EXPLORING CLIMATE-RESILIENT ADAPTATIONS OF FARMED FISH FOR CLIMATE-SMART AQUACULTURE IN AFRICA

Stephanie Ichien, Amanda Hyman, Briana Goodwin, Jenna Borberg, and Hillary Egna
The Feed the Future Innovation Lab for Collaborative Research on Aquaculture & Fisheries
Oregon State University, USA
email: aquafish@oregonstate.edu
website: aquafish.oregonstate.edu

Introduction

Exploring climate-resilient adaptations in farmed fish is one strategy for helping improve food security for the world's growing population under changing environmental conditions. People rely on fish as a primary source of protein and income, supporting a rapidly growing aquaculture industry that provides roughly half of the global fish supply. In an era of climate change and high demand for animal protein, increasing the production of fish through sustainable and environmentally sensitive practices is critical. The development of climate-smart aquaculture, which incorporates practices that improve climate resilience and mitigate negative environmental impacts, can provide responsible management strategies to the aquaculture industry. One aspect of this effort involves refining the culture of fish species that are adapted for coping with predicted impacts of climate change, including increased hyposaline conditions, wide temperature ranges, and poor water quality. The research highlighted here seeks to take advantage of the evolutionary ecology of these species in their native range to create more opportunities for climate-smart aquaculture. These efforts include: 1) incorporating the sustainable culture of the air-breathing African lungfish into the fish farming industry in East African and 2) identifying climate-resilient tilapia strains in Ghana. A major part of this work also requires the mitigation of adverse impacts, therefore, AquaFish researchers investigate the wide range of positive and negative tradeoffs associated with fish production to ensure that practices remain environmentally and socially responsible.

Climate Impacts on Aquaculture

Aquaculture, like agriculture and other human activities, will feel the effects of climate change in a multitude of varied and interconnected ways, particularly threatening the poorer in Sub-Saharan Africa (Figure 1), South Asia, and Southeast Asia. Global temperature increases (Figure 2), ocean acidification, and sea level rise will affect the world's coastal and inland aquaculture operations. Temperature changes will test the resiliency of domesticated varietals. The shifting distribution of global freshwater supplies and habitats will pose challenges as well as new opportunities for the aquaculture industry, small farms, and the marketplace.

Research challenges and opportunities include:
- Developing and refining cultivation techniques for new, climate-resilient species, such as air-breathing fishes.
- Cultivating indigenous species to contribute to the development of local communities as well as protecting ecosystems.
- Understanding the dynamic social, cultural, and economic impacts of climate change on the aquaculture industry and on communities.

Climate-Smart Agriculture

Climatic variability and its associated impacts can impose production risks that challenge the coping capacity of farming operations at all scales. A climate-smart approach to agriculture can easily be adapted for aquaculture, by which increased production is managed for sustainability, climate adaptation, and climate mitigation. This provides an approach to build resilient food production systems to more effectively support development and ensure sustainable food security in the face of climate change (Figure 3).

The climate-smart approach pursues three primary objectives towards reconciling tradeoffs for building resilient systems on local and global scales through time (*Lipper et al. 2014*):
1. Sustainably increase production and incomes
2. Climate change adaptation
3. Climate change mitigation

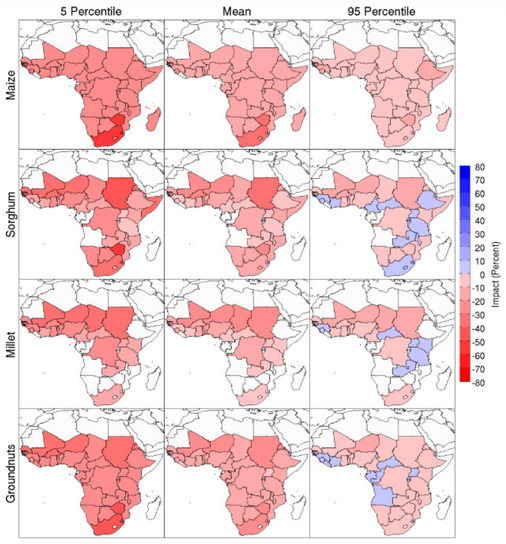

Figure 1- impacts of climate change on African agriculture. (*Figure from Schlenker et al. 2010*)

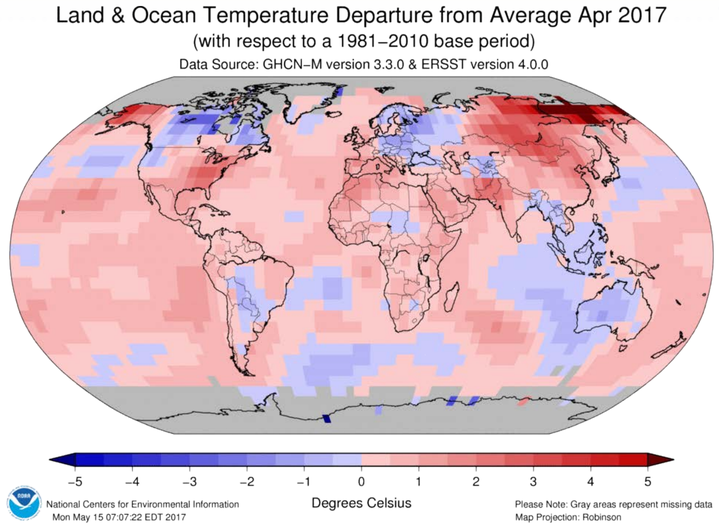

Figure 2- Last year (2016) was the hottest year on record. Increasing temperatures results in many compounding impacts on aquaculture world wide. (*Figure from www.ncdc.noaa.gov/temp-and-precip/global-maps/*)

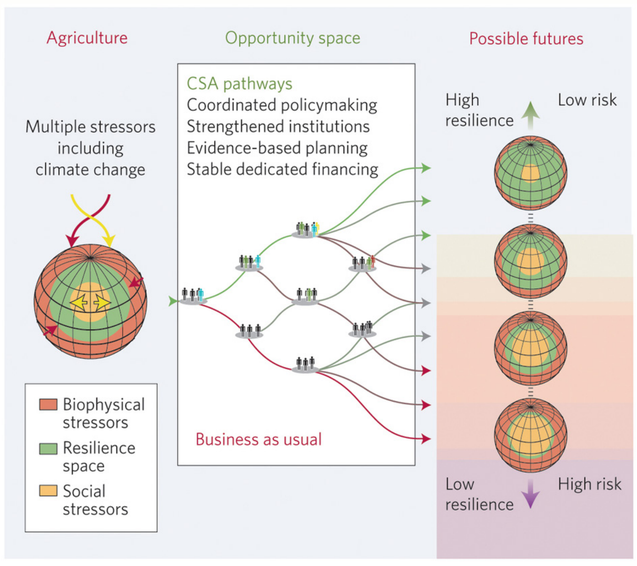

Figure 3- Climate-resilient transformational pathways for climate-smart agriculture. Actions taken at various decision points along a climate-smart pathway result in higher resilience. Alternatively, business as usual leads to higher risk and low resilience. (*Figure from Lipper et al., 2014*).

Climate Resilience in Farmed Fish

One step towards implementing climate-smart aquaculture involves the diversification of the industry through climate resilient species and varietals that are also good candidates for aquaculture. Taking into consideration the dynamic tradeoffs, exploration of climate resilient fish for aquaculture can include the optimization of already cultured species, creating sustainable options for new species, and evaluating the socio-ecological impacts. The AquaFish Innovation Lab is investigating climate resilient species in Africa (listed below) for their ability to withstand many of the realized and projected impacts of climate change, such as increased water temperatures and poorer water quality.

African Lungfish (*Protopterus aethiopicus*) in Uganda

- As an air-breathing fish, the African Lungfish is resilient to droughts and poor water quality, offering potential for future African aquaculture.
- A delicacy among certain groups in Uganda, markets are reliant on wild-caught fish for market size fish and aquaculture for juveniles in the limited production that takes place. AquaFish partners from Auburn University, North Carolina State University, Oregon State University (OSU), and the National Fisheries Resources Research Institute of Uganda are developing sustainable, low-cost breeding techniques for the nascent industry.

Nile Tilapia (*Oreochromis niloticus*) in Ghana

- Nile tilapia is one of the most important cultured fish globally. AquaFish researchers from Purdue University, Virginia Polytechnic Institute and State University, OSU, University of Development Studies (Ghana), and Kwame Nkrumah University of Science and Technology (Ghana) worked to identify local Strains that are adapted to future climate conditions in Ghana.
- The results of the laboratory growth studies showed no evidence of superior performance of the domesticated Akosombo strain over the wild strains under current or predicted future climatic conditions of temperature, dissolved oxygen (DO), or salinity.

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