AQUAFISH INNOVATION LAB

Oregon State University - Corvallis, Oregon, USA 97333
www.aquafish.oregonstate.edu

STRATEGIES FOR REDUCING FEED COSTS IN SMALLHOLDER TILAPIA AQUACULTURE

Caleb Price, Stephanie Ichien and Hillary Egna

Lower Costs = Larger Profits

The cost of fish feed continues to rise as global demand for fishmeal increases, and harvest of wild fish stocks drives down availability. Feed costs are also rising through the supply chain because of increasing demand and transport costs for feed inputs, including grains. For tilapia farmers in developing countries, the cost of feed can account for 80% of total operational costs.

Reducing the costs associated with feed inputs is the primary way to help promote income generation and ensure viability of smallholder tilapia farms, and is a chief focus area for research sponsored by the AquaFish Innovation Lab. Smallholder farms are especially vulnerable to changes in operating costs. Augmenting feed inputs with naturally produced in-pond food items by stimulating pond productivity reduces reliance on intensive feeds, mitigates effluent pollution, increases fish yield and promotes sustainability.

Focus areas for reducing feed costs in small-scale tilapia production include:

- Pond optimization strategies
- Improved feeding strategies
- Cage-pond, integrated production systems
- Alternative protein sources for feed

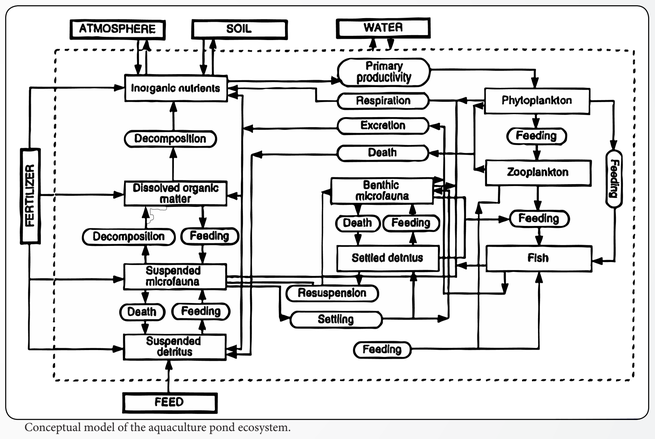
Image courtesy of Russell Borski.

Pond Optimization

When buying expensive fish feed is not an option, farmers can use **extensive or non-fed pond management technologies** to raise tilapia. Production of natural food in the pond is optimized under this type of management, which depends on a constant supply of the basic nutrients necessary for the growth of autotrophic phytoplankton, which in turn drive the growth of zooplankton.

Understanding the **water quality and carrying capacity of a pond system** is important for farmers to optimize productivity and yield while managing diseases to maintain fish health.

For aquaculture systems, where maximum growth is a common goal, a crop of young fish will likely grow at a near maximum rate **until food or other environmental conditions become limiting.** After this point, supplemental feeding may be used to enhance the carrying capacity of the pond, or to grow fish to a larger size than is possible with natural foods.



Conceptual model of the aquaculture pond ecosystem.

From 1982-1987, the Pond Dynamics/Aquaculture Collaborative Research Support Program conducted research on pond dynamics through the Global Experiment, a **unifying strategy for optimizing the technological and economic efficiencies of pond production systems.** The program developed a scientific method to examine variation in pond performance both spatially and temporally between sites across the globe, and provide recommendations and techniques to farmers for optimizing their pond production.

Improved Feeding Strategies

In many cases, locally-produced tilapia feeds are unavailable, or unreliable (the quality can be variable and poor), though costs remain high. One way to reduce total feed costs for tilapia farming is by **decreasing the amount of feed used for grow-out** of the same amount of marketable fish.

Photo courtesy of Russell Borski.

AquaFish researchers in the Philippines tested the grow-out performance of tilapia fed at different daily rations, including 100% daily feeding, 50% daily feeding and 100% alternate day feeding.

Variable	Feeding schedule: Daily	Feeding schedule: Alternate day
Initial mean weight (g)	0.19 ± 0.03	0.19 ± 0.03
Final mean weight (g)	167.35 ± 53	137.79 ± 72
Total weight gain (g)	167.16 ± 53	137.60 ± 72
Mean daily weight gain (g/d)	1.39 ± 0.44	1.15 ± 0.60
Specific growth (%)[a]	5.58 ± 0.22	5.35 ± 0.31
Survival (%)	55.34 ± 20	63.42 ± 26
Feed conversion ratio[b]	2.24 ± 0.73	1.00 ± 0.34
Fish yield (kg)	222 ± 102	200 ± 88
Quantity of feeds (kg)	475 ± 185	208 ± 145
Extrapolated fish yield (kg/ha)	2,994 ± 808	2,807 ± 857
Extrapolated quantity of feeds (kg/ha)	6,331 ± 1,088	2,690 ± 601

[a]Specific growth rates (SGRs) were calculated as SGR = 100 · ($\log_e W_f$ - $\log_e W_i$)/(t_f - t_i), where W_i and W_f are fish weights at the beginning (t_i) and end (t_f) of the feeding trials.
[b]The difference between the two feeding treatments was significant ($P < 0.05$).

Mean (+/- SE) performance parameters of pond-reared Nile tilapia subjected to daily and alternate-day feeding schedules after the 120-d culture period at commercial farms in Luzon, Philippines.

Six separate farms found that **alternate day feeding at full ration was as effective at producing tilapia** of similar yield as fish fed at full daily ration, providing a significant cost-savings for the grow-out of tilapia.

AquaFish researchers In Bangladesh are investigating whether equivalent production yields can be achieved with a significant reduction (>50%) in feeds for semi-intensive tilapia farmers using improved feeding strategies – particularly the alternate-day feeding.

This approach could help to **increase feed conversion ratios by up to 100%** and reduce feed costs by as much as 66%, without compromising grow-out of marketable fish.

Cost and profit	Feeding schedule: Daily	Feeding schedule: Alternate
Variable costs		
Feeds	$1,987.86	$865.31
Labor	$323.17	$161.58
Profit per hectare[a]	−$447.50	$556.01

[a]Includes deduction of approximate fixed costs.

The analysis takes into account the variable costs and revenues associated with the two feeding strategies as well as two categories of fixed costs, namely, labor (estimated as US$2.69/d) and other fixed costs (construction, fuel, fertilizer, and acquisition of fingerlings; estimated as $588 per pond per grow-out cycle).

Cage-Pond Integrated Production Systems

Integrated cage-pond aquaculture builds off of the pond optimization concept to combine **intensive cage culture of high-value species with non-fed pond culture of lower-value species,** or younger cohorts of the same species of fish. In this type of system, fish reared in cages are fed with high protein artificial diets, while the fish stocked in open pond water are dependent on natural food items produced in the pond and fertilized by nutrient inputs from cage wastes.

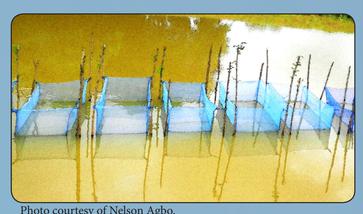


Photo courtesy of Nelson Agbo.

The aim is to increase economic returns for fish farmers by optimizing efficient use of resources. Adding planktivorous, non-fed fish to a cage-pond system **can help supplement food and income for farmers** by increasing pond productivity. In such practices, the nutrient utilization efficiency has the potential reach more than 50%, compared to about 30% in most intensive culture systems (Yi, 1997).

Photo courtesy of Kwamena Quagrainie.

Integrated cage-pond aquaculture offers several advantages:

(1) Wastes from the high-protein diets of caged fish are recycled in pond-water and help generate food items for non-fed fish.

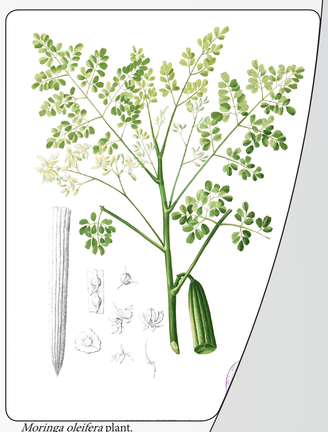
(2) Nutrient cycling of cage wastes through primary productivity can help prevent eutrophication from nutrient-rich pond effluents.

(3) Integrating low-value planktivorous species into a multi-trophic aquaculture system can increase economic returns for farmers.

Alternative Protein Sources for Feed

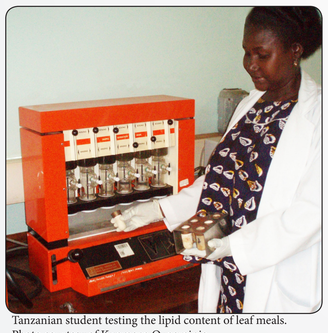
The nutritive value of fish diets depends on the quality of the protein ingredients used in formulation.

Incorporating **locally available plant-based protein sources** can help to offset feed expenses while reducing the negative environmental impacts of using refined animal-based feeds. In Tanzania, AquaFish researchers conducted feed trials for tilapia using leaf meals from the locally available native trees *Moringa oleifera* and *Leucaena leucocephala* as protein substitutes. Results show that the *Moringa* diets produced tilapia of similar size and quality, with similar apparent protein digestibility as soy-protein diets. However, *Moringa* is potentially more valuable to Tanzanians as an export product than as fish feed, because of the demand for this plant in the neutraceutical market.



Moringa oleifera plant.

In some cases, animal-based proteins are considered better alternatives than plant-based proteins for fish diets because of their **superior amino acids, micronutrients, and digestibility.**



Tanzanian student testing the lipid content of leaf meals.
Photo courtesy of Kwamena Quagrainie.

AquaFish researchers are currently investigating a promising new protein source for fish feed: **invertebrates, such as insects and earthworms**, which have higher protein content and higher digestibility than plant-based proteins.

Moreover, these invertebrates are abundant, fast-growing, and low trophic-level species, making them a sustainable alternative protein source for fish feed.

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