Feed the Future Innovation Lab for Collaborative Research on Aquaculture & Fisheries (AquaFish Innovation Lab)

IMPLEMENTATION PLAN 2016-2018 ADDENDUM

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AquaFish Management Office
Oregon State University
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AQUAFISH INNOVATION LAB
IMPLEMENTATION PLAN 2016-2018 ADDENDUM

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The mission of the AquaFish Innovation Lab is to enrich livelihoods and promote health by cultivating international multidisciplinary partnerships that advance science, research, education, and outreach in aquatic resources. Bringing together resources from Host Country institutions and US universities, the AquaFish Innovation Lab emphasizes sustainable solutions in aquaculture and fisheries for improving health, building wealth, conserving natural environments for future generations, and strengthening poorer countries' ability to self-govern.

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Cover Photo
Fish at market, Thailand. Photo courtesy of Stephanie Ichien.

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AquaFish Innovation Lab
College of Agricultural Sciences
Oregon State University
Strand Agriculture Hall
Corvallis, Oregon 97330-1643 USA

INTRODUCTION

This addendum to the AquaFish *Implementation Plan 2016-2018* includes the project summary and Work Plans for US-based desk studies focused on fisheries and aquaculture in Burma, led by Michigan State University. The two Work Plans, or investigations, are titled, *Determining the role of wild-caught and aquaculture-based inland fisheries in meeting Burma's human nutritional needs* (16HHI05MS) and *Developing a conceptual model to evaluate the potential changes in inland food fish supply under various global climate change scenarios* (16IND04MS). This work will contribute to the AquaFish mission by cultivating international multidisciplinary research partnerships in the US and Burma that can be further developed in the future. Using existing data, the investigations are exploring the importance of inland fisheries, both wild-capture and aquaculture, in supplying micronutrients to the Burmese diet, and they will also contribute to the goal of strengthening fisheries management and addressing issues of food security and human wellbeing in Burma in relation to its freshwater fisheries resources.

The Work Plans included in this addendum were reviewed by three technical experts, as well as by the AquaFish Management Team, and were approved on 31 May 2017.

RESEARCH PROJECT SUMMARY

ASIA PROJECT: BURMA

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Project Title

SUSTAINABLE INLAND FISHERIES FOR BURMESE FOOD SECURITY IN AN ERA OF GLOBAL CHANGE

Investigations

16HHI05MS Determining the role of wild-caught and aquaculture-based inland fisheries in meeting Burma's human nutritional needs

16IND04MS Developing a conceptual model to evaluate the potential changes in inland food fish supply under various global climate change scenarios

Collaborating Institutions

Michigan State University (Lead US Institution)
U.S. Geological Survey

Project Summary

Burma is economically one of the poorest countries in Asia, with up to 26% of its population currently living in poverty (UNOPS 2012). The Burmese people rely heavily upon their local inland fisheries for nutrition and livelihoods, particularly in rural communities (Soe 2008). The average Burmese citizen reportedly consumes 22.7 kg of fish per year (FAO 2003), compared, for example, to 7.03 kg of fish consumed by the average American per year (NOAA 2016). In addition to food security, inland fisheries contribute greatly to the local economy and livelihoods. For instance, the Burma Department of Fisheries (DOF) estimates that the entire (marine, inland, aquaculture) fisheries sector provided about 3,201,923 jobs (including part time and daily workers and people working in fish-processing related jobs), approximately 30% of the total workforce in Burma (Ei 2010).

Despite the importance of fish to the well-being (e.g., food, nutrition, and livelihoods) of the Burmese people, there currently is limited information concerning the dynamics of the productivity of the diverse set of small-scale wild-caught fisheries and aquaculture systems that comprise the inland fisheries resources of Burma. While 1,381,030 tonnes of inland catch and 962,156 tonnes of aquaculture harvest were reported from Burma to the Food and Agriculture Organization of the United Nations (FAO) for 2014 (FAO FishStat), these estimates are not considered reliable (Bartley et al. 2015) due to difficulties in collecting these data. These difficulties include the lack of infrastructure, time, and resources to collect data, the geographically diffuse nature of Burma's inland fisheries, and the potential social and political pressures to meet pre-determined fisheries production targets. Additionally, no recent comprehensive assessments of the productivity of the Irrawaddy river (or other large river systems in Burma) and their contributions to food and nutrition security and livelihoods have been conducted. As a result, there remain crucial gaps in understanding of the drivers, functions, and dynamics of the inland fisheries production systems in Burma.

Information on the production of fisheries provided by Burma's rivers is especially important given the current prominence of hydropower and irrigation development, especially on the Irrawaddy and Salween rivers, in Burma's current policy agenda. With limited professional capacity in the region and a complex and poorly understood inland fisheries system, opportunities for understanding resource dynamics and capitalizing on the potential contributions of aquatic resources from wild caught and aquaculture produced fish to human welfare and economic well-being are likely to be undervalued. This can lead to the exclusion of inland fisheries from water policy decisions and negatively impact the people who depend on these freshwater resources. Therefore, using existing data, this project addresses the data gaps of the inland fisheries resource systems in Burma by determining the role of wild-caught and aquaculture based inland fisheries in meeting Burma's human nutritional needs and providing a risk assessment of how that contribution could be affected by the impending changes in climate conditions.

RESEARCH PROJECT INVESTIGATIONS

TOPIC AREA:

HUMAN NUTRITION AND HUMAN HEALTH IMPACTS OF AQUACULTURE

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DETERMINING THE ROLE OF WILD-CAUGHT AND AQUACULTURE-BASED INLAND FISHERIES IN MEETING BURMA'S HUMAN NUTRITIONAL NEEDS

ASIA PROJECT: BURMA
US Project PI: William W. Taylor, Michigan State University

Human Nutrition and Human Health Impacts of Aquaculture/Study/16HHI05MS

Collaborating Institutions and Lead Investigators

Michigan State University	William W. Taylor
	Ben Belton
	So-Jung Youn
U.S. Geological Survey	T. Douglas Beard Jr.
	Abigail J. Lynch
	Emily Argo

Significance

The average Burmese citizen is estimated to consume about 55 kg of fish on an annual basis (FAO 2015), although average yearly fish consumption likely varies among regions of Burma (Kyaw 2009). Fish consumption from inland areas (both wild capture and aquaculture sources) is estimated to provide 30% of total yearly intake of protein (from both animal and plant sources) in Burma (FAO 2011). However, total fish consumption data, especially for inland fishery resources has been reported to severely miss-estimate both total consumption and total harvest in the rural regions of the world due to the lack of data or sociopolitical pressure to meet specified government production targets (Bartley et al. 2015, Beard et al. 2011). Because of these factors, data from Bangladesh and rural Thailand, for example, suggest that consumption estimates reported to FAO can be as low as 50% of actual consumption (Dey et al. 2005). Furthermore, total caloric amount is just one component of the contribution of inland fish to human nutrition. Inland fish have been reported to provide key contributions to the intake of protein, omega-3 fatty acids, and micronutrients (e.g., iodine, vitamin A, calcium) which can be difficult to obtain through other local food sources (Aung et al. 2010, Youn et al. 2014). Calcium, lysine, and omega-3 fatty acids, all of which are provided by these fishes, are vital for human growth and development, especially for children. The nutritional contributions of fish to the Burmese diet are critically important, especially when considering that more than 35% of Burmese children show signs of stunted growth caused by chronic malnutrition (World Food Programme 2017). Given the key contribution of fish to the nutrition and food security of the Burmese population, and the availability of key nutrients needed for proper child growth and development in inland fish, understanding the contribution of wild-caught inland fish and the role of aquaculture in Burmese food security is critical for ensuring food security and human well-being.

Available Data

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The Integrated Household Living Conditions Assessment survey (IHLCA), conducted in Burma by the United Nations Development Program (UNDP) in 2005 and 2010, is a nationally representative household survey of 18,660 Burmese households conducted by the Ministry of National Planning and Economic Development and the United Nations Development Programme. The purpose of the IHLCA is to provide statistical data for determining living conditions in Burma. To meet this purpose, the survey collected household food consumption data during two rounds in each of the survey years, corresponding to pre- and post-monsoon paddy harvesting season, which captured some seasonal variability in food consumption. Seven-day recall was used to capture the quantity of foods consumed, including the amount sourced through the market, the household's own production, and other source (e.g. gifts). The list of fish and fish products is detailed, listing a total of 36 different pre-coded items in the survey. Fish categories listed in the IHLCA fall into 3 categories: species specific (e.g. snakehead, Bombay duck), generic but denoting source (e.g. small marine fish), and generic but not denoting source (e.g. fish paste). For fish categories that are generic and do not denote source (e.g. marine, freshwater, or aquaculture), it will be necessary to infer source and composition as far as possible using available information (e.g. it is likely that most fish paste consumed in coastal state is of marine origin). Trade data show that very little fish is imported in Burma, so import trade should have little impact on the results.

Many of these IHLCA categories are species specific, but some items also cover a variety of generic categories of product (e.g. "other small river fish <= 4 inches", "other dried medium sea fishes"). In these cases, it will be necessary to make some assumptions, based on the knowledge of key informants, about the most important fish species when conducting nutrient analysis. Unfortunately, IHLCA 2010 is the most recent round of the survey and no recent, comparable datasets exist. Because data for 2005 and 2010 provide a time-series, however, it will be possible to identify the direction and rate of trends over this period and thus possible to derive estimates of subsequent change.

Additionally, Dr. Belton (MSU) has collected data (the Myanmar Aquaculture-Agriculture Survey; MAAS) on the aquaculture production practices and socioeconomic characteristics of 224 fish farming households in the main aquaculture areas of Burma (e.g. lower Irrawaddy delta). The survey was implemented in May 2016. MAAS adopted a two-stage sampling strategy. For the first stage, 40 village tracts identified from analysis of satellite images as having the highest densities of fish ponds in Burma were purposively selected from four townships (Maubin, Twantay, Kayan, and Nyaungdon). The townships fall within a radius of approximately 60km from the country's main city, Yangon. For second-stage sampling, enumeration areas (EAs) were selected from these village tracts by probability proportional to size, using the national population census of 2014 as the sampling frame. This procedure yielded a sample of 78 EAs. A census of households was conducted in every selected EA to serve as the final sample frame for randomized selection of respondent households. Eight farm and seven non-farm households were selected for interviews in each EA, using a structured questionnaire. Respondents from 1,102 households, representing a total population of 37,390 households, were interviewed. Among these households, 246 were fish-farming households. Fish-farming households answered a set of questionnaire modules on fish farm stocking and management practices, costs, returns, and yields. Aquaculture households represented the entire population of fish-farming households' resident in the sampled village tracts. Data have been analyzed and a report, not yet publically available, prepared for publication. The data from the MAAS will inform the proposed project because they contain data on the area of land used for aquaculture and yields from fish farms. This information can be used to triangulate and validate projected changes in consumption of farmed fish for the 2011-2017 period that will be calculated using the IHLCA data.

In addition to the two datasets described above, secondary production and consumption data of freshwater fish are available from the Burmese government and United Nations surveys and accessible by Dr. Belton. Fish (marine, inland and aquaculture) production data reported by the Burmese government to FAO (FAO FishStat database) and monthly data on retail fish prices for approximately 10 main fish products collected by the Burmese Central Statistical Office (used to calibrate Burma's consumer price index) will be used to provide an indication of changes over time in the relative availability of fish from different sources (e.g. marine, inland, and aquaculture).

Research Design and Activity Plan

Location

Michigan State University, East Lansing, Michigan, USA.

Methods

Using the data from the IHLCA survey, we will develop a map of Burma's fisheries that illustrates the contribution of marine, inland wild capture, and aquaculture fisheries to Burmese food and nutritional security. This map will show consumption of various types of fish by region, identify the relative contributions of aquaculture and wild-capture fish to the diet, and illustrate how fish consumption has changed between 2005 and 2010. Data from Bogard et al. (2015) will be used to obtain estimates of the nutrient content for the most commonly consumed fish, determined based on data from the IHLCA survey. These estimates will be used to estimate the nutritional benefits (e.g., calcium, vitamin A, iron, zinc) different fish species provide and how nutrient availability differs in various regions of Burma, depending on which fish species are available and their presence in the diet of Burmese people. Because dried, fermented, and salted fish account for a large share of the fish consumed in Burma, we will consider the impacts of processing (e.g. fish consumed whole, dried, or as paste) on the nutritional content of fish consumed and the potential nutritional implications of processing. These considerations will be based on secondary source information available for accounting for differences in nutrition due to processing.

Additionally, using data from the Integrated Household Living Conditions Assessment survey, we will also compare changes in Burmese fish consumption between 2005 and 2010. We will analyze the species and origin of the fish (e.g., inland wild-capture, aquaculture, marine), location (region, urban, or rural), and income level of consumers. We will also use weekly fish price data collected by the Central Statistical Office for at least 10 key species of fish (used by the government to construct the consumer price index) to evaluate the change in fish prices over time, which may provide an indication of the relative abundance or scarcity of different fish species during that same time period. Combined with the description we develop of the Burmese fishery system, we will track changes in fisheries production and consumption across Burma over this 2005 to 2010 time period. If fish consumption patterns have changed in these regions between 2005 and 2010, these areas may be of potential concern for food security and nutrient-deficiency related human diseases. We hope to provide a descriptive analysis of temporal changes in fish consumption by fish source (marine, inland, aquaculture) and estimate changes in dietary micronutrient intakes derived from these fish sources.

Schedule

Project Month	Tasks/Events
1	Compile existing consumption data
2	Kick-off project team meeting
3	Workshop at American Fisheries Society Annual Meeting
4	Estimate contribution of inland fish to nutrition in 2005 and 2010
5	
6	
7	
8	
9	Wrap-up project team meeting
10	Complete final project report and submit by February 2018

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Deliverables

A map showing the relative contribution of fish (marine, inland, and aquaculture) to Burmese diet, food security, and micronutrient contribution for various regions in Burma in 2005 and 2010. The map will indicate the relative level of dependence of different regions in Burma on fish as a food and nutrient source.

TOPIC AREA:

CLIMATE CHANGE ADAPTATION: INDIGENOUS SPECIES DEVELOPMENT

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DEVELOPING A CONCEPTUAL MODEL TO EVALUATE THE POTENTIAL CHANGES IN INLAND FOOD FISH SUPPLY UNDER VARIOUS GLOBAL CLIMATE CHANGE SCENARIOS

ASIA PROJECT: BURMA
US Project PI: William W. Taylor, Michigan State University

Climate change adaptation: Indigenous Species Development/Study/16IND04MS

Collaborating Institutions and Lead Investigators

Michigan State University	William W. Taylor Ben Belton So-Jung Youn
U.S. Geological Survey	T. Douglas Beard Jr. Abigail J. Lynch Emily Argo

Significance

In Burma, the limited availability of reliable data on the status of fish populations constrains the ability of fisheries managers and policy makers to determine the current status of local fish stocks and thus are often unable to effectively intervene when fisheries are in decline, until the system has virtually collapsed. This makes management efforts to anticipate the impacts of global change drivers (e.g. climate alterations) on fisheries resources exceedingly difficult. For example, Allison et al. (2009) found that the Bangladesh and Cambodia national economies were highly vulnerable to climate change impacts on fisheries, however, the authors were unable to estimate similar impacts for Burma due to the lack of needed information on fishers and fisheries. Therefore, given the importance of inland fisheries to food security in Burma, anticipating the potential impacts of global climate change agents to these critical resources will help managers, policy makers and development programs prepare for and address potential challenges to inland fisheries and local communities in Burma.

Available Data

Projections of climate change for Southeast Asia from the Intergovernmental Panel on Climate Change (IPCC) will be used to estimate how the climate is expected to change in Burma and then how these changes will potentially impact inland fisheries productivity. We will incorporate broad scale (time and space) data from two GCM models that most mirror the monsoon impact that drives SE Asia across the four IPCC scenarios. These models generally produce broad changes in temperature and precipitation patterns since the data are limited and at a broad scale (e.g. one data set for all of Burma). We will focus on up to 5 of the most commercially important inland fish in Burma (e.g. rohu, catla, common carp, snakehead, and tilapia; FAO 2003). These fish include a mix of wild and aquaculture species. Stock-recruitment relationships for these fish are available from the FAO FishStats database and FishBase.

Research Design and Activity Plan

Location

Michigan State University, East Lansing, Michigan, USA

Methods

We will use a simple linear transformed Ricker stock-recruitment model (Ricker 1954), with the inclusion of environmental variables (e.g., changes in precipitation) to model the effect of climate on the selected wild-capture fisheries:

$$log\ \frac{R_i}{S_i} = log\alpha_i - \beta_i S_i + \beta_2 env1_i S_i + \gamma_i env2_i \ldots + \epsilon_i$$

For a given year class, i, R_i is recruitment, S_i is spawning stock, α_i is the productivity parameter, β_1 is the density dependent shape parameter, β_2 is the density dependent shape parameter for a given density-dependent environmental variable (*env*1) , γ_1 is the density independent shape parameter for a given density-independent environmental variable (*env*2)and ϵ_i is normally distributed random error. Because there are limited climate data for Burma, fine-scale downscaling is not feasible at this time. These data are not site specific, so we will create a conceptual framework to illustrate general patterns that drive changes in potential fish production.

We understand that the potential to gain stock and recruitment data for Burmese fisheries specifically is unlikely. However, the fish groups we will focus on are common throughout Southeast Asia. In the instance that these data are not available for Burma for these fishes, we will use recruitment data from other areas of Southeast Asia, or for similar species (in terms of life history, habitat, and relationship to target species) for which data are available in FishBase or the FAO FishStat database. We will modify the basic stock recruitment model with projections for environmental variables that could be influenced by climate, such as changes in precipitation.

The output for this model will be eight projections (two models multiplied by four scenarios) of potential changes to wild fish production. We will develop a Ricker stock-recruitment model with environmental variables to estimate potential wild-fish production. We will also collect climate data for Burma and Southeast Asia. The Ricker model will then be used to simulate wild fish production based on environmental relationships and forced out through 50-100 years. For farmed fish, we will use a simple statistical relationship between environmental variables (measures of temperature and precipitation) and fish growth and likewise produce eight projections (sixteen projections total – eight for aquaculture and eight for wild-capture). Through these projections, we will look for initial relationships between fish production (both wild and farmed) and climate variables. These relationships can then be further developed and explored in a future model, once more climate and production data become available.

Building on this basic model, we will also create a descriptive conceptual framework, through a vulnerability lens, linking aquaculture production (as a component of Burma's GDP) to projected changes in climate variables (e.g. temperature), using the temperature model developed by Burke et al. (2015) and the vulnerability framework developed by Handisyde et al. (Figure 1; 2014). Due to lack of data on aquaculture pond area and other climate variables, this conceptual framework will provide a description of a potential culture production model. This description can then serve as a basis for future models, when data necessary to quantify the model are either accessible or collectible.

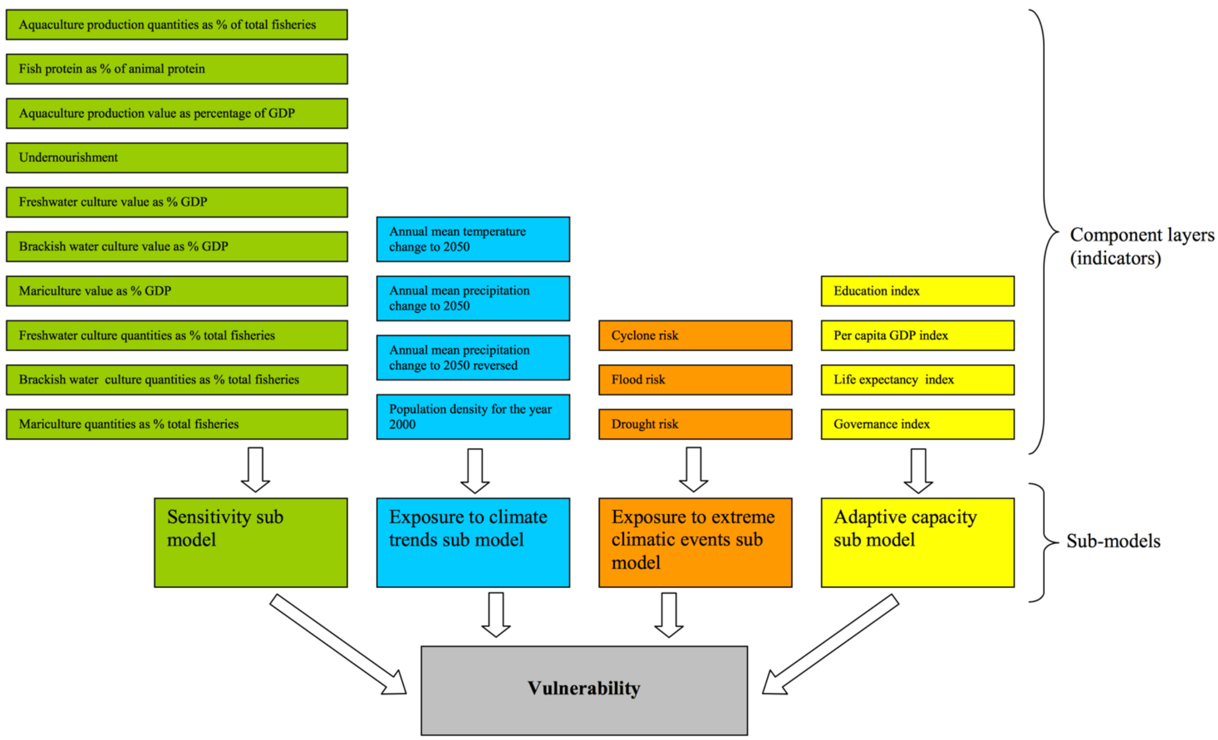

Figure 1. Vulnerability assessment framework developed by Handisyde et al. (2014). We will modify this framework to qualitatively describe factors that can affect vulnerability, then link total production to the stock-recruitment model for Burmese fisheries. The model will be both conceptual and empirical, as provided by the quantity and quality of data available.

Schedule

Project Month	Tasks/Events
1	Compile existing stock-recruitment data for common wild-caught fisheries in Burma
2	Kick-off project team meeting
3	Workshop at American Fisheries Society Annual Meeting
4	Develop simple stock-recruitment relationships for Burmese fisheries including environmental variables
5	Compile SE Asia global change scenarios
6	
7	Project impacts on global change on Burmese fisheries
8	
9	Wrap-up project team meeting
10	Complete final project report and submit by February 2018

Deliverables

A descriptive scenario model of projected global climate change impacts on regional fisheries in Burma. Although these scenarios will be developed at a regional level, due to of the limited nature of the accessible data, they should provide a broad understanding of possibility policy implications and gaps on the potential impacts of climate changes on Burma's inland fisheries resources.

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