taking place prior the end of the funding period. Key stakeholders in Cambodia include government partners in the Ministry of Agriculture, Farm and Fisheries, Ministry of Health, and Ministry of Planning. The influence of the project's results will continue through HKI and UBC's broad network of researchers, development professionals and stakeholders as impact expands beyond the immediate beneficiaries and key findings are adopted not just by households, but by organizations and government partners. It is anticipated that research findings will be published from this work for a considerable time to come as UBC takes the lead in this area. Currently there are several papers published or at press, others under review, and more in process. The communication strategy for disseminating information to a range of stakeholders includes many different medium including:

Workshops, forums and meetings: Lessons learned and experiences are shared with stakeholders in Cambodia in the form of presentations and discussions via the Cambodian Council for Agriculture and Rural Development, the National Nutrition Working Group, the National Food Security Forum, and the National Seminar on Food Security and Nutrition. HKI is an active member of all these groups, some of which are invitation only forums open to high-level decision makers. The team will use these meetings and forums to communicate and disseminate information on the FoF project and its results regarding food security and nutrition.

Nutrition bulletins: Four bulletins have been produced and disseminated throughout the lifecycle of this project, summarizing research design, gender strategies, and process findings. Stakeholders receiving the bulletins included: community project participants; field staff; project partners; civil society; United Nations agencies; NGOs; government ministries; donors; private sectors; academies; and universities (Annex 8).

Policy brief: Results from the FoF project are also utilized to advocate for policy change at the national level. The information on potential solutions for improved nutrition and livelihood through evidence based polyculture of small and large fish was presented in the form of a policy brief and outlines the rationale for choosing the course of action in a current policy debate on promotion of small-scale aquaculture for subsistence farmers. The policy brief was shared with government stakeholders (Council for Agricultural and Rural Development, Ministry of Agriculture, Forestry and Fisheries, Fisheries Administration, Ministry of Health, Ministry of Planning), NGOs, and United Nations agencies. The brief focuses on the impact of polyculture and has implications for national policy on aquaculture, nutrition and livelihoods (Annex 9).

Outcome documentation ("Outcome Stories of change"): This document summarizes key outcomes based on evidence from the FoF project. Outcomes related to increased production and consumption of small and large fish; increased production and consumption of fruit and vegetables; increased income from the sale of fish, fruit and vegetables; and improved women's confidence in decision making were highlighted in the document. The paper was also widely shared with government stakeholders (Council for Agricultural and Rural Development, Ministry of Agriculture, Forestry and Fisheries, Fisheries Administration, Ministry of Health, Ministry of Planning), NGOs, and United Nations agencies (Annex 10).

Media coverage: FoF project activities such as workshops and visits of high government delegates to the project sites were covered by major TV channels (TVK, Bayon TV, ASEAN TV) and other media outlets including newspapers (Rasmey Kampuchea, Koh Santipheap, the Cambodia Daily) and online media. This type of media coverage has proven to be an effective means to share FoF information and results with the general public.

Case Studies: During the project, interviews were conducted with different stakeholders and beneficiaries of the project. These include beneficiary women, households, VMF owners, Village Health Volunteers, and women groups, and produced several case studies with the information. All the case studies have been shared with partners, beneficiaries, extension agents and NGOs. Altogether nine different case studies were produced with three produced during the last six months. (Annex 11)

Press releases: During the duration of this project, two press releases were developed and disseminated to the media and other organizations, especially during workshops (Annex 12).

Posters, leaflets, counseling cards and other BCC materials: The project developed and printed numerous training, behaviour change and promotional materials to be used for training and education on HFP, aquaculture and nutrition for government and NGO staff, Village Model Farms, Village Health Volunteers and target households. In addition, HKI handed over agriculture communication materials to the Ministry of Agriculture, Forestry and Fisheries for distributing to agriculture extension agents nationwide. Materials have been printed and distributed on the following topics: crop calendars; benefits of HFP; small fish processing; fish feeding; pond water quality management; stages of fish production; women's workload; breastfeeding; leaflets on breastfeeding and complementary feeding; nutrition counselling cards on women's nutrition and

infant and young child feeding; training manual/guidelines/hand-outs on home gardening; Essential Nutrition Actions; gender equity; and HFP marketing (Annex 13).

Video clips: Two video clips have been produced and distributed for the FOF project: (i) "Integration of small-scale aquaculture with homestead food production"; and (ii)"Homestead Food Production". These videos were useful during project implementation as they were shown to Village Model Farms and target households. The first clip was also shown in Day Two of the dissemination workshop and generated strong interest from the audience. These videos are also being used as a learning tool by other HKI programs in Africa and other international NGOs in Asia. In addition, the MoH in Cambodia asked HKI to translate the message in Khmer and this is in process. These short video clips describe key activities, outcomes and impacts of this project: Integration of Aquaculture: http://youtu.be/81ABOAT5lT4x and Homestead Food Production: http://youtu.be/rDKH5lUGXSg

3.4 Environmental impact surveys completed and report shared with stakeholders

In February 2014, a second Environmental Impact Assessment and report was commissioned to assess the fishpond construction and to ensure the recommendations made in the Environmental Assessment and Screening Report and first Environmental Impact Assessment report were followed. Additionally, this Environmental Assessment was designed to address water quality (particularly turbidity) and the percentage of space surrounding the fishpond utilized for gardening and agriculture (Annex 14).

3.5 Cost-benefit analysis survey completed and report shared with relevant stakeholders

HKI and UBC collaborated to conduct an economic evaluation of the FoF program with Prof. Larry Lynd and a UBC Master's student. The project PIs met with Prof. Lynd in June 2014 to finalize the protocol, methodology and tools for the economic evaluation study. The data collection took place in July 2014 with final results expected in late 2014. The report will be shared with stakeholders after final biochemical measures have been incorporated into outcome models. The research tools, study protocol, methodology and preliminary report are presented in Annex 15. Initial results suggest that HFP and HFP + Fish costs $240 and $600 worth of project inputs, respectively. In the first year, these farms in addition to providing the food provided on average $100 of income. These results are not unexpected due to the small scale of the pilot and the need to provide more inputs for the randomized control trial. It is expected that costs per household would be greatly reduced in a scaling up model and income will continue to increase over time. The methods and tools will serve to conduct similar analyses for future scaled up interventions.

3.6 Second round: Fish species sampled and analyzed for nutritional composition

First round fish sampling was followed by a second round as additional samples were required in order to undertake the full analysis of nutrient content; samples of six species of fish were collected from seven fishponds in May, 2014. Samples of all types of fish feed were also collected for analysis to determine the nutrient content of the fish feed. The following samples were collected for analysis: (i) Silver barb (*Barbonymus gonionotus*); (ii) Silver barb (*Barbonymus gonionotus*); (iii) Mrigal (*Cirrhinus mrigala*); (iv) Flying barb (*Esomus longimanus*); (v) Croaking gourami (*Trichopsis vittata*); (vi) A*mblypharyngodon chulabornae.*

Nutrient analysis was conducted in the laboratory of Fisheries and Oceans Canada in West Vancouver. The fish were ground whole, dried and then analyzed for moisture, crude protein, lipid and ash content. In addition, mineral profiles were determined. The results can be found in Annex

16, where the proximate compositions are summarized in Table 1, with the mineral content presented in Table 2.

There was consistency in the proximate composition values among the various species, but values for iron were highly variable between farms within one species (*Amblyphagagodon*) as shown in Table 3 (Annex 16). The reason for this is unknown, but is unlikely due to environmental factors such as water iron levels, since the fish were raised with other species in a common water source on each farm and this variability was not observed in other species. The zinc levels were consistently about 2.5 times higher in the smaller fish than in the larger fish. Similarly, the levels were higher for manganese and iron in the smaller fish, possibly because these were analyzed on whole fish, reflecting the manner in which they are consumed in the household.

3.7 Hatchery establishment

The development of a network of private sector fish hatcheries at local level is important to support the growth of household level aquaculture production. Recognizing this, our team established two fish hatcheries in the project area, in Svay Antor and Baphnom Districts. These local fish fingerling producers have been encouraged and trained to supply large quantities of fingerling to local farmers and to educate farmers on small-scale aquaculture. The two hatcheries supported by the project are functioning well and have been successful in ensuring local supply of fingerlings for targeted and non-targeted households.

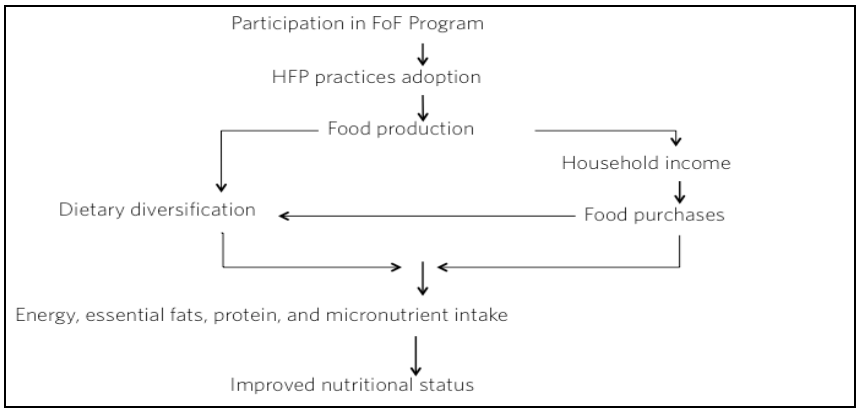
3.8 Research findings and scientific articles prepared

It is expected that within one year, a total of 15 peer-reviewed research articles will have been published or submitted. To date we have published (or at press) papers in the European Journal of Clinical Nutrition, The Journal of Nutrition, and Gender in Development. We have four more in various stages of review with The Journal of Nutrition, BMC Hematology, Asia Pacific Journal of Clinical Nutrition, and Journal of Water and Health. The titles and authors are listed in the manuscripts attached in Annex 18.

4. Synthesis of Research Results

In consideration of the study design the research results include both project outputs as well as development outcomes identified in the logic model and performance measurement framework. Having a control group allowed us to evaluate the impact of the intervention at endline across groups as well as across time. An ‘across group’ comparison that includes a control group provides much more robust findings than simple ‘across time’ comparisons although examples of the latter have been included where relevant. In this section we have highlighted and synthesized key findings in accordance with project objectives and evaluated the results in relation to our Program Impact Pathway (Figure 1).

Figure 1: Simplified Program Impact Pathway



Adapted from: BMJ 2012;344:d8222

4.1 To understand current knowledge, attitudes, perceptions, practices and needs of poor rural households and stakeholders on homestead food production with small pond aquaculture at the household level with a focus on women farmers.

Prior to developing specific training and behaviour change communication materials for the FoF project we needed to establish current knowledge, practices and needs of women farmers in the intervention areas of Prey Veng. As such we conducted both qualitative and quantitative research at baseline with the tools and reports in Annexes 4, 2, and 19. The Program Impact Pathway is dependent on there being a change in practices, which begins with knowledge. Our baseline report provided us with an extensive amount of information with which to guide the program while ongoing monitoring allowed for responsive feedback on areas that needed improvement. With regard to nutrition, it is often assumed that the mere presence of nutritious food is enough to bring about changes in health status, without the knowledge of who needs what foods and at what time in life, nutrition indicators will likely not change. For example, we learned that there were concerns about feeding small fish to young children, a perception we were able to deal with through the training, group discussion, and provision of recipes. We learned about gender perceptions that could stand in the way of empowering women. We developed gender training materials and protocols that involved both men and women. These materials are now being used by other organizations.

4.2 To test the integration of innovative, feasible, and sustainable year-round small-scale aquaculture with existing HFP model for food insecure households represented by women

To address the second objective we developed and tested an innovative model of small-scale aquaculture integrated with plant-based HFP for rural food insecure households represented by women. We measured the success of the model from baseline to endline in accordance with output indicators and targets, including the number of fish ponds developed and maintained, months of sustainable fish production, amount and type of fish, as well as standard measures of fruit and vegetable production. In the first five months of the project implementation phase, 300 fish ponds were newly dug or refurbished, and producing fish, in addition to 600 developed household gardens established in conjunction with 60 Village Model Farms. Full details of research outputs are presented in the endline report (Annex 3). Participation in the program is the first step towards adoption of improved practices (Figure 1).

Across the project time frame we tested different technologies in order to establish the most optimal and sustainable model for integrating small-scale aquaculture with HFP in Cambodia and

beyond. There were numerous lessons learned as some of the target communities encountered drought and crop disease. This provided an opportunity to continue refining technologies and solutions to deal with these issues. A number of technical solutions were adopted, including crop rotation, use of mulching techniques, and cover crop methods. By the end of the research period these solutions had decreased disease attacks, reduced loss of yield for the 70% of the households who had these problems, and sustained improved soil fertility and soil moisture. Adoption of improved practices was widespread with almost all households in the intervention groups enthusiastically participating.

For household level small-scale aquaculture to be successful, sustainable sources of fry and fingerlings must be assured in the community. We developed a microcredit style model for developing fish hatcheries and based on this, two hatcheries have become successful and repaid the loans they received from the project in full. We assisted both hatcheries to develop their infrastructure on the condition that they agreed to cost-share by providing free fingerlings to FOF intervention households. These hatcheries fulfilled their cost-sharing requirements and are now generating income from fingerling sales to both target and non-target households. In 2013 and 2014 the hatcheries produced and distributed/sold approximately 575,000 fingerlings to households both directly and indirectly involved with the project demonstrating successful adoption and spillover.

The project linked with existing technical resources in the area in order to provide a sustainable technical backstopping resource for HFP, with or without an aquaculture component. We successfully integrated comprehensive training on HFP for technical officers from our partner local NGO ODOV, Government Fisheries Administration extension workers, and Agriculture extension workers. This will provide a sustainable mechanism for scale-up.

Success of the aquaculture components was also measured by the indirect influence and adoption of the new technologies. In addition to intervention households and other stakeholders, more than 40 staff from eight NGOs visited HFP households and received training on HFP technologies. We estimate that at least 4,000 households (500 households in each NGO's target areas x 8 NGOs) benefited by adopting some or all FoF technologies. In addition, we estimate that 3,600 indirect households in each targeted commune in Prey Veng (200 households x 18 communes) benefited from the integrated model of HFP + Fish, by replicating one or more techniques or receiving inputs such as seeds and/or seedlings and/or fingerlings from the project. As such, in terms of development outcomes, knowledge and practices have been improved at not only the household level, but also the organizational level in Cambodia through project activities.

4.3 To determine the impact of HFP with or without small-scale aquaculture on year-round household food production and consumption in terms of both quality and quantity

Importantly, while we were able to demonstrate that small-scale aquaculture integrated with HFP is feasible and acceptable in rural Cambodian households, we needed to determine the actual impact of the model on household food production and ultimately consumption of a higher quality more diverse diet. As we had three groups in the trial, we were able to determine whether there were actual differences across the groups through intensive monitoring and evaluation activities.

The main method used for impact evaluation was a baseline and endline survey of all 900 households. We compared households on numerous variables and the full survey tools are presented in Annex 4 with endline results in Annex 3. Baseline and endline comparisons for all three groups in the tables presented below are found in the endline report (Annex 3).

Regular process monitoring every four months allowed us to measure food production on a regular basis such that modifications to the protocols could be made as needed. The monitoring questionnaire included output indicators such as vegetable, fruit and fish production, and consumption by mothers and children, as well as income from the surplus produce and use of the income generated. Our final round of data collection most accurately reflects the benefits achieved across time regarding vegetable, small and large fish production.

Historically most rural households grow some vegetables near their homes, however, most of the gardening is seasonal and the varieties are limited. The FoF project aimed to increase the number of improved and developed gardens maintained by intervention households. Usually, gardens are classified as traditional, improved or developed. *Traditional gardens* are characterized as scattered plots with a limited number of traditional vegetables, which are cultivated seasonally. *Improved gardens* produce a number of vegetables that are cultivated seasonally on a fixed plot. *Developed gardens* produce a wider range of vegetable varieties in fixed plots throughout the year.

In **Table 2** we compare gardening practices across the three trial groups in the final monitoring period, February-May 2014. We have shown that households who have been participating in HFP and HFP + Fish in the last two years had enhanced gardening practices, as 93% of HFP + Fish households and 90% of HFP households had an improved or developed garden type, while only 9% of control households had an improved garden type. This is an important achievement as those households with an improved or developed garden type typically produce higher quantity and variety of vegetables than those with a traditional garden or no garden. The proportion of households with no gardens remained high in control group.

Table 2: Gardening practices

Garden Type	HFP (n=150)	HFP + Fish (n=150)	Control (n=150)
No garden	6%	3%	71%
Traditional	4%	4%	20%
Improved	25%	33%	9%
Developed	65%	59%	0%

According to our Program Impact Pathway, increasing year-round production of a variety of vegetables and fruits and fish should lead to an increase in family consumption. In **Table 3** we show production status of vegetables, fruits, small fish and large fish from data collected in the final two months of the project. Of the households, 97% of the HFP + Fish group and 93% of the HFP group produced vegetables, while only 26% of households in the control group produced vegetables during the same period of time. More households in HFP and HFP + Fish groups had produced fruit compared with the control group (67%, 65% and 20% respectively). As expected, 85% of households in the HFP + Fish group produced large fish while only 13% and 3% of households in the HFP and control group respectively had produced large fish in the last two months of the project intervention period. The proportion of households producing small fish also follows a similar trend: 62% of HFP + Fish households, 5% of HFP households and 3% of control households produced small fish.

Table 3: Production of vegetables, fruits, small fish and large fish in the final two months

Food Production	HFP (n=150)	HFP + Fish (n=150)	Control (n=150)
Vegetables produced	93%	97%	26%
Fruits produced	67%	65%	20%
Small fish harvested	5%	62%	3%
Large fish harvested	13%	85%	3%

We have demonstrated that production increased, with the greatest variety in the HFP + Fish group. With respect to relevant behavior change, the project encouraged household consumption of a diversity of nutritious foods, particularly energy and nutrient dense fish and micronutrient dense fruits and vegetables. Both traditional and new varieties of were promoted in the HFP gardens, including water spinach, amaranth, collard greens, mustard greens, Chinese cabbage, yard long bean, sweet potato, and tomatoes. These micronutrient-rich varieties were found to be used mainly for household consumption. **Table 4** presents information on the main source of vegetables for household consumption in the last three days as determined by the endline survey. Ninety-four percent of households from the HFP + Fish group cited their own production as the main source of vegetables for household consumption while only 1% of households in this group purchased vegetables from market for own consumption. Eighty-six percent of the HFP only households depended on their own production of vegetables as the main source for household consumption. Conversely, 55% of households from the control group had purchased vegetables from market for household consumption in the last three days.

The project's contribution to overall household food consumption has been important in the HFP and HFP + Fish groups (intervention households). By choosing vegetables and fruits that are rich in micronutrients and by improving the nutrition education component to promote their consumption, the HFP approach improved dietary diversity among household members, and especially among women and children.

Table 4: Main source of vegetables for household consumption in the last three days at endline

Food Production	HFP (n=150)	HFP + Fish (n=150)	Control (n=150)
Own production	86%	94%	22%
Market	5%	1%	55%
Collected from outside	8.0	4%	23%
Gift	1%	1%	1%

Our model encouraged target households in the HFP + Fish group to produce both small and large fish species in their fish ponds and to harvest and consume small whole fish frequently providing key nutrients on a regular basis. Large fish provide a regular food source but are also highly marketable, enhancing household income, allowing for the purchase of additional important foodstuffs needed by the household. Presented in **Table 5** are the sources of fresh fish for household consumption in the final round of data collection. Fifty-two percent of households from the HFP + Fish group reported consumption of fresh fish harvested from their own ponds while only 7% of households in HFP group and 1% of control households reported consumption. As expected, 72% of households in the control group and 63% of households in the HFP group reported that they purchased fish from the market, compared to only 29% in the HFP + Fish group.

By comparing the intervention groups to a control group we are able to compare the benefits of the models. The HFP + Fish group households were able to use more of their household resources for purposes other than buying fish. They had a ready source of food energy, high quality protein, fat and vitamins and minerals at a considerably lower cost, beyond the initial outputs. Interestingly while the control group may be considered a reflection of where all the households might be without any intervention, in fact they may also be better off than those without the intervention as they tended to adopt beneficial practices and other components of the interventions. This type of adoption is key to scalability.

Table 5: Sources of fresh fish for household consumption

Food Production	HFP (n=150)	HFP + Fish (n=150)	Control (n=150)
Own production	7%	52%	1%
Market	63%	29%	72%
Captured fish (outside)	29%	17%	26%
Gift	1%	2%	1%

4.4 To determine the impact of HFP with or without small-scale aquaculture on household food security, household dietary diversity and intakes

One of the most important findings from the trial was the significant difference in measures of household food security across time and group as measured by the Household Food Insecurity Access Scale (HFIAS, FANTA). The HFIAS indicator is both a categorical indicator — it categorizes households into four levels of household food insecurity (access) — and a continuous measure of the degree of food insecurity (availability). Importantly, in the HFP + Fish group, across the study time period, the percentage of households who were food secure almost doubled, increasing from 18% to 34% (Annex 3). We then conducted a multinomial logistic regression to ascertain the effects of the intervention (HFP and HFP+ Fish) on the likelihood that respondents are food secure, mildly food insecure, moderately food insecure, and severely food insecure across groups at endline (**Table 6**). Of all the possible comparisons, two were statistically significant: respondents in the HFP+ Fish group were 42% less likely to be moderately food insecure than food secure as compared to respondents in the control group (P-value=0.03); and respondents in the HFP + Fish group were 29% less likely to be severely food insecure than food secure as compared to respondents in the control group (P-value=0.017). In other words, respondents in the control group were more likely to be both moderately and severely food insecure as compared to respondents in the HFP + Fish group. Interestingly, there was also a trend towards significance for respondents in the HFP group to be more likely to be food secure than moderately food insecure as compared to respondents in the control group (P-value=0.055).

Table 6: Household Food Insecurity Access Score category (endline)

	HFP n (%)	HFP+Fish n (%)	Control n (%)	Total n (%)
Food secure	48 (26)	64 (34)	43 (24)	155 (22)
Mildly food insecure	109 (59)	96 (51)	87 (49)	292 (53)
Moderately food insecure	20 (11)	23 (12)	37 (21)	80 (14)
Severely food insecure	8 (4)	5 (3)	12 (7)	25 (4)
Total	185	188	179	552

As a continuous measure, the degree of food insecurity (access) in the household in the four weeks (30 days) prior to the survey is assessed. A maximum score of 27 is obtained if the respondent answers "often" (coded with a value of 3) to all of the nine frequency-of-occurrence questions and minimum score of 0 is obtained if the respondent answers "no" to all of the nine occurrence questions. A high score corresponds to a higher degree of household food insecurity. Conversely, a low score corresponds to a lower degree of food insecurity experienced by the household. As shown in **Table 7**, households in the control group had a significantly higher mean HFIAS score (4.06) as compared to mean HFIAS score for respondents in the HFP+ Fish group (2.83) (P-value= 0.005). While the mean HFIAS score was also lower in the HFP group (3.08) as compared to the control, the value was not statistically significant (P-value=0.188). Again it is notable that the HFP + Fish group had the lowest HFIAS score, indicating the least food insecurity among the three groups.

Table 7: Average Household Food Insecurity Access Score by intervention group (baseline/endline)

	Mean ± SD Baseline	Mean ± SD Endline
Control	5.9 ± 4.2	4.1 ± 3.6[a]
HFP	5.0 ± 3.7	3.1 ± 2.8[a]
HFP+ Fish	4.8 ± 3.6	2.8 ± 2.7[b**]
Total	5.2 ± 3.9	3.3 ± 3.1

Notes: [a,b] Means differ significantly between values in columns not sharing a common superscript (Kruskall-Wallis Test). All missing values were deleted pairwise. ** P-value < 0.05

Access to food is not only dependant on production but on income as indicated in the Program Impact Pathway (Figure 1), as many foodstuffs need to be purchased. One of the most important findings from this study was that the HFP + Fish households had significantly greater reported income from fish production. As shown in **Table 8**, on average, significantly more (P-value<0.001) money was earned in the HFP + Fish group (USD $13.02) as compared with the HFP (US$1.37) and control (US$0.46), or almost 30 times more income was generated. Further, on average, the sale of fruit and vegetables were highest in the HFP (US$8.23) and HFP + Fish (US$12.05) groups as compared to the control group (US$1.10).

Table 8: Money earned from sale of fish in past 2 months (endline)

Money earned from sale of fish in past 2 months	Control	HFP	HFP+Fish
Yes	6 (3.4)	8 (4.2)	55 (29.3)
No	173 (96.6)	177 (95.7)	133 (70.7)
Amount (US$) [$\bar{x}$ (Range)]	0.46[a] (0-25)	1.37[a] (0-75)	13.02[b] (0-750)

[a,b] means differ significantly between values in rows not sharing a common superscript (by one-way ANOVA and Tukey's multiple comparisons)

The project promoted dietary diversity, including increased consumption of animal foods, in order to optimize intake of energy, protein, fat, and micronutrients. **Table 9** describes the use of income generated from sale of surplus HFP produce among the three study groups. Thirty-seven percent of households from the HFP + Fish group used income generated from the sale of surplus HFP produce to purchase food. Fifty-two percent of households in the HFP group used income for purchasing foods, while control group households used most of their income to buy food (70%). This is understandable because the HFP+ Fish group of households produced significantly greater amounts of vegetables, fruits and fish, and consumed a large portion of this produce, therefore they did not need to purchase a lot of food from external sources.

When asked what types of food items they purchased, most households in all three groups purchased high quality nutrient rich food items such as beef/pork, iodized salt and oil, thereby increasing their consumption of energy, protein, fat and micronutrients. Only 18% of the HFP + Fish group purchased fish for household consumption because they produced more fish than the other two groups of the trial (see **Table 10** for more information). This was a very important outcome of the trial showing the dietary diversity improved from two components of the Program Impact Pathway, increased production and increased income.

Table 9: Use of income earned from HFP and fish products (endline)

Use of income	HFP (n=150)	HFP + Fish (n=150)	Control (n=150)
Food	52%	37%	70%
Medicine	3%	2%	0%
Saving	0%	1%	0%
Social activities	8%	18%	0%
HFP inputs (seeds, chicks, etc.)	15%	22%	20%
Education	22%	20%	0%
Others	0%	0%	10%

Table 10: Food items purchased with income from sale of HFP and fish products

Food items	HFP (n=150)	HFP + Fish (n=150)	Control (n=150)
Beef/pork	59%	56%	71%
Fish	30%	18%	43%
Eggs	8%	7%	14%
Iodized salt	44%	53%	57%
Fat/oil	49%	40%	14%

Increased availability of vegetables

By endline, there was a significant difference in the number of vegetable varieties produced in the 2 months prior to the final survey in the intervention groups ($P< 0.001$). Approximately 4 varieties were grown in the control group (range: 1-17) and approximately 6 varieties were grown in the HFP and HFP + Fish groups (range 1-21). There was no significant difference between the number of varieties grown in HFP and HFP + Fish groups.

On average, more vegetables were produced per household within the two months prior to the endline survey than reported in the baseline survey (Annex 3). Significantly higher overall quantities of vegetables were produced in both the HFP and HFP + Fish groups as compared to the control group. **Table 11** presents these findings in more detail.

Table 11: Vegetable Production between baseline (July 2012) and endline (May 2014)

Item	HFP		HFP + Fish		Control	
	Baseline	Endline	Baseline	Endline	Baseline	Endline
Number of vegetables varieties grown (median with range)	3 (1-10)	6 (1-21)	3 (1-8)	6 (1-21)	3 (1-10)	4 (1-17)
Vegetables produced in last two months (kg) [$\bar{x}$±SD]	8.6 ±11.59	49.74 ±50.88	17.4 ±64.28	61.56 ±75.85	6.2 ±10.51	15.22 ±23.80

4.5 To determine the impact of HFP with or without small-scale aquaculture on anthropometric and biochemical nutritional status among women of reproductive age and young children

The next step in the Program Impact Pathway, is an actual change in indictors of nutritional status. We were interested in whether HFP alone, or HFP + Fish would impact anthropometric or biochemical indicators as proxy measures of overall nutritional status among women and children in the study. Notably, the greatest change was in the HFP + Fish group where there was a 50% decrease in the prevalence of underweight (low BMI) among women and a decrease of 10% in the prevalence of anemia. With regard to anemia reduction, we also learned that there were limitations to the impact of a food-based intervention.

At baseline we found the rate of anemia in non-pregnant women was 41%. While it has always been assumed that a high percentage of anemia in Cambodia was due to iron deficiency, we determined from multiple regression models that haemoglobin disorders, which were present in 50% of the women, explained a large amount of the low haemoglobin concentrations. Based on infection adjusted serum ferritin (<15 µg/L), only 2% of women had depleted iron stores and based on serum transferrin receptor (>8.3 mg/L), 19% had tissue iron deficiency. Less than 3% of women showed biochemical evidence of vitamin B12, folate, or vitamin A deficiency. Curiously ferritin, vitamin A and vitamin B12 were still significant predictors of haemoglobin, suggesting

that these micronutrients may still be contributing to anemia. As is often the case, our research has raised more questions and we have obtained funding from IDRC (doctoral scholarship), Sight and Life, as well as the Micronutrient Initiative to conduct a 2x2 factorial randomized control supplement trial in Cambodia to determine if iron alone, other micronutrients (not iron), iron + other micronutrients, compared with placebo increases haemoglobin. Given our current understanding that much of the anemia in Cambodian women is of genetic origin, coupled with the short duration of the intervention, it is not surprising that we did not see a greater impact of HFP on anemia but as noted above, we did find the prevalence of anemia in the HFP + Fish group decreased where it did not in the plant based HFP or control group.

What we also found was perhaps equally or more important in terms of new biochemical findings. While we only measured zinc at endline, deficiency (< 70 µg/dL) was present in 50% of women across all groups. This has important implications for stunting, one of the main nutritional issues in Cambodia. Our study also identified very high rates of riboflavin and thiamine deficiency, the latter being 60% based on a low erythrocyte thiamin diphosphate (<90 nmol/L). This likely explains the high rates of infantile beriberi in Cambodia. While we will be modifying our nutrition training materials based on these findings, most foods produced by HFP do not contain high amounts of thiamin or riboflavin, and we are therefore exploring fortification of fish sauce with a private partner as a means of improving thiamine status in the population. We have received funds from IDRC (doctoral scholarship) and Grand Challenges to conduct a randomized control trial with fish sauce.

At endline, 30% of children measured were stunted and 23% underweight with no differences across groups. As underweight is a consequence of low height and/or weight we may presume that most of the underweight is due to low height (stunting) as wasting (low weight for height) was considerably lower (Annex 3). As stunting is considered a consequence of the first '1000 Days' of life, or conception to about two years of age, it is not likely that our intervention would have impacted young children measured in this study as this window of opportunity would have been prior to project interventions missed and the project time period not long enough to see a change.

As mentioned in the first paragraph of this section the prevalence of low BMI among non-pregnant women decreased across time with the greatest improvement in the Fish on Farms group although the means across treatment groups did not differ. As all groups improved we attribute some of the change to the spill-over effect as more food was available at the local markets and the education and technologies were adopted although this is a hypothesis at this point.

In conclusion, where we did see an improvement in indicators of nutritional status, it was most notable among women in the HFP + Fish group, and while we expect it will take longer for the full impact of the interventions to be realized, the trend definitely exists. We need to intervene early in women's reproductive years as well as across pregnancy and early childhood to impact stunting and other indicators of children and women's nutritional status. The micronutrient deficiencies we uncovered, including zinc, thiamine and riboflavin, may be particularly important for child health and growth across the 1000 Days.

4.6 To assess the impact of HFP with or without small-scale aquaculture with emphasis on women: women's time and empowerment, gender equity, participation and decision-making at the household and village levels and livelihoods

In most households, women decide which crops are planted and when, which foods are eaten at family meals, and how income earned from surplus produce is spent. This also has a potential positive impact on overall household spending, food preparation, food choices and intra-household

food allocation as well as care-seeking behavior of the women. Full or partial control over HFP resources and income is therefore a key factor in the enhancement of women's participation in household decision-making. Gender was an important component of this project as women's autonomy has been shown to be linked to maternal and child nutrition and food security outcomes.

Table 12 identifies the main caretakers of HFP in participating households. A woman, most often the wife/mother, was found to be the main caretaker of HFP activities for all three groups. A lead woman, most often a wife, and senior male, most often the husband, took joint responsibility for gardening activities in 45% of households in the HFP group, 42% of households in the HFP + Fish group, and 25% of households in the control group by the end of the project. In this case, HFP in the control group refers to traditional gardens, and this is not comparable to the high level of food production in HFP and HFP + Fish groups. These findings show that a woman was in charge or jointly in charge of HFP in 80% of households in the HFP and HFP + Fish groups, meaning that women also had a major role in the decision making related to increased food production and consumption in these households.

Table 12: Main household member in charge of HFP

Main care takers	HFP (n=150)	HFP + Fish (n=150)	Control (n=150)
Husband	6%	10%	3%
Wife	36%	37%	64%
Both	45%	42%	25%
Children	1%	0%	0%
Grandparent	12%	12%	8%

One of the other key findings from our research is that women typically have considerably more work than men and less leisure time. In order to respond to this issue, the project urged men and other family members in both HFP and HFP + Fish groups to share household tasks with their wife in order to free up time for her HFP tasks. We found that after capacity development sessions by the project team, husbands from both HFP and HFP + Fish groups were willing to help their wife with household chores **(Table 13)**. For instance, 97% of husbands in the HFP + Fish group and 92% of households from the HFP group helped their wife in gardening activities while only 28% of households in control group did so, suggesting a positive effect of the training. Similar trends were found for cooking tasks, buying food and taking care of animals. Sixty-one percent of households from the HFP + Fish group shared household tasks with their wife, including child feeding, while 55% of control households did the same.

Table 13: Contribution of husband to household chores

Items	HFP (n=150)	HFP + Fish (n=150)	Control (n=150)
Helping in garden	92%	97%	28%
Cooking	60%	67%	54%
Washing clothe	43%	52%	43%
Washing dishes	42%	58%	42%
Taking care of animals	87%	94%	81%
Buying food	44%	56%	41%
Feeding children	43%	61%	55%

In addition to the individual participant household members, we estimate that 25 organizations (NGOs, United Nations agencies and government agencies) outside of project areas indirectly benefited from materials and discussions in regard to gender and women's empowerment through field visits and informal information sharing. This benefited approximately 125 staff (25 organisations x 5 staff) and 12,500 households (25 organisations x 500 households) from these organizations.

4.7 To assess the environmental impacts of HFP with or without small-scale aquaculture

An Environmental Assessment and Screening was conducted at the start of the project in June 2012 to determine environmental feasibility of constructing fishponds in the project area. An independent consultant conducted this assessment at each of the 330 households scheduled for construction of new or renovated ponds for fish cultivation. The assessment found that erosion and groundwater quality were the only potential environmental impacts associated with the project, and were minor in nature. The report also provided recommendations on how to effectively and efficiently mitigate these potential impacts by planting crops on pond banks and ensuring ground water wells were located more than 10 meters distance from fish ponds. The report concluded that this project could proceed to the next phase without the need for any significant mitigation measures.

The first Environmental Impact Assessment (EIA) was conducted in February 2013, by the same consultant, with the objective of assessing impacts resulting from the fish pond construction activities and to check whether the recommendations from the initial Environmental Assessment and Screening Report were followed by the project team. A random sample of 42 ponds in eight villages was selected for follow-up assessment. Each pond was photographed, inspected for erosion, and the depth and distance of the nearest wells used for drinking were recorded. No significant adverse environmental impacts were found to have occurred as a result of the fish pond construction activities and 100% of earlier recommendations were followed.

A second EIA was conducted in February 2014, again by the independent consultant. A total of 105 ponds in 10 villages in three districts were visited and assessed. Ponds were inspected for erosion and the depth and distance of the nearest wells were surveyed. Observations were also made on the percentage of land area surrounding the pond that was used for agriculture and the quality of the pond water (turbidity levels). No significant adverse environmental impacts were observed as part of the fishpond component of the Fish on Farms project. Only very minor erosion was observed in 5% of the ponds and erosion did not appear to threaten the structural integrity of the ponds or the surrounding environment. Only one of 105 households visited had a pond located closer to the household well than recommended (due to the household land being unusually small). Although high turbidity levels (which are potentially indicative of adverse environmental conditions for fish) were reported at 96% of the ponds, sampling during the dry season meant

water levels were lower and not diluted by rainwater. The project team developed low cost, sustainable solutions for turbidity, including placing lime on the sides of ponds and emptying and refilling the ponds to remove sediment. In the future, measuring dissolved oxygen and nutrients may be better indicators of habitat condition for fish and should be considered for future EIAs.

4.8 To evaluate the economic impact of HFP with or without small-scale aquaculture

The final round of data collection shows that a significant percentage of households in both HFP (75%) and HFP + Fish groups (79%) generated income from sale of vegetable and fish produce, whereas only 7% of control group households sold vegetable produce. Thirty-two percent of households in the HFP + Fish group reported generation of income from sale of fish (see **Table 14**). Income differences across groups were discussed in Section 4.4 as was how the income generated in the intervention groups was spent. This is an important component of our Program Impact Pathway to improving nutritional status as many key foodstuffs can't be grown or raised e.g. iodized salt and oil. As was discussed in earlier section, the production of more food at the household level also meant more income, generated from any sources, was usable for different purposes such as education. This is part of an overall step towards improving livelihoods.

Table 14: Household income generated from sale of HFP and fish products

Food Production	HFP (n=150)	HFP + Fish (n=150)	Control (n=150)
Income from vegetables	75%	79%	7%
Income from fruits	11%	12%	1%
Income from small fish	0	1%	0
Income from large fish	3%	32%	1%

4.9 To increase the capacity of government, Commune Councils, local NGOs, and other stakeholders in the community particularly smallholder female farmers with regard to food security and nutrition

HKI has demonstrated its ability to influence the capacity of government, Commune Councils, local NGOs and stakeholders in Cambodia over the last 15 years and the results from the FoF project will build on these strong relationships. More than 100 NGOs have received nutrition/agriculture technical training, behavior change communication materials and HFP tools, as well as help with monitoring and evaluation activities, and technical assistance regarding HFP. The addition of the aquaculture component was a natural next step in capacity building of these groups. HKI is currently the only NGO included in the National Technical Working Group on Food Security and Nutrition, and the Scaling-Up Nutrition (SUN) technical advisory committee where they will influence policy and strategies. HKI plays a key role as technical assistant for the Ministry of Health, National Nutrition Program and Council for Agriculture and Rural Development. Through sharing of research findings, resources, and experiences in a range of forums and formats, and at multiple levels, capacity will continue to be strengthened. Direct support will be provided to partners, stakeholders, and extension workers through training, field visits, and knowledge transfers, as it has in the past.

Extension support services for HFP are essential for the development strategy's sustainability and capacity building. The project is providing technical support for the integration of HFP models into National Policy within the Council for Rural Development, the Ministry of Agriculture, Farm and Fisheries, and the Ministry of Health, and by institutionalizing HFP technical support through curriculum development and capacity building with the responsibilities of Village Health

Volunteers and agriculture/fisheries extension workers. Table 15 describes the government agencies who have been, and will continue to be, influenced through the project's activities.

Table 15: Government Agencies and target area for capacity development

Government Agency	**Role and project target area for capacity development**
Council for Rural Development	Changing and creating food security and nutrition policy and strategy; coordinating other ministries with regards to engaging in project activities.
Ministry of Health (National Nutrition Program)	National level: Changing and creating national policy and strategy on nutrition and maternal and child health. Provincial and District Level: Preparation, training, and quality control for Essential Nutrition Actions and Behaviour Change Communication for Village Health Volunteers and beneficiaries. Community level: Village Health Volunteers provide training and nutrition counseling to direct and indirect beneficiaries.
Ministry of Agriculture, Farm and Fisheries (Fisheries Administration)	National level: Changing and creating national policy and strategy for agriculture and aquaculture. Provincial and District Level: Participating in the preparation, training, and quality control for agriculture, aquaculture, and food processing for beneficiary households; aquaculture capacity-building for hatcheries; agriculture and aquaculture extension workers provide longer-term technical backstopping to beneficiary households.
Commune and village authorities	Facilitate access and acceptance of the project in the target communities; community sensitization and mobilization.

At the community level, multiple trainings were held to achieve this objective (Annex 17 for full list of trainings). These are indicative of what happens at the local level and how capacity is built for smallholder farmers, particularly women. The project also shared training and behaviour change communication materials with other organizations and government agencies. We estimate that 125 staff from 25 organizations and 800 agriculture staff from different provinces benefited from this training and behaviour change materials. The total number of training participants was 1,161. The following is a summary of trainings held during the final project phase that have not be reported elsewhere and have increased capacity of organizations and **individual farmers, particularly women:**

Refresher training on HFP and Aquaculture for NGO/Government staff: During this one day event topics addressed included: production techniques for fruits and vegetables, seeds, seedlings and saplings; irrigation management; pest and disease control; fish and fingerling production.

Refresher training of staff from NGO/Government staff on nutrition, gender and marketing: Twenty-seven partner staff received a two-day training on nutrition topics such as maternal nutrition, dietary diversity, micronutrient-rich foods, breastfeeding, complementary feeding, food hygiene and how to conduct behavior change communication.

Refresher training of village model farms (VMF) for both HFP and HFP + Fish groups: Sixty women VMF owners received a two-day training on improved production techniques for vegetables, fruit and fish; fish feeding, fingerling distribution, production of seeds, seedlings and saplings; constraints and solutions to develop year-round gardens; pest and disease control; and fertilizer and water management.

Refresher training of VMFs on marketing of HFP products: HKI and ODOV staff provided a one-day refresher training course and regular follow up counseling for the 60 women VMF owners on agricultural marketing techniques.

Refresher training of target households: Each of the 300 women headed households from the HFP group and 300 households from the HFP + Fish group received trainings on HFP and aquaculture, nutrition, gender and marketing.

5. Synthesis of Results towards Agriculture and Food Security Outcomes

Impact on targeted communities at project end and potential uptake within 3 years: We demonstrated the HFP model, particularly HFP + Fish, improved agricultural practices, increased food production and income in households and improved some measures of nutritional status among women, by the end of the project. Our findings showed that women had additional income from selling the surplus of fish, fruits and vegetables in the HFP + Fish group, and ensured the prioritization of income earned from HFP for improving family nutrition and wellbeing. This reduced household food insecurity and improved livelihoods and is expected to impact significantly on nutrition in the medium to long term (within 3 years). This merits further measurement over time to verify the trends in improved nutritional status seen at endline in our research.

In targeted communities we have shown that low cost fishponds can be constructed and stocked with small and large fish species and remain operational for at least part of the dry season. We have further proposed a trial to test methods to optimize fish yields and bridge gaps associated with sustaining fish in order to test hypotheses around stocking densities and fish feed using a robust, multifactorial experimental design. In addition, development of fish feeds using local ingredients has the potential to improve production and support expansion and intensification of aquaculture. UBC's Center for Sustainable Aquaculture has also proposed developing a locally produced fish feed for widespread use in Cambodia.

The following provides an overview of how the project's objectives and results have contributed to AFS program outcomes:

5.1 New technologies and/or farming systems and practices

Obj 2. To test the integration of innovative, feasible, and sustainable year-round small-scale aquaculture with existing HFP model for rural food insecure households represented by women

The FoF project developed and tested an innovative small-scale aquaculture model integrated within a plant-based Homestead Food Production (HFP) model that uses new or improved agricultural technologies and practices to increase food production among poor households. In order to maximise the potential sustainability of the FoF model, all of the new or improved technologies and practices have been designed to be simple, low-cost and replicable including:

Pond Water Treatment: The project found that highly turbid water inhibited fish production in some fishponds and this led the project team to develop, test and implement a low-cost and simple pond water treatment technique to address the turbidity issue during the last six months of the project. The solution was well accepted by households and at the end of the project over 70% of households experiencing turbid water issues successfully adapted the technique.

Natural feed growth in ponds: The project team trained households to add cow dung and green manure to ponds in order to promote the growth of zooplankton and phytoplankton and how to monitor the status of plankton growth in the water using simple visual tests.

Sustainable Fish Feed supply: In Cambodia, farmers traditionally do not provide feed to fish, and one of the major initial constraints for the project has been the lack of locally produced high-quality fish feed. The project has assisted farmers to improve the rate of fish growth by providing training on sustainable and improved fish feeding technology and practices. The project worked with households to develop new methods to prepare fish feed from readily available ingredients including rice bran, trash fish or broken rice and trained 330 target households (300 households and 30 associated VMFs) on these new methods.

Experimentation with Different Technologies of Fish Culture: The Fisheries Administration and WorldFish experimented with different technologies in order to determine the ideal combination of small and large fish for maximum production in fishponds in Cambodia, as this work has never been conducted. The findings indicate that the introduction of small indigenous species and carp polyculture was a success and did well in many cases, except in a few cases where overpopulation of the pond was evident.

New Technologies for Small Fish Harvesting: To avoid disturbing the large fish in the ponds during periodic harvests, a specially designed fishing net and method to catch small fish was used for the first time in Cambodia. This technology saves time for households and is easy for women to operate, costs only $2.5 and can be shared by up to six households.

Fish production is not a new concept for Cambodian farmers, however, this is the first time that polyculture of small and large fish has been implemented as we have done with 330 households (300 households and 30 Village Model Farms). Raising small fish with large fish benefitted farmers throughout the region with the provision of nutrient dense fish for consumption and a larger fish for commercial gain. Adoption of practices by other households was observed through the project and will be included in training by Government extension workers. This system can now be expanded by Government and other development partners to other areas of the country.

5.2 Dietary diversity & nutrition

Obj 3. To determine the impact of HFP with or without small-scale aquaculture on year-round household food production and consumption in terms of both quality and quantity

Obj 4. To determine the impact of HFP with or without small-scale aquaculture on household food security, household dietary diversity and intakes

Obj 5. To determine the impact of HFP with or without small-scale aquaculture on anthropometric and biochemical nutritional status among women of reproductive age and young children

Our project addressed several objectives specifically related to dietary diversity and nutrition, with notable achievements in these areas. As discussed in Section 4, we demonstrated that with increased production of energy and nutrient dense food, as a result of improved agricultural methods, households spent less money purchasing food and consumed more of their home grown or raised food. Specifically, the fruits and vegetables that are promoted as part of HFP are micronutrient dense. Small fish are rich in micronutrients, including vitamin A, iron, zinc and calcium, as well as protein and essential fats, and are particularly nutritious as they are usually consumed whole. Women farmers in the intervention group were highly accepting of the small fish consumption but our qualitative research, including the gender analysis, uncovered concerns about small fish for young children (e.g. due to small bones and risk of choking). The project promoted three different types of micronutrient-rich small fish for household consumption, along with behaviour change communication and simple recipes targeting young children.

Training on nutrition was provided to Village Model Farm owners and intervention households as well as participating NGO staff and other community members. Men were in attendance as well as women. Many topics were covered including the importance of dietary diversity (three food groups each meal), maternal nutrition, micronutrient-rich foods, breastfeeding, complementary feeding, and food hygiene. We evaluated knowledge, attitudes and practices at baseline and endline and there was an increase in the percentage of women that knew of iron and vitamin A rich foods (Annexes 2 and 3). An improvement in knowledge precedes changes in practice so this is an important step as we found at baseline there was great misunderstanding about nutrient rich foods. The trainings have been incorporated into Government approved materials and are now available for wide distribution. As in the past, we anticipate wide demand for behaviour change materials organizations working on food security and nutrition in Cambodia.

5.3 Engagement of Canadian researchers with Southern researcher organizations

Obj 9. To increase the capacity of government, Commune Councils, local NGOs, and other stakeholders in the community particularly smallholder female farmers with regard to food security and nutrition

Researchers from UBC worked in close partnership with HKI, CGIAR's WorldFish, and Cambodian Government Ministries throughout the project. HKI's staff are primarily Cambodian nationals and the collaboration provided them with the opportunity to learn more about data management and evaluating agricultural and nutritional interventions. Dr. Viseth from the Fisheries Administration travelled to Vancouver to meet with the team at UBC's Center for Sustainable Aquaculture and Oceans Canada Aquaculture Research Station, including Canada Research Chair, Dr. Tony Farrell. Specifically, the researchers from UBC worked to build capacity on fish research methodologies among their Cambodian counterparts.

Professor and Director of Outcomes Research in the School of Public Health made more than one trip to Cambodia as did numerous other UBC faculty to work directly with researchers in the Government and HKI staff. By working collaboratively capacity was built on both sides as the UBC team learned aspects of conducting gender based research in a field setting they previously had not experienced which will help guide them with further work in the region. UBC also developed new skills working with partners in Southern Organizations who shared their wealth of experience with operations research. Moving forward, researchers will continue collaboration as they did prior to this project with partnerships strengthened.

5.4 Research groups

Obj 9. To increase the capacity of government, Commune Councils, local NGOs, and other stakeholders in the community particularly smallholder female farmers with regard to food security and nutrition

As stated in 5.3, all of the groups have been strengthened through this partnership. It should be noted that the research group that includes HKI and UBC did not begin their collaboration with this project but the team has worked closely on other research in Cambodia as well as on policy. One of the most important aspects of this partnership is the ability to impact food policy and decision making in Cambodia. HKI has a long-standing relationship with government officials and researchers from UBC have played a major role in policy and decision-making, having contributed to the country's 'Policy for Preventing Micronutrient Deficiencies' in collaboration with the

Ministry of Health and the WHO. Together the team also oversaw the design and evaluation of the MDG 'Joint Programme for Children, Food Security and Nutrition' in Cambodia. The FoF project is strengthening the existing research group as HKI, UBC and Ministry of Agriculture, Farm and Fisheries work together to build an optimal model for homestead food production in Cambodia.

5.5 Food distribution

Obj 4. To determine the impact of HFP with or without small-scale aquaculture on household food security, household dietary diversity and intakes

One aspect of food distribution that was addressed by the FoF project is intra-household distribution. Within households, country data suggest that women and children may not receive the most energy and nutrient dense foods, even when these foods are present in the household. In many rural communities it is common to prioritize men and older household members (and visitors) in the distribution and quality of household foods, as this is believed to be auspicious in tradition culture and religion. The project has addressed this difficult issue by: (i) increasing food availability at household level; (ii) provided women with specific training to improve how children are fed and the ability to produce the quality and quantity of food needed for all members of the households; (iii) addressing traditional beliefs through culturally sensitive behavior change messaging. Households in the HFP and HFP + Fish groups are producing greater quantities and varieties of food which led to a reduction in food insecurity and improved access to nutrient dense food such as animal foods, iodized salt and oil, as indicated in Section 4.3 , Table 10. Simply by increasing food access there will be more food available for women and children without having to change culture as this may take time.

Additionally with regard to food distribution, in Cambodia there is the issue of household vs national food security. While the country is categorized as food secure, and based on rice exports this may be true, there are great differences as the household level as national numbers do not reflect unequal distribution (or waste) and meeting nutritional needs. Our project sought to increase food availability and quality at the household level and we were able to show a reduction in food insecurity, particularly as measured by access to high quality food. We anticipate this to continue as practices are adopted as seen in other regions and countries where HKI has implemented HFP.

5.6 Food processing and storage

Obj 3. To determine the impact of HFP with or without small-scale aquaculture on year-round household food production and consumption in terms of both quality and quantity

Processing and storage is a very important component of year round consumption of micronutrient rich food. There are times of the year when fish ponds dry out and a lack of water reduces access to seasonal micronutrient rich fruits and vegetables. Particularly with fish, it is important to find ways to deal with a surplus other than simply by marketing. One traditional example in Cambodia is the processing of prohoc, which is fish that has been chemically broken down by a fermentation process until it reaches the consistency of a soft creamy paste. Prohoc is used as a seasoning to add flavour to food or to complement a main dish. Households in intervention areas were encouraged to produce and use prohoc throughout the year, but more frequently during the lean season when availability of other food is scarce. With increased production of small fish promoted by the project, households were able to produce prohoc to use in the lean season. Our next step is the promotion of dried fruits. These may be consumed at home as snacks or sold and are highly acceptable in Cambodia. While this was not a component of FoF1, however processing and

preservation techniques are part of our scale-up proposal as we have seen the need for ensuring use of excess production and access to nutritious snacks and products.

5.7 Risk-mitigation

Obj2. To test the integration of innovative, feasible, and sustainable year-round small-scale aquaculture with existing HFP model for rural food insecure households represented by women

A driving force behind the project was risk mitigation as small-scale rural farmers are particularly vulnerable to climatic factors, fluctuations in market pricing for food staples, and seasonal decreases in production. By enhancing and diversifying agricultural production we have extended the seasonal production of food thus helping to provide insurance against these shocks. The project has mitigated the risks from crop disease and soil infertility through technologies such as crop rotation, mulching and crop intensification. These techniques have helped to maintain environmental balance and achieved increased and year round production of vegetables and fruits. By increasing food production the project is also reducing vulnerability to food insecurity by increasing the income produced from small farms, which is particularly important during the lean season when more food must be purchased. Furthermore, fish offers a higher potential for income generation than staple crops that are highly vulnerable to price fluctuations. We demonstrated that households in the HFP + Fish group had significantly higher income from the sale of fish (30 times that of controls). Moving forward, we will work to improve the sustainability of the fish ponds through experiments designed by UBC and conducted in the field in Cambodia to further mitigate risk of food insecurity among rural households, particularly those represented by women.

5.8 Access to resources

Obj 4. To determine the impact of HFP with or without small-scale aquaculture on household food security, household dietary diversity and intakes

The project has improved access to food through the assisting households to produce increased quantities of more nutrient dense food. HFP, particularly HFP + Fish has also provided opportunities for marketing of produce and income generation, and this income has been used to purchase a wide variety of services and goods including education and more varied foodstuffs that can't be grown e.g. iodized salt and oil (Section 4.3 Table 10). This will continue after project funding ends as households in the intervention groups have new knowledge and have adopted the new practices in which they were trained by the project. In addition, the spill-over effect that began during the life of the project will continue to benefit others in the intervention and control villages.

The private sector fish hatcheries and nurseries developed by this project will also continue to serve as local resources that support sustainable HFP and other types of local agriculture and aquaculture. The project established 60 Village Model Farms that will continue to provide ongoing technical resource for all households in their communities, especially in terms of inputs supply, training support and training/demonstrations. As these farms have become profitable, the assumption that this will continue is more than reasonable. The next step is scaling-up successful components of FoF1 incorporating lessons learned.

5.9 Income generation

Obj 8. To evaluate the economic impact of HFP with or without small-scale aquaculture

Evaluation of the project shows that a higher percentage of households in both HFP (75%) and HFP + Fish groups (79%) generated income from sale of vegetable or fish produce, whereas only

7% of control group households sold and vegetable or fish produce as shown in Section 4.8, Table 14. In the HFP + Fish group, 30 times the income was generated from the sale of fish compared to the control group. Fish is a much higher value product than vegetables so this is quite meaningful. Growing vegetables and fruits protects income generated from other sources, as there is less need to buy these products. Our research showed that control households spent more money on vegetable purchases than in the intervention groups. In other words, the intervention generated income, and also 'spared' income such that it was available for other household needs.

Households also received training on group marketing, and the project fostered linkages between the Village Model Farms and buyers. In this way, households have the option of transporting and selling a portion of their produce through the group, which can reduce the transportation costs and help households achieve a higher sale price for produce. This marketing component of the project requires further development in the scale-up phase of FoF, including the provision of support that is better adapted to the various types of markets used in rural areas.

5.10 Policy options

Obj 9. To increase the capacity of government, Commune Councils, local NGOs, and other stakeholders in the community particularly smallholder female farmers with regard to food security and nutrition

The success of the project's two hatcheries and household level fish ponds has provided support for the Cambodian Government's proposed '**Hatchery per Commune'** and **'Pond per Farm'** strategy. In addition, the Fisheries Administration is now considering incorporating the polyculture model into their next five year-national strategy on promotion of small-scale household aquaculture. This is the first time that Cambodia has tested the polyculture of small and large fish in the same pond and the success of the mode has been met with enthusiasm from the Government. The Ministry of Agriculture, Farm and Fisheries, plans to advocate for adding Homestead Food Production to the National Strategy for Food Security and Nutrition.

5.11 Gender

Obj 1. To understand current knowledge, attitudes, perceptions, practices and needs of poor rural households and stakeholders on homestead food production with small pond aquaculture at the household level with a focus on women farmers.

Obj 6. To assess the impact of HFP with or without small-scale aquaculture with emphasis on women: women's time and empowerment, gender equity, participation and decision-making at the household and village levels and livelihoods

One of the project objectives focused on empowering women in terms of household decision making, and particularly in terms of decisions on food production and distribution. A gender situation analysis was conducted as part of the baseline and the findings were used to adjust the activity design and implementation approach. Our results were published in Gender and Development (Annex 18). One of the main recommendations emanating from the gender analysis was a need for training specifically designed for and orientated towards women. The training was designed based on the result of the qualitative and quantitative analysis of women's needs conducted in the first 12 months of the project.

The FoF project has empowered women participants, particularly by providing them with more resources over which they have control, including income from HFP activities. This had an impact on overall food purchases and therefore consumption, as women are generally the decision makers around food preparation, food choices and intra-household food allocation. This was determined in

our baseline gender analysis. In most HFP households, women decided which crops would be planted and when, which foods would be eaten at family meals, and how income earned from surplus produce would be spent leading to more nutrient dense foods being purchased e.g. animal foods, iodized salt and eggs. This bodes well for the future as the combination of trainings on agriculture, nutrition and marketing have a greater chance of impacting women and children's health when they have control over these decisions.

5.12 Environment

Obj 7. To assess the environmental impacts of HFP with or without small-scale aquaculture

The FoF project incorporates environmentally sustainable practices such as the use of non-chemical methods of pest and disease control such as botanical pesticides, mulching, composting, crop rotation, insect repellent plants and crops, and live fencing and promotion of locally adapted varieties which do not require high levels of inputs, hence avoiding negative impacts such as decreases in soil organic matter associated with long term inorganic fertilizer usage. FoF households received training on the negative effects of pesticide use and the benefits of using non-chemical alternatives, including higher sale value for produce that has not been treated with pesticides. The environmental sustainability of the FoF pond aquaculture approach is also supported by the use of locally available organic materials for fish feed from readily available ingredients. Methods are being adopted by other farmers as they observe the intervention households having greater production than with traditional methods.

6. Problem and Challenges

The project has encountered challenges as reported in each of the last three reports for the respective reporting periods. The following is a summary of the problems that were faced during the last six months and the project as a whole.

Fishponds drying out prematurely during the dry season (March-May) was a challenge and we have taken steps to mitigate this in the future. Based on the monitoring results, about 30% of the ponds completely dried up and the rest retained some water at the bottom where small fish could survive. In order to address this issue; (i) we developed two nursery ponds, in addition to two hatcheries, to ensure sufficient stock of fingerlings at local level. Immediately after the rains start, households are able to purchase fingerlings for large fish and small fish and (ii) we also promoted fish processing, e.g. as prohoc, as an option to provide minimum access to fish during the dry seasons. Maintaining fish production during the dry season is critical to the success of the project, as this is when there is a fish shortage and market prices for fish are high. If approved for scale-up funding we will conduct experiments to extend the life of the fish ponds, already designed by UBC's Center for Sustainable Aquaculture.

Seasonal migration of the targeted beneficiaries was an unexpected issue in the project area. During the dry season when there is less access to work and food costs are higher, many adults go to Thailand and Phnom Penh to access work opportunities. In some cases both the husband and wife migrate for 3-4 months and the wife's mother takes care of children and other household activities. After conducting case studies, we found that it will be possible to minimize the impact of migration on future projects by improving targeting criteria and process, and by sensitizing participants on the potential negative impacts of migration on child health and nutrition. Importantly, if households can see that they can generate comparable income from their farm, they will be less likely to leave. Community sensitization needs to be improved in this area.

Mobilisation and household selection: In this phase of FoF, the selection process was influenced by the need for randomization, whereby participating households were informed which trial group they were assigned to and did not have an opportunity to choose. Going forward, more time should be allowed for community mobilization and the selection of households and VMF. Households should be selected according to their level of interest and willingness to invest in HFP, among other criteria. A carefully planned and conducted household selection process will be a very important factor in the success of HFP scale-up in Cambodia.

7. Recommendations

The FoF project benefitted from having an excellent advisory team at IDRC, Dr. Sara Ahmed and Dr. Annie Wesley. We found the personal interaction to be very useful and recommend this type of working relationship for any future projects.

We also were fortunate to have very dynamic and enthusiastic government partners, particularly the Fisheries Administration under the Ministry of Agriculture, Forestry and Fisheries and government at all levels from Central, Provincial and Districts and Commune levels. These structures will be instrumental in efforts to scale-up HFP in Cambodia and we highly recommend continuing to advance these relationships in order to develop a sustainable technical backstopping capacity at the local level, and a policy framework at national level that supports and promotes HFP.

One major concern was with the duration of the project. We managed to conduct a rigorous randomized controlled trial of Homestead Food Production among 900 households, with 300 initiating fishponds, with all milestones and objectives met. We were on a very tight timeline having to complete all the activities, achieve outputs and development outcomes in 30 months. We were optimistic to think the timeframe would be long enough to impact nutritional status as the actual time from significantly increasing production to measurements was short. It is a significant achievement that the ponds were constructed, producing fish and generating income within the project period.

The other important aspect of the project is the time required for data collection, analysis and reporting. Our endline survey took place took place within two months of the end of the funding and reporting period due to the need for the greatest possible duration for implementation. Normally, the evaluation process would take up to 6 months of full time work. We will be completing data analysis and reporting for quite some time to come and have included preliminary analyses in this report. Randomized control trials may be the gold standard for determining programmatic input but there are practical field level limitations and the data must be viewed in a number of different ways before final, implementable recommendations can be made. We will be evaluating the characteristics of successful farmers, or ‘positive deviants’ across the 900 households and conducting more sophisticated analyses in the near future, which was not possible given the short report deadline. One recommendation regarding IDRC administration would therefore be to consider increasing the period of time between the end of the project and the deadline for final reporting, which will provide the project team with a longer period to complete the final project report.