FEED THE FUTURE INNOVATION LAB FOR COLLABORATIVE RESEARCH ON AQUACULTURE & FISHERIES
(AQUAFISH INNOVATION LAB)

PROGRAMMATIC TRAINING PLAN 2016–2018

Updated April 2017

AquaFish Innovation Lab
Oregon State University • Corvallis, Oregon USA

USAID FROM THE AMERICAN PEOPLE

AQUAFISH INNOVATION LAB

OSU Oregon State University

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Program activities are funded in part by the United States Agency for International Development (USAID) under CA/LWA No. EPP-A-00-06-00012-00 and by participating US and Host Country institutions.

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Acknowledgments
AquaFish's Management Entity gratefully acknowledges the contributions of AquaFish researchers and the support provided by participating US and Host Country institutions.

Cover Photo
Women examine plankton samples while participating in an AquaFish-sponsored workshop in Tanzania. Photo courtesy of AquaFish Innovation Lab.

This publication may be cited as:
AquaFish Innovation Lab. Goetting, K., Goodwin, B., Bodman, S.L., and Egna, H., (eds). January 2017. AquaFish Innovation Lab Training and Outreach Plan 2016–2018. AquaFish Innovation Lab, Oregon State University. Corvallis, Oregon. 18 pp.

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INTRODUCTION

OVERVIEW

Aquaculture and fisheries are integral to the health, income, and livelihoods of many coastal and inland communities. According to the United Nations, food production must grow by 70% globally to meet the demands of an estimated 2.3 billion additional people by 2050, most of whom will live in developing nations. To keep pace with demand, the aquaculture and fisheries industries must increase productivity in ecologically, socially, and economically sustainable ways. To do so, these sectors must address numerous challenges, which confront developing and developed nations alike. These include financing, water and land access, water quality, access to technical expertise, climate change, and food safety and processing.

To address these challenges and develop more productive and sustainable aquaculture and fisheries sectors in developing nations, government leaders, scientists, and other stakeholders must work to strengthen the knowledge and technical expertise of local people and institutions. This enhanced human and institutional capacity can then foster progress in local governance and best management practices that further address challenges the sectors face.

Building and strengthening the capacities of institutions and individuals is a key objective of the Feed the Future Innovation Lab for Collaborative Research on Aquaculture & Fisheries (also known as AquaFish Innovation Lab or, simply, AquaFish). AquaFish focuses on developing public and private partnerships with various stakeholders in Host Countries (HC) to create training and outreach opportunities, connect them to an international network of aquaculture and fisheries experts, and provide them with new skills and professional development.

A participatory process involving public-private partnerships can engage Host Country stakeholders in an international network and provide them critical information for self-governance. AquaFish capacity building efforts benefit stakeholders in the US and participating Host Countries through the transfer of knowledge and technology, the dissemination of information about best management practices, and increased economic opportunities, ultimately increasing the sustainability of aquaculture and fisheries in all regions.

STRATEGY FOR MAXIMIZING TRAINING AND CAPACITY BUILDING

Human and institutional capacity development (HICD) underpins AquaFish's research mission, with a focus on providing aquaculture training in the form of workshops and other activities (short-term), as well as support and mentoring to students pursuing post-secondary degrees (long-term). AquaFish aims to support and strengthen universities, fish farming co-operatives, and other aquaculture and fisheries institutions in Host Countries and beyond. AquaFish further works to establish collaborative partnerships with governmental research institutions, commercial entities, and nongovernmental organizations (NGOs), culminating in an extensive network of HC and US professionals and institutions that can aid in the continued success and growth of capacity-building efforts. Building an international network, enhancing local capacity in aquaculture and aquatic resource management, and investing in HC capacity of both people and institutions will ensure long-term impacts at community and national levels.

AquaFish works to foster equity and maximize impacts through its training and capacity-building work, including striving to create equal opportunities for women and men to participate in and benefit from the program's research, training, and educational activities. AquaFish measures success by collecting disaggregated gender data to track on progress towards our 50% benchmark for including women in all programmatic activities. AquaFish also works towards gender equity by promoting an understanding of

the societal benefits of involving women in aquaculture and fisheries. AquaFish training and capacity building initiatives are designed in a manner that benefits targeted stakeholders in both the US and Host Countries. Effective short- and long-term training and capacity building focus on four specific levels of engagement: Institutional, Researcher, Extension Services, and End-Users (e.g., farmers and fishers).

AquaFish takes a Host Country-centric approach in creating opportunities for students. While US universities can provide educational and research opportunities to foreign students, the cost is not always prudent and can lead to funding imbalances that favor US universities over those in Host Countries. This imbalance can further deprive HCs from the larger impacts they could see by having students pursue research and education at their local universities — including opportunities to improve curricula and infrastructure at HC universities, increased numbers of personnel trained within the Host Country, and creation of in-country conferences and other networking opportunities. By investing in "local talent" in this way, AquaFish is helping Host Countries to lay the groundwork to become more competitive — academically, scientifically, and commercially — in aquaculture and fisheries on an international level over the long term.

Improving Institutional Capacity

A primary goal of AquaFish's efforts to foster the development of Host Country institutions is to develop highly competent local research capability utilizing Host Country citizens to design and implement internationally accepted research and outreach programs. Institutional strengthening occurs through collaborations with personnel at universities, resource and facility sharing, and curriculum development. This includes providing guidance on the infrastructure and equipment necessary to conduct research that addresses key issues confronting in-country aquaculture and fisheries management sectors. Further, every institution of higher learning involved with AquaFish activities benefits from the experience of international engagement.

AquaFish provides support, mentoring, and academic guidance for students in undergraduate and graduate programs in aquaculture, fisheries, aquatic ecology, economics, engineering, and many other disciplines. Long-term degree trainees constitute a pipeline of educated professionals who move on to careers in government, academia, and private enterprise upon graduation and are able to train the next generation of researchers, extension agents, and fish farmers.

Since 2006, AquaFish has helped HC institutions develop specialized curricula and institutional infrastructure for building local capacity. Increasing capacity at AquaFish's partner universities makes them more competitive for funding and attracting students, leading to a sustainable network of individuals well equipped to address community needs. AquaFish worked with faculty at Ghana's Kwame Nkrumah University of Science and Technology, for example, to establish new curricula and infrastructure, such as labs and ponds, enabling students to gain practical skills in fish farming.

Improving Researcher Capacity

Each AquaFish project has a strong commitment to foster collaborative research between US and HC scientists. Universities in developing nations often require external guidance and training on how to receive and administer international research awards. The ability to process awards from US universities tends to be underdeveloped, and basic research structures are seldom in place. AquaFish's collaboration with HC institutions allows these universities to build the administrative infrastructure necessary to be competitive for future awards. In addition, networking with international colleagues and publishing research findings in internationally recognized journals and trade magazines are of utmost importance for the development of professional careers and for fostering long-term relationships based upon credible scientific capabilities. To this end, AquaFish sponsors conference sessions and professional awards for conference attendance and develops symposia, proceedings, and awards for student posters and

presentations at various aquaculture, fisheries, and aquatic resource management meetings. Additionally, AquaFish Annual and Regional meetings provide HC partners and students with opportunities to learn from researchers in other countries, foster partnerships, and discuss solutions to obstacles that may be hindering success. These efforts also represent an important component of AquaFish's overall information and technology dissemination strategy.

Improving Extension Service Capacity

A high priority of AquaFish's extension efforts is the presentation of short-term "train-the-trainer" workshops. These workshops help train a core group of individuals in all Host Countries who can provide extension activities well beyond AquaFish's grant period. AquaFish also builds relationships with extension specialists, who are sensitive to diversity issues and have access to resources for women and other underrepresented groups. Involving such specialists enhances gender integration and ensures that women farmers and fishers feel welcome at AquaFish training opportunities. Previous experience in Kenya and elsewhere has demonstrated that involvement of new extension agents in short-term, farm-level workshops soon after their own training ensures retention of newly acquired knowledge.

Improving End-User Capacity

By interacting with farmers and understanding their ongoing problems, AquaFish researchers and farmers collaborate to develop economically-feasible and socially-acceptable solutions. AquaFish researchers work directly with fish farmers to develop and test new technologies using their own aquaculture ponds. This type of training allows farmers to participate in the research process and teaches them valuable skills such as pond management, record keeping, and yield calculation. Farmers who participate in AquaFish research can serve as role models who share what they have learned to other farmers who could benefit from adopting available technologies. Technologies and knowledge are communicated to end-users in a variety of ways, including on-farm trainings and demonstrations; workshops in local communities; and strategically developed and culturally appropriate outreach materials, such as brochures, manuals, and flyers.

TRAINING DEFINITIONS

AquaFish defines training as a learning activity with formally designated instructors or leaders, learning objectives, and outcomes. It involves the transfer of knowledge, skills, or attitudes through structured learning and follow-up activities or through less-structured means to solve problems or fill identified performance gaps. Training can consist of long-term academic degree programs, non-degree technical courses, non-academic seminars, workshops, occupational learning experiences, observational study tours, or distance learning exercises or interventions.

Short-term training is defined as non-academic training that lasts less than six months and does not lead to a degree or technical certificate. These activities typically include workshops, on-farm trainings, seminars, short-courses, and internships that transfer knowledge, technologies, and skills for HC farmers and fishers, producers, fisheries officers, extension specialists, policy makers, and others.

Long-term training is defined as formal academic training lasting six months or longer, including, but not limited to, degree programs. Long-term training typically includes formal education intended to culminate in a Bachelor's, Master's, or Doctorate degree (or equivalent), but that can also include training leading to a high-school diploma, a technical certificate, Associate degree, or post-doctoral studies.

CAPACITY BUILDING BENCHMARKS

The intent of AquaFish is to focus investments on building local capacity in aquaculture and aquatic resource management and to ensure long-term program impacts at local and national levels through strategic informal and formal training opportunities, while also integrating gender-related items.

The following Milestones and Benchmarks are excerpted from the AquaFish Monitoring & Evaluation Plan, approved by AquaFish AOR, USAID on 09 September 2013.

Capacity Building Target

Focus AquaFish investments on building local capacity in aquaculture and aquatic resource management and ensuring long-term program impacts at local and national levels through strategic informal and formal training opportunities. Integrate items related to gender.

Capacity Building Milestones – Regional

(1) Forged professional and managerial relationships between US and Host Country researchers and institutions.
(2) Established a track record of successful formal long-term training of Host Country and US students and researchers.
(3) Delivered relevant short-term training opportunities that provide positive Host Country societal benefits beyond the life of AquaFish.
(4) Identified gender issues in aquaculture and fisheries and adopted gender program-wide integration policies.

Year 1 Benchmarks:

a. Gender integration strategies adopted within all sub-awards.
b. Regional Centers of Excellence continued within the AquaFish regions for research activities (i.e., Asia, Africa, and Latin America and the Caribbean).
c. Formal Memoranda of Understanding adopted between all US and Host Country partners.

Years 2-5 Benchmarks

a. Partnerships strengthened among US and Host Country universities, NGOs, NARS, and USAID Missions through Associate Awards.
b. At least 100 degree seeking men and women enrolled through formal long-term training opportunities in US, Host Country, and Regional universities.
c. Equal numbers of women and men trained through short- and long-term training opportunities.
d. Numerous train-the-trainer workshops convened to provide Host Countries with highly skilled extension specialists.
e. At least 30 workshops convened over the course of this 5-year award and encouraged equal participation from women and men.

TRAINING METRICS AND DISSEMINATION

In order to ensure that AquaFish meets its training and capacity building objectives, data is collected on short- and long-term training activities. Trainee information collected includes: name, gender, nationality, training location, training dates, and type of degree earned (if applicable). Information is updated quarterly and disaggregated data summaries are disseminated through reports written by the AquaFish MT for USAID, as well as in outreach materials, including oral and poster presentations at conferences, symposia, meetings, and workshops in the US and throughout the world.
The following Milestones and Benchmarks are excerpted from the AquaFish Monitoring & Evaluation Plan, approved by AquaFish AOR, USAID on 09 September 2013.

Information Dissemination Target

Disseminate AquaFish research results to foster broad applications of results among local stakeholders within governmental and non-governmental organizations, private sector, as well as for end-users, and the general public.

Information Dissemination Milestones

(1) Successful diffusion of AquaFish research results and technologies between countries within a region having comparable social and environmental conditions.
(2) Increased awareness of local stakeholder constraints and opportunities related to responsible aquaculture and fisheries management.
(3) Applicable extension activities associated with each research project conducted to ensure wide dissemination of research results.
(4) AquaFish results and technologies for farm operations adopted and policies fro responsible aquatic resource management created.
(5) AquaFish research published in regional, national, and international peer-reviewed journals.

Year 1 Benchmarks:

a. Dissemination efforts have continued through AquaNews, EdOpNet, and the searchable online publication database.
b. The importance of extension evident through integration of at least one outreach activities within each funded project.
c. Research adoption encouraged by prioritizing the use of on- and off-farm trials to conduct research.

Years 2-5 Benchmarks:

a. Intra- and inter-regional diffusion of AquaFish results and technologies accomplished.
b. Training manuals with local and regional scopes published following completion of AquaFish research projects.
c. Continuous academic output of AquaFish data as publications within recognized journals and presentations provided at regional, national, and international forums.

PROJECT TRAINING PLANS

The AquaFish Training and Outreach Plan 2016–2018 outlines the training goals of each AquaFish project for the Implementation Plan 2016–2018. Summaries of proposed short-term training events and long-term trainees are included for each project. The following information on proposed trainings and trainees is based on information provided in the proposal for each project.

The Outreach and Dissemination Plans are printed as submitted by project PIs. Complete work plans, including all investigations, can be found in the Implementation Plan 2016–2018.

AFRICA PROJECT: KENYA AND UGANDA

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AQUACULTURE DEVELOPMENT IN KENYA AND UGANDA: ADVANCING COST-EFFECTIVE TECHNOLOGY, MARKET ASSESSMENT, AND END-USER ENGAGEMENT

Summary

Poor families in developing countries typically spend 50% to 70% of their income on food. When quality food becomes too expensive, women tend to modify their consumption, often turning to cheaper alternatives, typically lacking in necessary nutrients. To increase income and reduce the prevalence of undernutrition, enhancing access to fish and sustainable aquaculture is key. This project will build on previous work by AquaFish researchers to address obstacles to the development and growth of aquaculture in Uganda and Kenya. Researchers will develop low-cost captive breeding and hatching technologies of African lungfish (*Protopterus aethiopicus* and *P. amphibius*) that will introduce new opportunities for farming popular native species that are less vulnerable to a changing climate than many non-native species. To increase incomes for fish farmers and improve (and expand) markets of farmed fish, researchers will assess price volatility in the fish supply chain in Uganda, in addition to creating a cell-phone network that will connect people throughout the aquaculture value chain. With the hope of mitigating negative environmental impacts of aquaculture, researchers will measure various metrics of water quality in farmed waterbodies and evaluate the need for water quality amendments. Beyond direct improvements to aquaculture in Kenya and Uganda, researchers plan to train and support women in aquaculture. With the help of institutional partners and industry, researchers will hold a series of capstone events that will train women on the nutritional value of new species and augment women's access to information about the entire value chain of aquaculture.

Outreach and Dissemination Plan

Activities. The overall Uganda outreach plan features key events and partnerships with farmer organizations that amplify and extend the insights and recommendations emanating from AquaFish research. In Uganda, the Annual Fish Farmers Symposium and Trade Show has proven to be a singular event drawing hundreds of participants, including active fish farmers, would-be fish farmers, and others who service or support fish farming in Uganda. We plan a joint symposium with Nutrition Innovation Lab researchers in collaboration with the Fisheries Training Institute in Entebbe. In the next two years, we are planning training events with three fish-farmer associations in other parts of the country.
In Uganda, outreach efforts will be augmented by cell-phone applications that provide access to vetted production strategies, marketing information, and problem resolution mechanisms that should be more immediately available and responsive than existing extension arrangements. In turn, farmers will have direct ways to communicate to national experts about fish disease and other technical problems in ways that were heretofore not available. In particular, cell networks should facilitate access to nutrition information, markets, prices, and inputs. Finding fingerlings, nets, feed, and other material for fish farming should be more readily available to participants in the network enabled by the cell-phone

application. The application also should counter misinformation and fraudulent claims that often accompany a period of enthusiastic expansion and opportunities in aquaculture.

Methods. The Uganda project seeks to equip and enable its Host Country colleagues to be central sources of guidance and activation of fish farming. The faculty members involved with this project will lead this effort by organizing and hosting annual conferences and farmer field days. They will also provide one on one guidance and advice for potential and existing fish farmers. Uganda faculty will contribute and present content in their Annual Fish Farmers Symposium and Trade Show in addition to the organization and hosting aspects. In some situations, outside investors and changing water body access policies are causing surges in industrial aquaculture development.

The feed and fingerling infrastructure expansion that accompanies this growth can benefit all farmers if small and medium producers are guided and supported to participate in new opportunities to produce fish for the rapidly growing population in Uganda. Advice and guidance will be provided to these investors, farmers, and vendors to improve their efficiencies and profitability, which should benefit the entire aquaculture sector as it continues to grow and provide additional supplies of high-quality, affordable fish products to local consumers and potential exporters.

Timeline. In the remaining first year of the project, we will hold a fish-farmer symposium in Uganda to forge new partnerships with fish-farmer associations in other regions. We will have fish-farmer applications on cell phones in Uganda by the end of Year 1. We have engaged a private firm that operates cell-phone applications in other sectors to develop applications for fish farming in Uganda. The firm has established mechanisms for marketing and providing technical support to other farm enterprises. We are proceeding while also informing stakeholders in the National Fisheries Resources Research Institute (NaFIRRI), NGOs, and private entrepreneurs in Uganda.

In the second year, we will continue our relationship with the Fisheries Training Institute in Entebbe to hold conferences and trainings that focus on the needs of women in aquaculture. We will endeavor to clarify the role of women in fish culture value chains and to articulate and disseminate ways for women to augment their participation and benefits from fish farming. FTI will have an enduring role.

Short-Term Trainings

Table 1. Auburn University scheduled short-term trainings for Implementation Plan 2016–2018

Investigation Title	Event Name	Location	Beneficiaries
Implementing and assessing cell-based technical and marketing support systems for small and medium-scale fish farmers in Uganda (16FSV02AU)	Workshop on profiled information packages (x2)	Uganda	Fish farmers, researchers, policy makers, and professionals
	Farmer training on using the aquaculture phone application (x2)	Uganda	

	Workshop to introduce mobile- phone application (x3)	Uganda	
Assessment of price volatility in the fish supply chain in Uganda (16MER02AU)	Presentation to farmer conference	Uganda	
Women in Uganda Aquaculture: Nutrition, Training, and Advancement (16HHI04AU)	Conference on Women in Uganda Aquaculture	Uganda	Women, fish farmers
	Training on women's organization. in development for women farmers and service providers	Uganda	Women and children
	Training on value chains and marketing in aquaculture for farmers	Uganda	
	Presentation to fish- farmer cooperative members and leaders (x3)	Uganda	Fish-farmer cooperatives
	Fish- farming conference and trade show	Uganda	
Water, water quality, and pond bottom soil management (16BMA05AU)	Conference presentation	Uganda	
	Presentation to fish -farmer cooperative members and leaders (x3)	Uganda	Fish farmers

Long-Term Trainings

Eleven students will be supported for degree training by the Auburn University project in Implementation Plan 2016–2018, including two PhD students and four Master's students. Students will be trained in Kenya at the University of Eldoret; in Uganda at Makerere University and the National Fisheries Resources Research Institute; and in the US at the University of Arizona, Auburn University, and Alabama A&M University.

ASIA PROJECT: NEPAL

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ADVANCING AQUACULTURE SYSTEMS IN NEPAL FOR MORE SOCIAL AND ENVIRONMENTAL SUSTAINABILITY

Summary

Nepal is a poor country; most residents are, at best, educated at the level of primary schooling, and many are undernourished or even malnourished. As a result of this poverty, most planning documents produced by the government, as well as outside organizations, concentrate on human health and nutrition as the main focus for future development of aquaculture in this region. The primary focus of this project is to improve food security and nutrition for rural communities in Nepal through a suite of investigations on small-scale aquaculture as well as through continued outreach programs for rural farmers and their families and expanding school ponds for education of rural youth. To improve productivity of production systems without increasing inputs, researchers will investigate polyculture of carp with Nile tilapia (*Oreochromis niloticus*) and sahar (*Tor putitora*). Additionally, the project will explore ways to enhance periphyton growth in aquaculture ponds. Periphyton is a community of tiny organisms (e.g., algae, bacteria, fungi, and animals) that can cover rocks and other surfaces underwater and form the base of aquatic ecosystems and food chains. Increased periphyton, as it removes excess nutrients from water, could decrease negative environmental effects of aquaculture while augmenting production of periphyton feeders, such as rohu, *Catla*, and common carp. Researchers also will focus on enhancing the production of native fish species, with particular attention to sahar, an economically important, highly valued indigenous fish species in Nepal. By incorporating sahar in on-farm trials for improving culture techniques, researchers hope to expand seed production, a major bottleneck to aquaculture development in Nepal. Researchers will inquire about the sources of aquaculture information for local households and whether and how that information changed household aquaculture.

Outreach and Dissemination

AquaFish intends to develop outreach to affect four different communities: end users; HC decision-makers, including government, researchers, and extension agents; USAID personnel; and other stakeholders, mainly the broader educational and user community. We intend to focus our efforts on these four groups in an appropriate and targeted way for each user, as defined below.

We have considerable experience throughout Southeast Asia in communicating our aquaculture research to farmers and other end users through the development of outreach materials, workshops and short training courses, and partnering with the NGO community. US Project PI Dr. James Diana has been involved in aquaculture projects in Southeast Asia since the inception of the Pond Dynamics/Aquacultur**e** Collaborative Research Support Program (PD/A CRSP) in 1982. Dr. Diana and HC Project PI Dr. Madhav Shrestha have collaborated since 1994 and have worked together in Nepal since 2001. In Nepal, outreach is limited by one serious problem — illiteracy is widespread, causing a greater need for in-person training than written outreach materials. All Nepal investigations have some form of outreach planned. These include:

- At least 20 farms or households doing on-farm trials and instructing more than 20 fish farmers (Investigation 1);
- More than 100 people receiving direct training through existing school ponds and women's groups (Investigation 4);
- Formation of two new school ponds and two new women's fish farming groups to disseminate information to more than 40 students and 20 adult women (Investigation 4);
- Long-term training of six graduate and 18 undergraduate students in aquaculture research and extension (all investigations);
- Training of 10 culturists on sahar production in one workshop (Investigation 3); and

- More than 20 women receiving training through on-farm studies on periphyton enhancement (Investigation 2).

Agriculture and Forestry University (AFU) has a mission to provide training to farmers, extension agents, and government staff on the research conducted by their faculty and by AquaFish. The main avenue for such training has been short courses at host institutions. Through these outreach venues, the project team will extend our information mainly to end users in private business.

One important means to multiply technology transfer is to work with entities already providing such service in Nepal. To this end, partnerships have been established with the Nepal Agricultural Research Council and Directorate of Fisheries Development to further extend our results to the larger community. Two private and two government hatchery workers will be trained on monosex production of tilapia (Investigation 2), and researchers will work closely with additional NGOs in Nepal to ensure the widest distribution of our research results. One method of outreach to these professional groups is to involve scientists and extension agents in in-country and regional meetings. Furthermore, faculty from AFU regularly will attend in-country meetings to foster the exchange of technologies and practices. In support of this outreach, Nepal project researchers intend to produce at least one fact sheet for each investigation and one overall briefing on proposed research to the larger technology transfer community.

Keeping the USAID Mission in Nepal, as well as other offices of USAID, informed of our work and results is another important outreach activity. Nepal project leaders have contacted Navin Hada at the Mission about planned research and will keep him and the Mission informed as the project progresses to actual field work and workshops. Hada and the Mission also will be informed of results through at least annual meetings with the Mission, as well as invitations sent to Mission officers to attend workshops and training activities.

Finally, in the research field, it is important to provide information to the research community to better inform them on possible improvements in aquaculture systems. Nepal project researchers have extensive experience with publishing materials under the previous CRSP in peer-reviewed journals, Global Aquaculture Advocate and other trade journals, and books. This extension is equally important in the development of new knowledge, and a focus on research publication will continue. Researchers also have made a special effort to present early results of their work at local, regional, and international meetings on aquaculture and have been especially conscious of involving all HC personnel in these presentations. As one past example, Nepal project researchers helped co-sponsor a symposium on biodiversity and lower intensity aquaculture held at the Annual Meeting of the American Fisheries Society in Seattle in 2011. Under the present proposal, financial support has been requested for each one of the scientists involved to travel to international meetings, as well as to conferences within Nepal, to present their results and network with aquaculture colleagues. As deliverables in this area, the Nepal project will target the presentation of research results to regional and international research communities through presentations at local fisheries meetings, the Asian Fisheries Society, and the World Aquaculture Society.

Short-Term Trainings

Table 2. University of Michigan scheduled short-term trainings for Implementation Plan 2016–2018

Investigation	Event Name	Location	Beneficiaries
Improving seed production of sahar (*Tor putitora*) in Chitwan (16QSD02UM)	Workshop	Chitwan, Nepal	Fish hatchery farmers, commercial fish farmers, government scientists, and extension officers

A comparison of monoculture and polyculture of tilapia with carps for pond production systems (16BMA03UM)	Demonstration trial on new production system	Nepal	Fish farmers
	Workshop on results		
Developing new systems for periphyton enhancement in farmers' ponds (16BMA04UM)	Workshop about alternatives for pheriphyton substrates (x2)	Majhui and Kawasoti, Nepal	Fish farmers
	On-farm trials	Nepal	Fish farmers
	Workshop (x2)	Nepal	Fish farmers, extension personnel
Outreach to increase efficiency of aquaculture (16HHI03UM)	Training on pond construction and farming (x2)	Nepal	Students, communities
	Training for women's group on aquaculture and its role in household nutrition (x2)	Nepal	Womens' groups, communities

Long-Term Trainings

Twenty-one students will be supported for degree training by the University of Michigan project, including one PhD student, 10 Master's students, and 10 Bachelor's students. All students will be trained at Agriculture and Forestry University in Nepal, under various advisors.

ASIA PROJECT: BANGLADESH

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ENHANCING AQUACULTURE PRODUCTION EFFICIENCY, SUSTAINABILITY, AND ADAPTIVE MEASURES TO CLIMATE CHANGE IMPACTS IN BANGLADESH

Summary

Bangladesh, one of the most densely populated countries in the world, has high rates of poverty and widespread malnourishment, particularly among women and children. Sustainable aquaculture in Bangladesh is one solution for increasing food security, enhancing dietary nutrition, and improving the economic livelihoods for its poorest citizens. However, technical, environmental, and economic barriers limit aquaculture production in the country. This project, through five investigations, seeks to address such barriers by developing technologies for enhancing aquaculture production efficiency, intensification, and sustainability to improve household income and nutrition, particularly for low-income farming households. With the hope of increasing feed efficiency and reducing associated costs, researchers will evaluate the effectiveness of nutritional conditioning and characterize the respective changes in gut microbial communities and nutrient absorption in tilapia. To address environmental and economic concerns for the existing farming industries of shrimp and prawn, researchers will continue to assess the potential for farming *Pangasius* catfish in brackish (hyposaline) waters in regions traditionally reliant solely upon shrimp farming. Researchers also will examine a novel polyculture/land-farming strategy, culturing mola (*Amblypharyngodon mola*) with prawns and using pond muds as fertilizer to grow fresh vegetables on unflooded gher-dykes. Lastly, researchers will evaluate the effects of reducing feed and investigate polyculture technology — particularly in indigenous, air-breathing fishes such as shing and koi (nutrient rich and hardy fish) — to enhance incomes and dietary nutrition, while reducing environmental impacts. To maximize the adoption and impact of improved technologies, researchers will hold a series of workshops and trainings, complemented by the distribution of outreach materials.

Outreach and Dissemination

The research and outreach activities proposed should improve polyculture and integrative seafood production systems; generate strategies for better feed management and cost efficiency for fish culture; and enhance the participation of women in seafood production, including for nutrient-dense, small indigenous species and vegetables. These technologies should improve the income opportunities and production of nutritious fishes for farmers. Bangladesh project leaders believe the incorporation of these ideas, transmitted through working interactions with local farmers is the best approach for extending effective management options to aquaculture. Project researchers will work directly with women in households in several of the on-farm trials, who will be key to managing the feed trials as well as quantifying vegetable and small indigenous fish consumption within the households. Other aspects of the proposed research will be conducted at Bangladesh Agricultural University (BAU), the primary research/extension center supporting freshwater aquaculture in Bangladesh, and will promote the training and education of students necessary for promoting sustainable aquaculture practices. Farmers frequently visit the university through extension workshops and routinely interact with faculty, staff, and students to obtain the latest news and research related to fish farming. This could be similarly said for Khulna and Patuakhali University of Science and Technology, whose roles in research and extension in coastal fisheries and aquaculture are taking on a greater role in Bangladesh. Additionally, six workshop events will be held in the second year in Mymensingh, Khulna, and Barishal regions of Bangladesh to provide hands-on, practical instruction to about180 farmers on aquaculture technologies for improving production efficiency, sustainability, and adaptive measures for climate change impacts. About three to five fact sheets will be provided in the local language on the developed technologies and their economic benefits to farmers, NGOs, and extension officers of the government. In Southwest Bangladesh, more than 30 to 60

women will play a key role by undertaking studies on improving management and production of mola and vegetables for home consumption and prawn as a cash crop.

In addition, the project will involve more than 50 farmer households in the research and best management practices, including women stakeholders, and provide research and extension training to more than 10 graduate and undergraduate students through BAU, Khulna University, and North Carolina State University (NCSU). This will enhance the research capacity needed for developing the aquaculture and fisheries sectors in Bangladesh.

Project results also will be disseminated to the global community through publications in scientific journals, presentations at the annual World Aquaculture Society and regional aquaculture meetings, and through AquaFish's progress and final reports.

Short-Term Training

Table 3. North Carolina State University scheduled short-term trainings for Implementation Plan 2016–2018

Investigation Title	Event Name	Location	Beneficiaries
Better management practices for mola-prawn-carp gher farming integrated with pond dyke cropping for increased household nutrition and earnings of rural farmers in Southwest Bangladesh (16HHI01NC)	Training on nutrition and best management practices for producing fish and vegetables	Bangladesh	Women and girls
Dissemination of AquaFish technologies for improving food production efficiency and livelihoods of people of Bangladesh (16MNE02NC)	Reduced feeding strategies and/or polyculture (x2)	Mymensingh, Bangladesh	Fish farmer, government fisheries extension agents, and NGOs
	Pangasius culture in brackish water (x2)	Barishal, Bangladesh	
	Mola polyculture and integrated aquaculture-agriculture systems (x2)	Khulna, Bangladesh	

Long-Term Training

Ten students will be supported for degree training by the NCSU project, including six Master's students four Bachelor's students. All students will be trained at institutions in Bangladesh.

AFRICA PROJECT: GHANA AND TANZANIA

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AQUACULTURE DEVELOPMENT AND THE IMPACT ON FOOD SUPPLY, NUTRITION, AND HEALTH IN GHANA AND TANZANIA

Summary

In sub-Saharan Africa, fish is an important source of protein, essential micronutrients, and minerals in the diet of most households. Thus, fish and their sustainable production are major contributors to food security and improved livelihood in Ghana and Tanzania. However, supply of fish is low, causing limited consumption levels. Through five investigations, this project builds on previous AquaFish work to enhance the various facets of aquaculture and its contribution to food supply, nutrition, and health in Ghana and Tanzania. The cost of quality feed frequently limits aquaculture production; hence, researchers continue working to develop cost-effective diets from locally available ingredients (e.g., earthworm and maggot meals) and evaluate the profitability of such feeds in comparison to commercial feeds. To aid fish farmers in determining better methods of feeding, fertilizing, and managing water quality, the project will compare fertilization and feeding strategies and evaluate the physical, chemical, and biological characteristics of ponds during grow-out. To better inform stakeholders along the fish-value chain and more efficiently support markets, researchers will train farmers and fishermen on the use of a cell-phone-based information system and broaden its applicability to include marine fisheries. Through a household survey on dietary diversity and an analysis of household consumption practices, researchers plan to formulate policy measures that improve aquaculture and fisheries practices in order to increase household food security.

Outreach and Dissemination

Outreach and dissemination strategies will focus on increasing human and structural capacity at Kwame Nkrumah University of Science and Technology in Ghana and Sokoine University of Agriculture in Tanzania and the aquaculture subsector in general. Knowledge generated from the various investigations also will be disseminated through formal and informal presentations at local training programs; regional and national conferences and seminars; farmer's education and extension education meetings; and publications. Publications will include research articles in peer-reviewed journals and extension publications in local languages. The project also includes short-term and long-term training programs. Long-term training involves a total of 17 graduate and undergraduate students to be trained at US institutions, KNUST, and SUA. Various investigations also involve short-term training programs. In Ghana, the investigation on the use of commercial feeds in semi-intensive pond production includes a workshop to disseminate the results to fish farmers. A target of 100 fish farmers and nursery operators will participate in this workshop. In addition, the cell-phone-based fish market information system (FMIS) investigation includes two training programs on how to use mobile phones to receive information on seafood prices and other market data. It is anticipated that 50 participants will be trained at each of the two sessions (producing a total of 100 trainees). Similarly, there will be two training programs in Tanzania: one on pond dynamics and the other on alternative protein sources for fish feed. A total of 80 participants is expected for the two workshops.

Accomplishing the various investigations and outreach activities presented in this proposal will help farmers to better understand on-farm pond dynamics and make better use of pond resources; will aid in creating profitable fish farming enterprises from reduced feed costs; and will lead to expanded markets and trade, particularly for women to ensure long-term sustainability of aquaculture in Ghana and Tanzania. The project outreach activities will incorporate the active engagement of stakeholders that include input suppliers, fish farmers, fish traders and retailers, policy makers, and NGOs.

Dissemination efforts will include developing working partnerships, including participation in the various workshops, with the national aquaculture association, government institutions, and nongovernmental agencies to achieve a common purpose. Industry and government representatives will be active participants in every step of the implementation process. To engage policy makers, politicians will be invited to organized workshops and taken on tours to project sites. To keep the USAID Mission in the respective countries properly informed, visiting US and HC PIs will visit USAID Mission offices for discussions on potential areas of collaboration on AquaFish projects. All reports and published materials from this project will be made available to USAID Mission offices, government offices, nongovernmental agencies, and the respective universities and agencies that have a stake in aquaculture and natural resources. Host Countries also will promote AquaFish project activities on various campuses and highlight accomplishments to administrators.

The focus of outreach and dissemination strategies will not only be in-country but across the region among Ghana, Kenya, Uganda, and Tanzania. South-South cooperation is being adopted in this project with cross-country visits by HC PIs in the form of joint sponsorship of and participation in training programs and involvement in cross-country research through research supervision. The expertise of HC PIs will be brought into collaborative arrangements depending on the needs and objectives of each country.

Short-Term Trainings

Table 4. Purdue University scheduled short-term trainings for Implementation Plan 2016–2018

Investigation Title	Event Name	Location	Beneficiaries
Experimental Pond Unit Assessment in Tanzania (16BMA01PU)	Workshop on water- quality management	Tanzania	Fish farmers, extension officers
Increasing productivity of Nile tilapia through enhanced feeds and feeding practices (16SFT03PU)	Workshop on feed formulations and best feeding strategies/diets	Ghana	Fish farmers
Optimizing the use of commercial feeds in semi-intensive pond production of tilapia in Ghana (16BMA02PU)	Workshop on optimal production techniques	Ghana	Fish farmers
Enhancing the functionality and applicability of fish market information system (FMIS) to marine artisanal fisheries in Ghana (16MER01PU)	Training program on using mobile phones for market information	Ghana	Artisanal fishermen

Long-Term Trainings

Seventeen students will be supported for degree training by the Purdue University project, including two PhD students, 13 Master's students, and one Bachelor's student. Fourteen of these students will train in Host Countries at KNUST and SUA. The remaining three students will train at affiliated universities in the US.

ASIA PROJECT: CAMBODIA AND VIETNAM

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IMPROVING FOOD SECURITY, HOUSEHOLD NUTRITION, AND TRADE THROUGH SUSTAINABLE AQUACULTURE IN CAMBODIA AND VIETNAM

Summary

The productive Mekong fisheries are essential to the food security and nutrition of the 60 million people of the Lower Mekong Basin. Fish, from capture and culture, are a significant source of income and food security in Cambodia and Vietnam. The rapid growth of freshwater aquaculture in both countries represents an opportunity to improve the livelihood of their residents. However, climate change, coupled with population growth and overexploitation of fisheries, poses a threat to productivity and viability of sustainable aquaculture operations. This project builds on past AquaFish work through five integrated investigations that support the development of sustainable aquaculture, enhancement of trade, and improvement of aquatic resource management, with a focus on sustainable snakehead aquaculture after the ban of snakehead farming was lifted in Cambodia in June 2016. To address the sustainability of the popular snakehead industry, researchers will work to develop alternative cost-effective feeds, compare growth performance and survival rate of different snakehead strains, and improve value-added processing techniques typically undertaken by women. A household survey will explore the availability of fish, as well as perceived versus actual benefits of consuming fish. The results of these efforts will inform strategies and policies that address nutritional deficits, particularly for women and children in Cambodia.

Outreach and Dissemination

There will be two audiences for the information and assistance from this project: end users, including women and commercial and small-scale aquaculturists and fishers; and HC decision-makers, managers, researchers, NGOs, and extension agents. Each audience group has unique outreach needs that will be addressed. Outreach and dissemination activities to be undertaken in this project will be directly linked to research outputs and included in the project's overall approach rather than in individual investigations. Earlier Aquaculture and Fisheries Collaborative Research Support Program (AquaFish CRSP) and AquaFish Innovation Lab projects found that a range of outreach methods are needed to address these multiple target audiences. For end users, emphasis will be given to capacity building, communication, and extension of knowledge in ways that are relevant to both commercial-scale and small-scale aquaculturists and fishers and to vulnerable groups, such as women. Outreach activities will focus on:

- Restarting snakehead farming, leading to increased household income and improved snakehead fish market and trade (Investigation 1);
- Providing economic information on different snakehead production systems in Cambodia and Vietnam to farmers (Investigation 2);
- Providing information on sustainable breeding, weaning and grow-out of snakehead in Cambodia (Investigation 3);
- Improved snakehead feed and feeding strategies (Investigation 4); and
- Improved nutrition from fish for women and children (Investigation 5).

Outreach methods to be used will include formal and informal workshops and training sessions (all investigations); one-on-one consultations (Investigation 4); development of best practice guidelines (Investigation 3); posters, leaflets, and fact sheets (all investigations); and on-farm trials (Investigation 4). Engaging end users requires a shift in extension thinking away from technology toward a more flexible people-centered and participatory approach using innovative communication mechanisms. This approach will involve using participatory rural appraisal (PRA) techniques, which involve researchers and extension agents working and learning with local farmers and aims to boost the ability of local farmers to analyze, plan, and take action, according to local aquaculture needs (Investigations 3,4). For example,

farmers will be trained to extend new feed and feeding strategies to other farmers. All outreach activities and materials will be produced in the local language. Outreach activities will be undertaken with extension staff in each country with support from university and government researchers. There will be intraregional diffusion of results not just in the two HCs but in neighboring countries such as Laos and Thailand. For HC decision-makers, managers, researchers, NGOs, and extension agents, the outreach activities will focus on information about genetic research methods and findings (Investigation 1); better recommended policies and strategies for sustainable snakehead aquaculture in the region (Investigations 1 and 3); economic information on different snakehead production systems in Cambodia and Vietnam to farmers (Investigation 2); sustainable snakehead aquaculture breeding, weaning, and grow-out strategies (Investigation 3); feed and feeding strategies for snakehead (Investigation 4); and improving food and nutrition security of women and children (Investigation 5). Methods to be used will include training and workshops, involvement in on-farm and off-farm research and trials, and policy briefs and fact sheets. These methods all worked successfully in the prior AquaFish project. Science-based policy recommendations will be provided in Cambodia to address the recently lifted ban on snakehead aquaculture. In workshops and training, participants will be trained to be more gender-sensitive in the delivery of information and assistance and to specifically address the role of women. All workshops and trainings will be conducted with other ongoing aquaculture projects in Cambodia, when possible.

Short-Term Trainings

Table 5. University of Connecticut scheduled short-term trainings for Implementation Plan 2016–2018

Investigation Title	Event Name	Location	Beneficiaries
Genetic diversity of striped snakehead in Cambodia and Vietnam (16QSD01UC)	Training on basic fish population genetics	Can Tho University	IFReDI staff
	Training on practical skills on DNA lab work, genetic data analysis, and reporting	Can Tho University	IFReDI staff
Guidance and policy recommendations on snakehead aquaculture and aquatic resource management in Cambodia and Vietnam (16PDV01UC)	Final National Workshop	Cambodia	
Sustainable snakehead aquaculture in Cambodia (16IND01UC)	Training on domestication breeding, weaning, grow-out, and feed formulation technologies of the striped snakehead	Cambodia	Fish farmers, government fisheries officers
Pellet feed improvements through vitamin C supplementation for snakehead culture (16SFT01UC)	Training on fish nutrition and data analysis	Can Tho University and FARDeC	IFReDI
	Training on snakehead feed formulation and manufacture		
	Training on feeding strategies		
	Training on improved snakehead processing technology		

Enhancing food safety and household nutrition of women and children through aquaculture and capture fisheries in Cambodia and Vietnam in the dry season	Training on dietary assessment by using the 24-hour food recall, fish species, food safety, nutrition, and data cleaning and entry	Cambodia and Vietnam	IFReDI staff and Can Tho University staff

Long-Term Trainings

Seventeen students will be supported for degree training by the University of Connecticut project, including eight Master's students and nine Bachelor's students. All of these students will train at various HC institutions, including Inland Fisheries Research and Development Institute (IFReDI) in Cambodia and Can Tho University in Vietnam.