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Producing tilapia feed locally: A low-cost option for small-scale farmers

Identifying locally available ingredients to formulate tilapia feed that is nutritious but cheaper than existing commercial feeds promises productivity, livelihood, health and environmental benefits, especially by enabling local feed manufacturers

Key Lessons Learned

1. Low-cost tilapia feed formulated from locally available ingredients should be nutritionally comparable with good quality commercial tilapia feed to maintain productivity.

2. Rapid and participatory appraisal of local farms, agro-industrial activities and rural markets can often yield suitable ingredients for formulating low-cost tilapia feed. In Bangladesh, such an appraisal identified high-protein ingredients such as mustard oil cake, dried duckweed, poultry viscera, dried animal blood and shrimp-head meal.

3. Feed preparation on small-scale farms is labor intensive, and feed quality can be compromised by deficiencies of amino acids in some ingredients.

4. Encouraging micro- and small feed making enterprises that process locally available resources like crop and livestock byproducts has potential for ensuring the supply of low cost tilapia feed without compromising its quality and also generating local employment

5. Relatively high prices for commercial feed in Malaysia favor large, vertically integrated fish farms; small-scale farms are becoming increasingly vulnerable to rising feed costs and the highly competitive market

INTRODUCTION

Tilapia first gained popularity as an easily farmed fish that could supply cheap but high-quality animal protein in developing countries. Demand has also began to rise in major export markets, with sales in the United States, for example, more than tripling in the first half dozen years of the new millennium. From 1981 to 2006, tilapia aquaculture grew at a compounded rate of 8.1% annually. In the same period, demand for tilapia feed grew by 11.2%

annually, reflecting increasingly intensified tilapia production (Figure 1). The amount of fishmeal used to formulate that feed ballooned from 12,804 tonnes to 75,767 tonnes.

Feed is the major operational cost for most fish farms, accounting for 50-70% of the variable cost depending on farming intensity. The rising cost of commercial tilapia feed is therefore inducing some farmers to opt for alternative feeds. Some rotate commercial feed with kitchen and restaurant waste or chicken byproducts. Others replace tilapia feed with cheaper chicken or duck feed. Still others have begun formulating farm-made tilapia feed pellets.

In countries like Bangladesh, commercial feed is simply beyond the reach of most marginal and landless farmers, limiting their ability to intensify aquaculture production. However, if fish feed ingredients are locally available, and labor can be drawn from the household at low opportunity cost, production costs can be reduced and profit margins can be increased. Besides tilapia culture in small-scale farming systems can enhance women's empowerment and status by providing entry into economic participation, as women are typically responsible for the day-to-day management of homestead ponds along with their other household chores.

In 2005, the WorldFish Center and the University of Guelph/ Ontario Ministry of Natural Resources (UG/OMNR) Fish Nutrition Research Laboratory began a systematic study of low-cost alternatives to commercial feeds using locally available ingredients. This was part of a more comprehensive study in Bangladesh and Malaysia on strategies to make tilapia aquaculture more flexible and input efficient.[1] The aims of identifying locally available feed ingredients and applying them to smallholder tilapia aquaculture were to:

1. better utilize household and locally available resources;
2. incorporate and improve indigenous technical knowledge;
3. enable the development of rural enterprises to produce affordable tilapia feed and provide local employment;

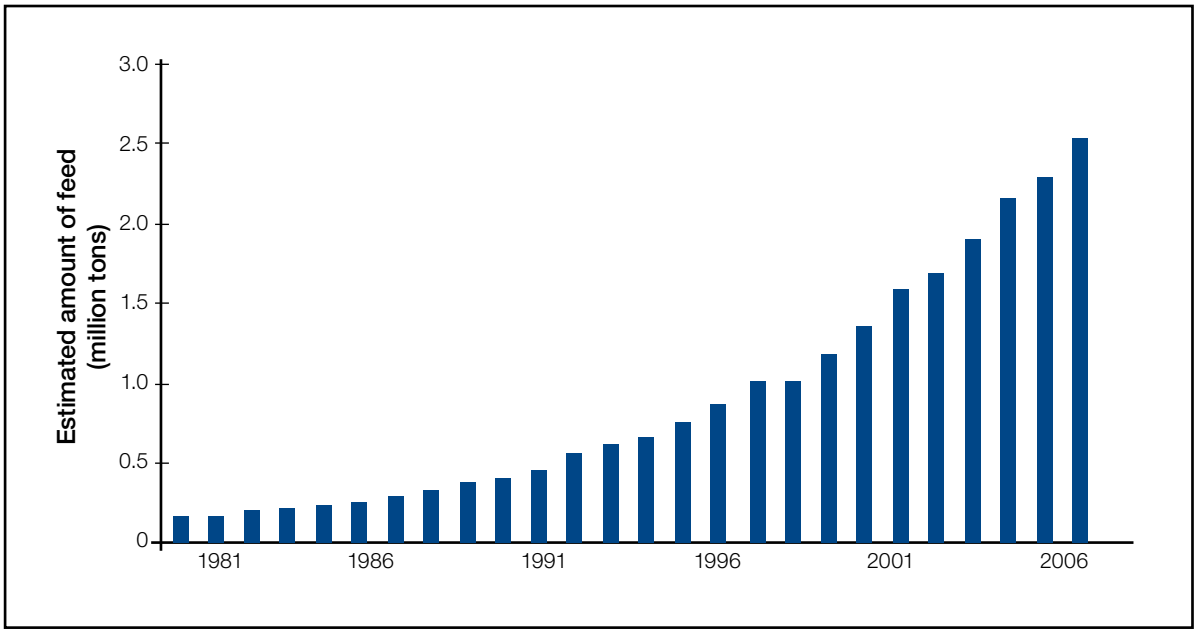

Figure 1. Consumption of commercial tilapia feed, 1981-2006

[1] **Chowdhury MAK. 2008. Flexible, low-input production strategies and feed for inland coastal aquaculture of tilapia. Final technical report of a project funded by the CGIAR-Canada Linkage Fund and the Canadian International Development Agency. WorldFish Center: Penang, Malaysia, and UG/OMNR Fish Nutrition Research Laboratory: Guelph, Ontario.**

4. increase self-employment and the economic participation of women;

5. improve the productivity of smallholder aquaculture in general and thereby increase supplies of fish to farm households and other poor people, help fill the human nutritional need for animal protein, and improve farm incomes to alleviate poverty; and

6. improve watershed management and water productivity.

This brief outlines the lessons learned from the study in Bangladesh and Malaysia where locally available resources having potential as tilapia feed ingredients were identified through Participatory Rural Appraisal (PRA). The PRA results in Bangladesh included: (a) formulating low-cost diets from locally available ingredients; (b) assessing the ability of these ingredients to meet the nutritional requirements of Nile tilapia; and (c) comparing the economic benefits of different production scenarios based on these three formulated feeds. The rapid appraisal approach was slightly modified to gather information in Malaysia and included assessment of existing tilapia farming systems including feed, feeding practices, water quality issues, marketing issues, and farmer's perspectives concerning these issues.

LESSONS LEARNED

1. Low-cost tilapia feed that is formulated using locally available ingredients should be nutritionally comparable with good quality commercial tilapia feed to maintain productivity.

The disadvantage of alternative tilapia feeding regimes that depend on cheap plant materials such as rice bran is slow fish growth. Reducing feed cost without compromising productivity requires formulating a diet comparable to that of a commercial feed but using locally available ingredients. This can be accomplished with great cost savings.

Commercial feed now used by some cage farmers in Bangladesh costs 35 US cents per kilogram. A sample farm-formulated feed consisting of rice bran (35%), brown wheat flour (18%), mustard oil cake (15%), fishmeal (10%), snail (10%), earthworm (5%), duckweed (5%) and wheat flour (2%) costs 22 cents per kilogram, including 2.2 cents in opportunity cost for collecting earthworms, snails and duckweed and 10 cents for fishmeal, which is by far the most expensive ingredient. Note however that quality of feed prepared on-farm may not be comparable with commercial feeds although minimizing operational costs can help sustain farming even with lower fish productivity.

2. Rapid and Participatory appraisal of local farms, agro-industrial activities and rural markets can often yield suitable ingredients for formulating low-cost tilapia feed.

The feed study aimed to improve cage culture in oxbow lakes in Bangladesh by identifying locally available feed ingredients, using them to formulate three low-cost diets and assessing them in different management scenarios. Having consulted secondary sources to compile a provisional list of locally available ingredients, the multidisciplinary team — a nutritionist, an aquaculturist and a socio-economist — held focus group discussions with stakeholders, which yielded transects of the study area that provided a cross-sectional view of the location and the distribution of its resources (Figure 2). This was followed by participatory resource mapping (Figure 3).

The team augmented standard techniques of rapid and participatory rural appraisal (PRA) with a questionnaire survey applied to a random sample of stakeholders in the study area (Figure 4). This further identified potentially useful feed ingredients and revealed individual perceptions regarding these ingredients, feed processing and cage management.

Among the ingredients found to be locally available in a study area in Bangladesh, those with the highest protein content were mustard oil cake, dried duckweed, poultry viscera, dried animal blood and shrimp-head meal. Dried animal blood and shrimp-head meal are not traditional ingredients for fishmeal but were included in the study because of their high animal protein content, superior profiles of essential amino acids, and availability, particularly in the vicinity of slaughterhouses and shrimp-processing plants.

A few drawbacks of using them in formulating fish feed were noted for each ingredient. Mustard oil cake can interfere with digestibility unless properly processed. As duckweed is available only 4 months of the year, during the wet monsoon, widespread cultivation would be necessary to ensure year-

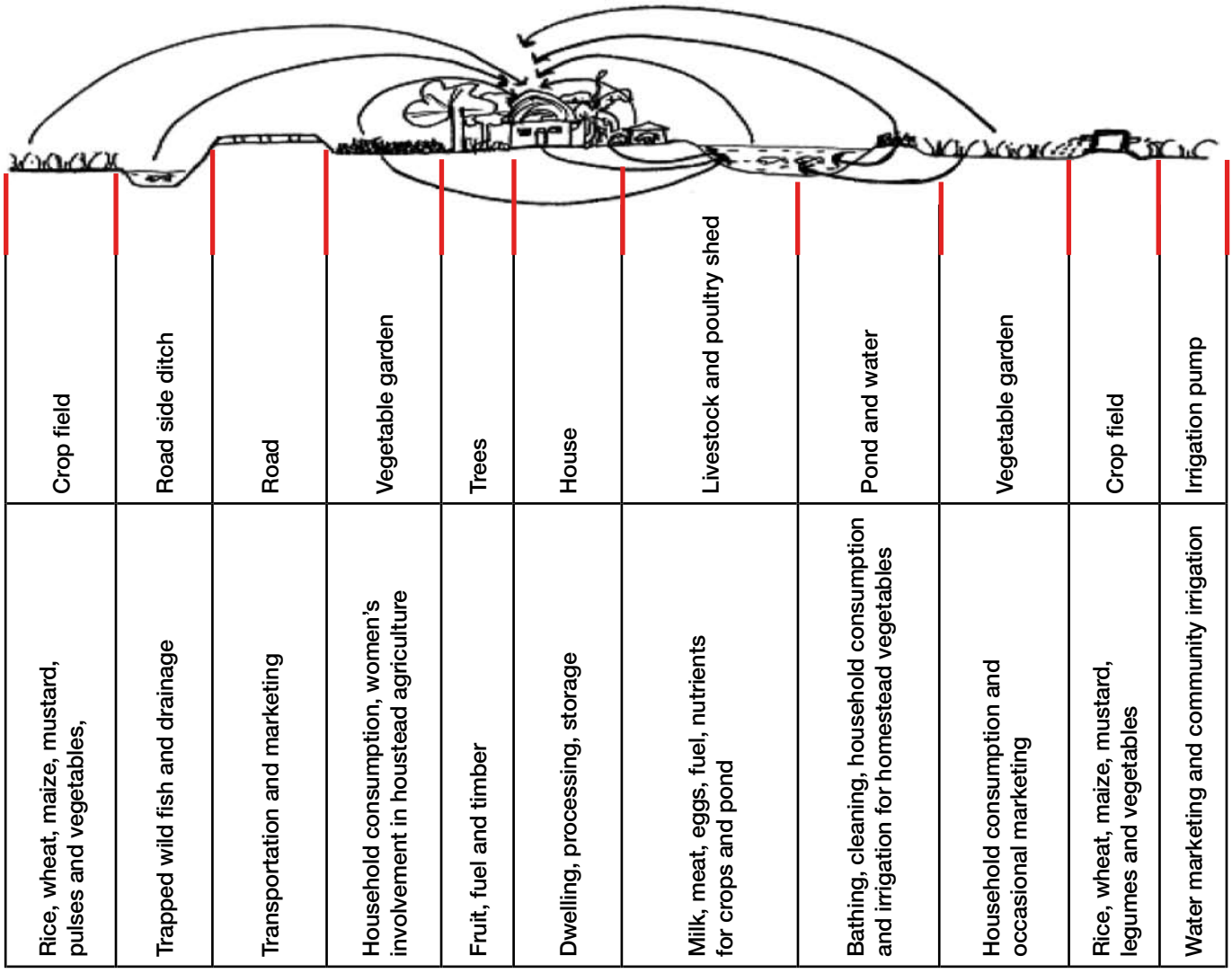

Figure 2. A transect of resources around a village household in Bangladesh indicates nutrient flow. This type of resource flow analysis can help identify ingredients for fish feed as well as potential competition between fish feed ingredients and domestic and other uses.

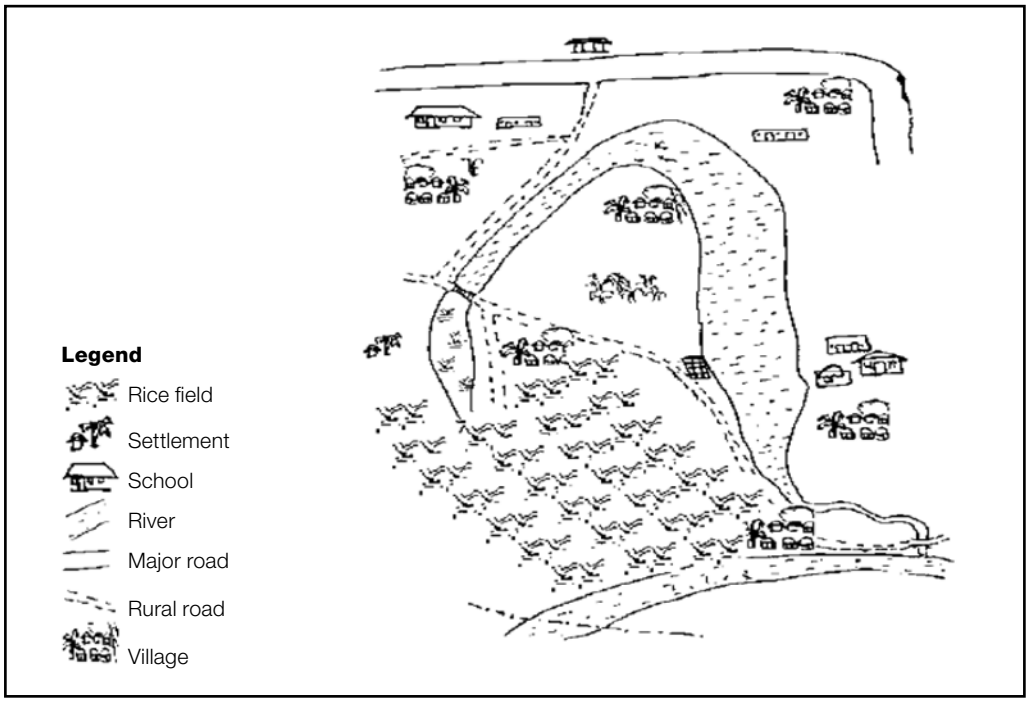

Figure 3. A resource map of a study area in Bangladesh drawn up by a focus group This resource map could provide spatial distribution of potential ingredients for fish feed in the locality.

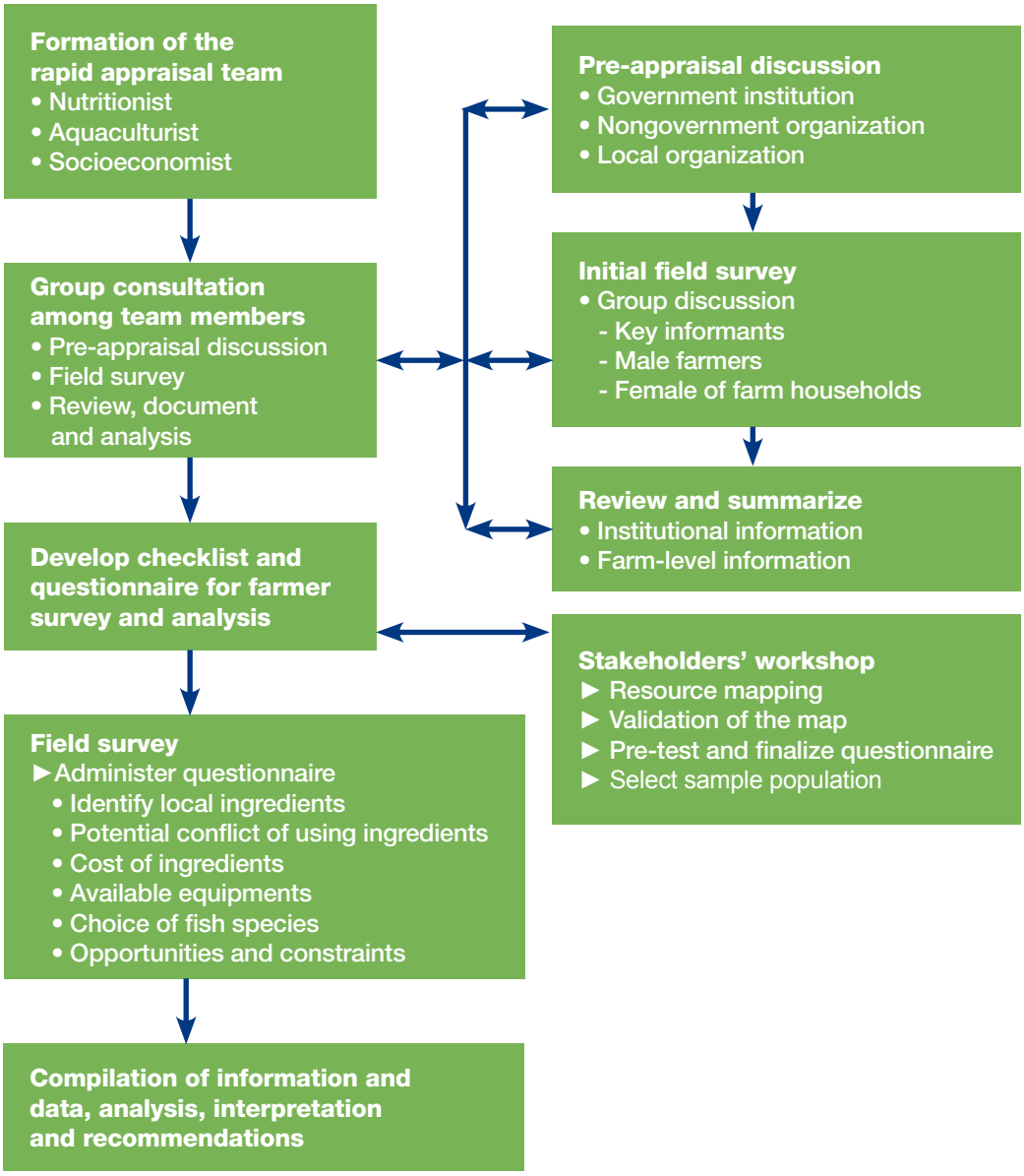

Figure 4. A flow diagram of the rapid appraisal process (modified from Chowdhury et al. 2006)

round availability and affordability. The high fat content of poultry viscera constrains its use as the sole protein source, as does the fibrous chitin of shrimp heads. Dried blood on the other hand may offend religious sensibilities in some communities. Participatory approaches can help yield suitable ingredients and an appropriate feed mix.

High-protein ingredients found in the study area in Bangladesh were mustard oil cake, dried duckweed, poultry viscera, dried animal blood and shrimp-head meal.

The study team devised three feed formulations using locally available resources assessed through PRA. The 35% crude protein diet assumed that all the ingredients were locally available and limited fishmeal content to 15% (Table 1). The 30% protein diet excluded shrimp-head meal and duckweed and further limited fishmeal content to 10%. The 25% protein diet had no fishmeal. Each diet was tested in culture cycles of 100 days (allowing three cycles per year) and 150 days (allowing two cycles), thereby establishing six production scenarios for comparison: (1) 35% protein for 100 days, (2) 35% for 150 days,

(3), 30% for 100 days, (4) 30% for 150 days, (5) 25% for 100 days and (6) 25% for 150 days.

The highest annual tilapia production was achieved in scenario 1, followed by scenario 2 (Table 2). As large fish sell for as much as half more per kilogram than small fish, scenario 2 was the most profitable, followed by scenario 1. The productivity and profitability of feed formulations declined with protein content. In each case the short cycle was more productive annually but at higher cost and, consequently, offering a lower benefit/cost ratio than the long cycle.

Three scenarios in a pond measuring 400 square meters (the assumed average in Bangladesh) offered more profit per day than the average day rate for agricultural labor (US$1.03) — scenarios 2 ($2.04), 1 ($1.57) and 4 ($1.54) — while taking much less time. Although the daily returns of the other scenarios were lower, scenarios 6 ($0.83), 3 ($0.73) and 5 ($0.50) can still improve the food and nutritional security of poor farmers, as well as their household income.

3. Feed preparation on small-scale farms is labor intensive, and feed quality can be compromised by deficiencies of amino acids in some ingredients.

As on-farm feed preparation is labor intensive, the approach of identifying locally available ingredients and subsequent application in feed formulation could be utilized for resource poor farmers to sustain the farming operation by minimizing operational cost. Clearly, feed prepared using on-farm resources

Table 1. Ingredients used in the formulation of feeds of different crude protein (CP content

Source	Ingredient (g/kg)	35% CP	30% CP	25% CP
Plant origin	Rice bran	150	190	150
	Wheat bran	190	200	300
	Mustard oil cake	160	250	250
	Duckweed	30	0	0
Animal origin	Fish meal	150	100	0
	Dried blood	130	100	100
	Poultry viscera	100	100	100
	Shrimp-head meal	40	0	0
Supplement	Corn starch	50	60	100
Total (g)		**1000**	**1000**	**1000**

Table 2. Annual costs, productivity and returns of 6 production scenarios, by hectare and in an average-sized pond in Bangladesh

Per hectare	1.35% CP 100 days	2.35% CP 150 days	1.30% CP 100 days	2.30% CP 150 days	1.25% CP 100 days	2.25% CP 150 days
Production (kg/yr)	16,994.5	16,547.2	14,162.0	13,789.4	11,329.6	11,031.5
Farm-gate price/kg (US$)	1.12	1.35	0.90	1.35	0.90	1.12
Gross return (US$/yr)	19,064.30	22,275.12	12,709.53	18,562.60	10,167.62	12,375.07
Total cost (US$/yr)	7,294.63	6,994.73	7,269.89	6,982.08	6,436.88	6,121.31
Unit cost (US$/kg fish)	0.43	0.42	0.51	0.51	0.57	0.55
Net return (US$/yr)	11,769.66	15,280.39	5,439.64	11,580.52	3,730.74	6,253.76
Net return (US$/yr)	39.23	50.93	18.13	38.60	12.44	20.85
Cost (US$/day)	24.32	23.32	24.23	23.27	21.46	20.40
[1]Benefit/cost ratio	2.61	3.18	1.75	2.66	1.58	2.02
Per 400-square-meter pond[1]						
Production (kg)	566.5	661.9	566.5	551.6	453.2	441.3
Total cost (US$)	291.79	279.79	290.80	279.28	257.48	244.85
Cost per day (US$)	0.97	0.93	0.97	0.93	0.86	0.82
Grosss return (US$)	762.57	891.00	508.38	742.50	406.70	495.00
Net return (US$)	470.79	611.22	217.59	463.22	149.23	250.15
Net retrun (US$/day)	1.57	2.04	0.73	1.54	0.50	0.83

CP = crude protein, kg = kilogram, yr = year.
[1] Tilapia farmgate price per kilogram divided by cost of production per kilogram.
[2] Assumed average fishpond size in Bangladesh.

can improve the performance of artisanal aquaculture systems to some extent. Hence, relevance of small-scale aquaculture based on on-farm resources (crop and animal by-products) as feed/pond inputs is highlighted in this study, particularly in the context of small-scale farming systems. Nevertheless, there is limited scope for intensification of fish production system with virtual reliance on feed prepared on-farm due essentially to inadequate resources available on-farm and lack of experience among resource-poor farmers in formulating fish feed containing right proportion of ingredients.

4. Encouraging micro- and small feed making enterprises that process locally available resources like crop and livestock byproducts has potential for ensuring the supply of low cost tilapia feed without compromising its quality and also generating local employment

Rising feed costs squeeze not only fish farmers, but also feed producers, driving them to search for alternatives to conventional feed ingredients to minimize their costs. Research that identifies locally available ingredients for smallholder aquaculture promises to encourage individual entrepreneurs and cooperatives to create small and medium-sized enterprises to process crop and livestock byproducts into nutritious tilapia feed. This will create local employment and enhance rural economic development. In the long run, this approach is likely to be more practical and sustainable than on-farm formulation by individual farmers in most situations.

5. Relatively high fish feed prices in Malaysia favor large, vertically integrated fish farms; small-scale farms are becoming increasingly vulnerable to rising feed costs and highly competitive market

Malaysia is at the crossroads of traditional fish farming practices and more intensive, vertically integrated modern systems. Whilst vertically integrated systems efficiently increase output and generate employment, small-scale farms are becoming increasingly vulnerable to the situation of rising input costs and highly competitive market. If current trends continue, the number of self-employed tilapia farmers in Malaysia is projected to increase at a much lower rate than the number of wage earners on tilapia farms (Figure 5). Household income on small farms is expected to rise by only 13% between 2005 and 2010, while large farms will see about 300% increase (Figure 6). As feed and management costs increase, large or medium-sized intensive, vertically integrated operations have clear advantages over smaller farms, as they are better able to withstand oscillations in prices for inputs and in earnings from production.

Rising cost of commercial fish feed has compelled many small farms in Malaysia, and even some large ones, to turn to local resources. Most Malaysian fish farms have facilities for cooking ingredients such as poultry offal, restaurant waste, beans, peas, copra meal, palm oil cakes, and other agricultural and livestock byproducts. Some have facilities for processing the concoction into pellets.

Most farms use feeds produced on the farm as cheap supplements to the commercial diet, not as replacements. Some farmers switch to a low-protein finisher diet, with less

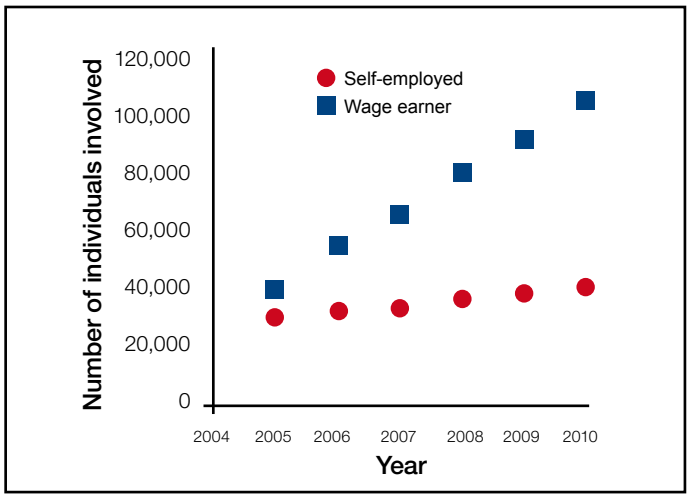

Figure 5. Projected number of self-employed and wage earners on tilapia farms

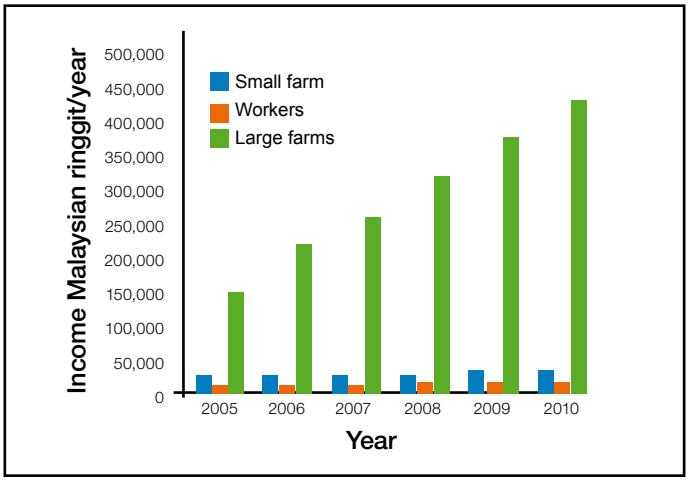

Figure 6. Projected income of Malaysian smallholder farmers, wage earners and large farms

than 20% protein, directly following the high-protein starter diet, completely skipping the intermediate grower diet. Farmers who use low-cost alternatives often complain of slow fish growth, illustrating that strategies to reduce feed costs can suppress operational profit. Combined with limited marketing capacity, declining profitability because of low-quality inputs threatens to reduce the number of small Malaysian fish farms.

FUTURE DIRECTIONS

The study emphasizes the need for the development of enterprises locally formulated feeds can contribute to improvements in aquaculture production in efficient ways that can improve livelihoods and food security of the poor, whilst making efficient use of low-cost locally available ingredients. Identification and utilization of locally available ingredients for small-scale aquaculture will also encourage individual entrepreneurs and cooperative based agriculture and animal by-product processing industries, feed mills and nursery operations. This would create further employment and will help to enhance the overall rural economy in developing countries.

Further research is needed across different agro-ecological environments to identify locally available ingredients for tilapia feed. Location-specific technology packages drawing from this research should be developed and disseminated along with clear reference materials in local languages to minimize the risk of failure among adopters. A promising avenue is to encourage entrepreneurs' development of small and medium-sized feed-producing enterprises. Model designs for such processing plants should thus be developed. Adequate training and technical support, especially when delivered through public-private partnerships, promote this development more cost effectively than do subsidies.

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