A GEOSPATIAL ANALYSIS OF SOCIAL AND ECOLOGICAL TRADEOFFS OF AIR-BREATHING FISH AQUACULTURE FOR DECISION MAKING IN A CHANGING CLIMATE

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Abstract

Climate change has profound implications for freshwater aquaculture-based production of finfish, especially at small- to medium-enterprise (SME) scales. Many interrelated changes are compounded by the needs of growing urban populations, resulting in complex tradeoffs between human demands and preservation of the natural world. A geospatial analysis can help producers and planners determine the best ways to adapt freshwater finfish aquaculture practices through species diversification and site suitability, providing predictive information and climate resilient management options. The overall goal of this work is to evaluate the complex social and ecological tradeoffs associated with the culture of climate-resilient air-breathing fish species under a changing climate through a novel conceptual framework (figure 1). This framework will inform a geospatial model for an interdisciplinary decision tool that explicitly considers human dimension with environmental conservation in a landscape setting for helping to improve the climate resilience of freshwater finfish production.

With a focus on the air-breathing pangasius catfish (*Pangasius hypophthalmus*) industry in the Mekong Delta, this study will employ the use of open-source data and data models to characterize the landscape in terms of suitability and tradeoffs for pangasius catfish farms. Considering the market potential for increased income and impacts on the receiving environment, the framework developed will provide policy makers, business owners, and other stakeholders with decision-making foresight into the associated social and ecological tradeoffs of various production priorities. Field studies in the region and physiological limits of the pangasius catfish will be used to inform the model, providing place-based and species specific information.

Aquaculture in the Face of Climate Change

Aquaculture will feel the effects of long-term climate change. Among the myriad of challenges, global temperature increases, changing precipitation patterns, and sea level rise will affect the world's coastal and inland aquaculture operations, much of which occur in poorer countries (figure 2). 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 farmers, and the marketplace.

Research challenges and opportunities involve:

- Developing and refining cultivation techniques for species, such as air-breathing fishes.
- Cultivation of indigenous species for contributing to the development of local communities and protecting ecosystems.
- Understanding the social, cultural, and economic impacts of climate change on the aquaculture industry and communities.

Climate Resilience in Farmed Fish

The focus of this work is on air-breathing fish because of their ability to survive outside of the water for extended periods and to withstand low-oxygen to anoxic conditions. Already, air-breathing fish offer a growing portion of the global seafood trade, with four families dominating the air-breathing fish production in aquaculture—*Clarridae, Channidae, Pangasiidae*, and *Synbranchidae*.

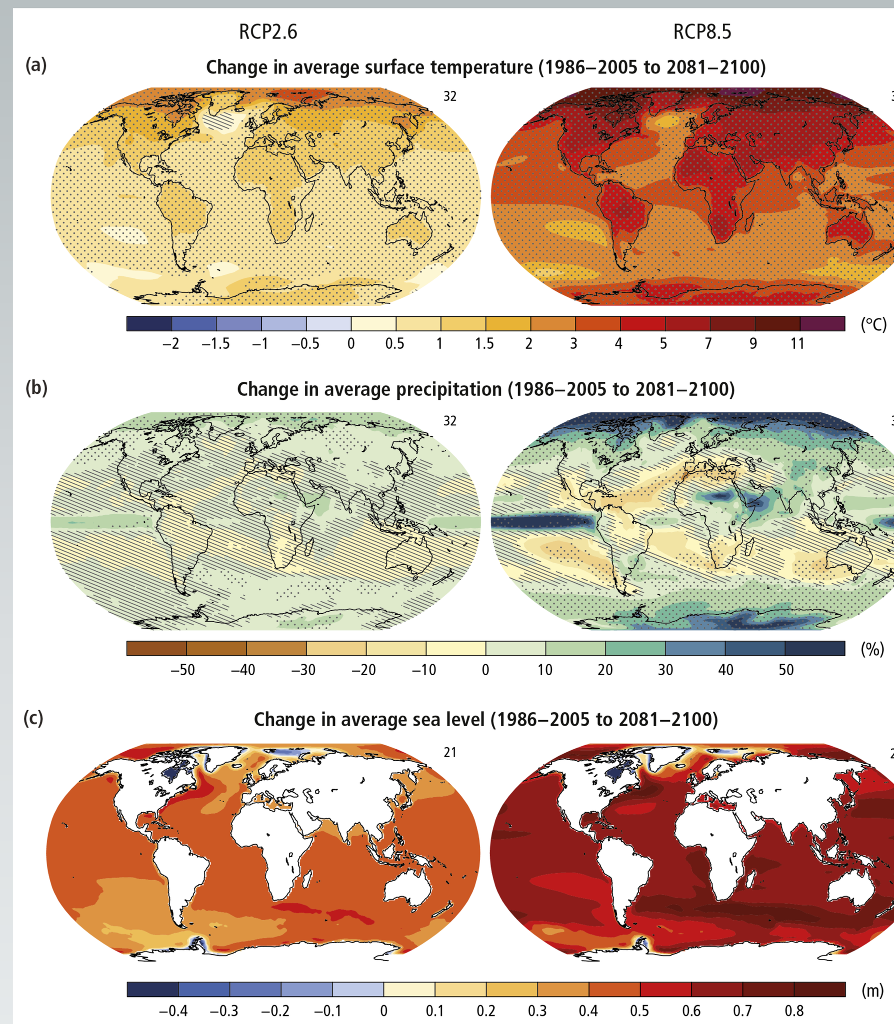
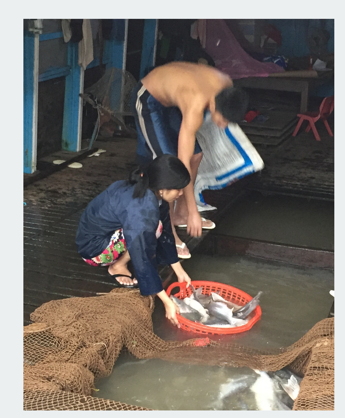
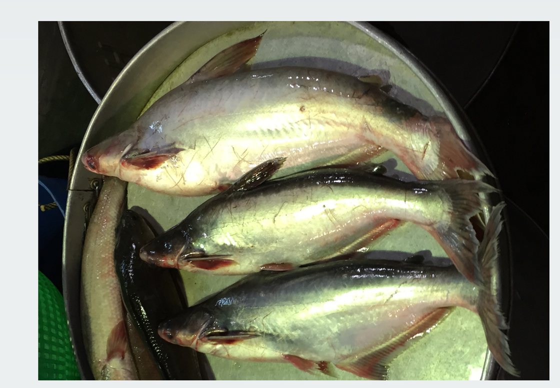


Figure 2- Using the relative radiative forcing to make some assumptions about future conditions, the multi-model mean projections for the 2081–2100 period under the RCP2.6 (left) and RCP8.5 (right) scenarios for (a) change in annual mean surface temperature and (b) change in annual mean precipitation, in percentages, and (c) change in average sea level. Changes are shown relative to the 1986–2005 period. (IPCC, 2014)



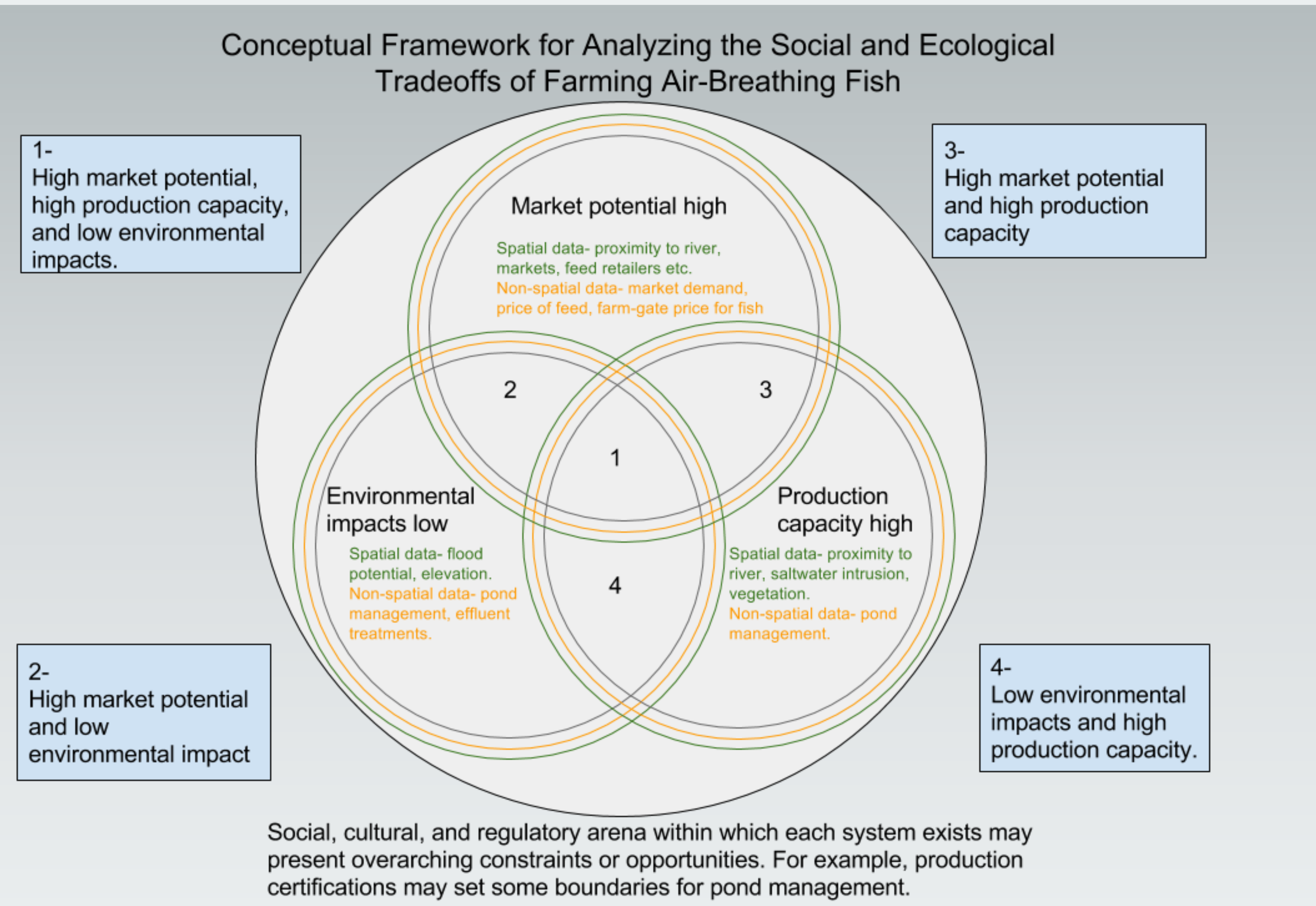


Figure 1- The conceptual framework developed for this research integrates elements from well-established frameworks used to evaluate sustainability, climate vulnerability, and climate-smart development. This framework provides a unique way of evaluating the economic, social, and environmental tradeoffs of fish farming, using both spatially explicit data and a-spatial information.

Geospatial Analysis Tools

Geographic Information Systems (GIS) offer a simplified view of the physical characteristics of the landscape with their spatial location, their extent, and can include additional information (including a-spatial data). Below are some of the geospatial analysis tools expected for use in this work, conceptualized in figure 3.

Cost Distance- The distance and access to inputs, markets, and retailers have an impact on any aquaculture operation. This tool provides an estimate of the distance between goods and services as well as the estimated cost based on the landscape characteristics (e.g., roads, river access, land use).

Overlay analysis- Combining features from two or more spatial layers, overlays provide a mechanism to identify patches across the landscape that satisfy a set of parameters. For example the biophysical requirements for growing *pangasius* catfish (e.g., water access, water quality, and soil type).

Digital elevation model (DEM)- DEMs are three dimensional representation of the earth's terrain built from elevation data of the terrain. These data models provide indications of such things as flood potential, fish escapement, and ease of access.

Representative Concentration Pathway (RCP)- Projecting future conditions, the RCPs represent four socio-economic emission scenarios reflecting carbon concentration pathways (RCPs) from 1850-2100 (2 scenarios visualized in figure 2).

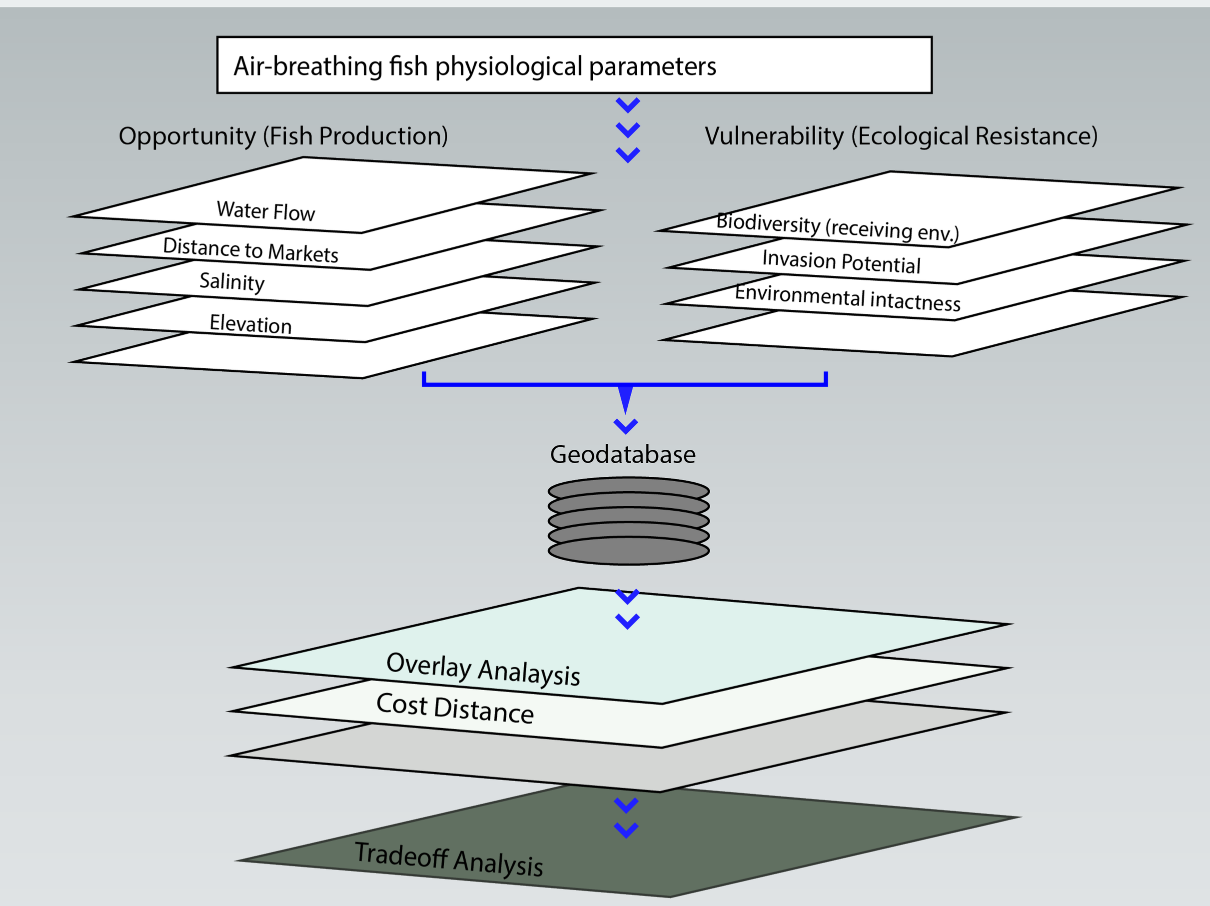


Figure 3- Using the physiological parameters required for growing air-breathing fish, all relevant spatial and a-spatial data will be integrated into a geodatabase. Once compatible (spatial resolution, units, temporal resolution), the several geospatial analysis tools can be applied to help evaluate the social and ecological tradeoffs associated with the changing climate and watershed development.

Acknowledgements- The Feed the Future Innovation Lab for Collaborative Research on Aquaculture & Fisheries (AquaFish Innovation Lab) is funded under USAID Leader with Associates Cooperative Agreement No. EPP-A-00-06-00012-00 and by the participating US and Host Country partners. This work was made possible by the generous support of the American people through USAID The contents are the responsibility of the authors and do not necessarily reflect the views of USAID or the United States Government.

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