Economics of aquaculture feeding practices: Viet Nam

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SUMMARY

Aquaculture has recently developed at an accelerated rate in Viet Nam. The main cultured areas are located in the Mekong River Delta with two major commercial species, black tiger shrimp (*Penaeus monodon*) and sutchi catfish (*Pangasianodon hypophthalmus*). Commercial catfish culture started to grow in the late 1990s, following the development and introduction of induced breeding technology. Three typical farming systems, currently in practice, are cage, pond and fence culture. Catfish pond culture production has been increasing rapidly, especially in the areas located along the river banks and islands, where there is good water exchange. Catfish production in ponds grew to 220 615 tonnes in 2004, 3.6 times as much as in 1999. This production growth is expected to continue. However, feeds and feeding are considered to be the main concerns for any further development in farming this fish species.

The general objective of this case study is to assess the economic implications of adopting various feeding practices in catfish production in Viet Nam. This study was conducted in An Giang province where 60 pond catfish farmers were interviewed using the designed questionnaires. Three different groups of pond farmers were considered for the comparative analysis of three different categories of feeding (i) intensive, with farms using manufactured pelleted feed; (ii) semi-intensive, with farms using a combination of farm-made & manufactured pelleted feeds; and (iii) traditional, with farms using farm-made feed. The case study assessed the impacts of these feeding practices in terms of specific human characteristics and economic indicators such as yield, costs, gross revenue and profit, and benefit cost ratio, as well as returns to investment and labour.

The results showed that 48 percent of farmers of all categories obtained secondary level education but 55 percent of intensive farmers had high school degrees. Farmers using an intensive technology had lower experience in terms of years in operation when compared to farmers from the other categories. However, farmers of all farming types attended training courses offered by governmental authorities and/or by private sectors such as feeds and drugs and chemical suppliers.

The average total pond area per farm ranged from 0.86 ha to 1.50 ha with average pond sizes ranging from 0.27 ha to 0.77 ha. The productivities of all three categories were very high but vary widely by farm category. The semi-intensive farms had the highest production of 243 900 kg/ha/year, followed by intensive, 240 200 kg/ha/year and traditional 157 500 kg/ha/year.

The feed conversion ratio (FCR) of farm-made feed was the highest. Feed costs accounted for the highest proportion of total variable costs in each of the farming systems (varying from 84 percent to 93 percent of the total variable costs). The net return differed by farming types. Traditional and semi-intensive categories registered almost similar net returns of US$21 515/ha and US$20 085/ha, respectively. The intensive farms received the highest gross return but a lower net return of US$14 193/ha as compared to other farming types.

This study showed that the farm-made feed showed better net returns than the other two feed categories. However, the survey also revealed that farm-made feed was gradually being replaced by manufactured pelleted feed or a combination of farm-made and manufactured pelleted feeds because of the reduced supply and increased price of feed ingredients for formulating farm-made feed. There were also increasing concerns over the impact of environmental pollution caused from farm-made feed.

The regression analysis showed that the total fish yield per hectare is significantly affected by five independent variables including the total quantity of feed use, proportion of farm-made feed to total feed, stocking rate, total fixed cost and number of ponds per farm.

1. INTRODUCTION

1.1 Rationale

Aquaculture production as practised today is represented by different types of production systems. In the history of civilization, addressing food scarcity has been directly associated with innovations in production practices/systems. Different production practices and systems co-exist with one another depending upon the level of technology that prevails. In aquaculture production, any change in the practice of feeding (*e.g.* from traditional/extensive to intensive feeding practice) represents a technological innovation and this is assumed to generate increases in aquaculture production and income. On the other hand, farmers' adoption of technology such as industrially produced complete feed for aquaculture production must be justified on the basis of its financial soundness. The technology that may provide reasonable financial incentives to the fish farmers will easier be adopted than the technology which does not. This case study is expected to shed light on the economics of the various feeding practices in catfish (*Pangasianodon* spp.) pond culture in Viet Nam.

1.2 Objectives of the study

The general objective of the study is to assess the economic implications of adopting various feeding practices in aquaculture production in Viet Nam.

Specifically, this country case study is aimed at:

(i) conducting a survey of twenty aquaculture farms for each of three different categories or systems of feeding practices, using a pre-tested questionnaire;

(ii) processing and analyzing the data to arrive at a comparative analysis of the different farm categories highlighting the following:

a) production (including feeding) practices,
b) production costs (fixed investment as well as maintenance and operating costs),
c) income (gross revenue and gross margin),
d) production problems,
e) returns on investments,

f) break-even analyses (break-even price, break-even production),
g) factor of productivities, and
h) suggestions/recommendations;

(iii) prepare a consolidated report of the case study based on the above information.

2. GENERAL APPROACH AND METHODOLOGY

2.1 Comparative analysis

The case study provided a comparative analysis of three different categories of feeding practices for catfish culture in ponds including (i) manufactured pelleted feed; (ii) a combination of manufactured pelleted and farm-made feeds; and (iii) farm-made feed.

Manufactured pelleted feed refers to feeding, for a whole culture cycle, catfish using industrially produced floating pellets with different feed sizes and quality suited to growth stages of fish. Farm-made feed refers to feeding, for whole culture cycle, catfish by feed prepared at farm site using locally available feed ingredients. A combination of manufactured pelleted and farm-made feeds refers to a feeding fish by commercially marketed pelleted feed for the first two to three months then by farm-made feed until harvest. For convenience sake, the three feeding practices will be referred to as (i) intensive (feeding only with manufactured pelleted feed), (ii) semi-intensive (feeding with combination of farm-made and manufactured pelleted feeds) and (iii) traditional (feeding only with farm-made feed).

2.2 Assessment indicators

The case study assesses the impacts of the various feeding practices in terms of: (i) gross margin; (ii) net margin/return; (iii) returns on investment; (iv) returns to labour; (v) break-even price coefficients; (vi) break-even production coefficients; (vii) gross total factor productivity; and (viii) net total factor productivity. The basis of estimating the above indicators shall be the cost and returns table that was developed based on a prepared questionnaire.

2.3 Sampling technique

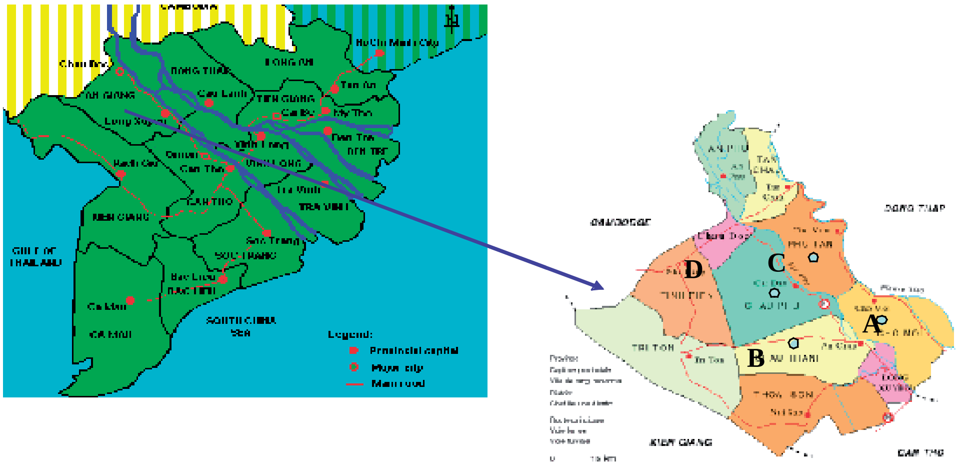
The case study included three representative feeding practices of pond catfish culture in the Mekong river delta, Viet Nam. Twenty farms (or respondents) were interviewed for each feeding system. An Giang province borders on Cambodia and is located along the Mekong river branches in Viet Nam (Figure 1). This location has a long history of catfish culture that started with cage culture in the 1960s (Nguyen, 1988) and then developed to other systems in the 1990s, notably, pond and fence culture.

The study was conducted from October, 2005 to January, 2006. The respondents were randomly selected from the list of farm owners, provided by the provincial fisheries agency. A total of 60 fish farmers were interviewed in four districts of An Giang province, Viet Nam (Table 1).

TABLE 1
Number and ratio of respondents by study locations

Locations (district names)	Number of respondents	Ratio (percent)
Cho Moi (A)	15	25.00
Chau Thanh (B)	5	8.33
Phu Tan (C)	33	55.00
Chau Phu (D)	7	11.70
Total	60	100

FIGURE 1
Map of the Mekong River Delta (left) and An Giang province (right). The circles are the survey locations



Source: Nguyen *et al.* (2004)

2.4 Data processing and analysis

A tabular analysis was employed to develop the cost and returns tables for the various feeding systems observed in the study sites. The cost and returns analysis indicated the variable cost categories including feeds, fingerlings, labour and electricity. Other input costs and capital investments were also determined. Information on gross revenues was also determined to be able to address the objectives of the case study. A cross sectional analysis using graphs, percent changes and/or growth rates were adopted to determine the basic relationships of feeding practices with selected impact indicators. Regression analyses using economic and bioeconomic models that relate net incomes derived from catfish productions with various predictors and state variables (e.g. shifters) have been undertaken. In particular, regression runs based on a profit function (for economic regression models) relating net profit with input and output prices and variables such as education and training attendance and farming experience were undertaken. Likewise bio-economic models relating net profit with economic variables (e.g. input and output prices) and non-economic variables (e.g. recovery rate, stocking rates, quantity of feeds and size of ponds) were also undertaken to determine the existence of statistical relationships between them.

2.5 Limitations of the study

This study has been limited in terms of its nature and scope. One major limitation of this study is its heavy emphasis on the economic and financial aspects of aquaculture feeding systems. The type and scope of data generated and analyzed have been largely focused on economic and financial parameters and has ignored other important non-economic parameters such as water quality, stocking rates, feed quality and types of training, which could have further enhanced the analysis and interpretation section of the report. For instance, the volume of feeds consumed by the various farm categories could have further improved the findings of the study if the feed consumption data had been broken down by the quality of feeds consumed.

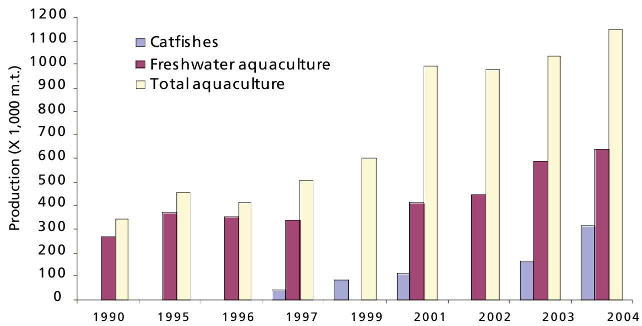
Another major limitation of the study is the nature of data gathering employed (e.g. personal interviews by recall) which may have influenced the overall reliability of the data generated by the study, e.g. data on the size of fingerlings and stocking duration. Finally, the number of samples per category of feeding system (e.g. 20 samples) could have been increased for the country case studies to arrive at more robust estimates. This was not possible due to financial constraints in increasing the number of samples.

3. RESULTS AND DISCUSSION

3.1 Description of the study area

The Mekong River Delta (MRD) in the Southern part of Viet Nam covers 12 percent of the total area of the country. The Delta comprises approximately 650 000 ha of freshwater bodies, and the freshwater surface may potentially be enlarged to up to 1.7 million ha during the flooding period (Le, 2001; Tran and Nguyen, 2001), suggesting significant potential for aquaculture growth. The freshwater area of MRD has diverse habitats that are suited for various types of freshwater aquaculture. The freshwater aquaculture therefore plays an increasingly important role in the economic development of the delta. The production of freshwater aquaculture is about 500 000 tonnes or about 70 percent of the total aquaculture production of the delta in 2004 (MoFI, 2005). Major culture species include Chinese and Indian carps, tilapia, snakehead and catfishes belonging to *Pangasianodon* genus. The culture of *Pangasianodon* catfish is increasing in terms of production and culture areas. The total production of catfishes in 2004 was 315 000 tonnes, 3.6 times as much as that in 1999 and shared approximately 60 percent of the total freshwater aquaculture production of the MRD (MoFI, 2005) (Figure 2). The export value of catfish products reached US$300 million and accounted for 12.5 percent of total export revenue from fisheries sector of Viet Nam in 2004. There are two species of catfishes being cultured, namely *Pangasianodon hypophthalmus* and *Pangasius bocourti.* The first is the main cultured species and accounts for more than 95 percent of total aquaculture catfishes. The total production of catfishes is expected to reach around 0.6 to 1.0 million tonnes in 2010 (MoFI, 2005).

FIGURE 2
Production of freshwater fishes and catfishes in the Mekong River Delta of Viet Nam from 1997 to 2004



Source: Tran (2005) and Do (2005)

3.2 The description of respondents

The average age of the three respondent categories was 45 years. The ages of respondents were quite similar among the categories (varying from 44 to 46 years old). The household size varied from 4.4 to 5.2 with farmers from intensive systems having marginally larger household sizes (Table 2). However, the years of experience in catfish production varied widely by respondents. Intensive farmers had fewer years of catfish activity (3.2 years), while semi-intensive farmers had the longest years of experience (11.8 years) (Table 2). The farm owners of all categories were married, with one exception.

The educational attainment of the respondents varied among the categories (Table 3). Most of respondents had received secondary and high school education. This implies that catfish farmers had no professional training at the level of technician or above. However, most farmers had participated in short training courses organized by governmental aquaculture extension or technical services (governmental training) and/or extension programmes organized by feed or chemical and drug companies (private training) (Table 4). The average duration of each training course for all categories was 1.82 days. Most feed and drug and chemical companies invite professional trainers from the universities and research institutions to provide lectures. However, most of the surveyed farms, especially large scale ones, had access to permanent consultants from a university or research institution or free consultants

TABLE 2
Average age, household size and experience of the respondents in catfish culture

Category (feeding practices)	Age	Household size	Years of experience
Intensive	43.8	4.40	3.21
Semi-intensive	45.9	5.15	11.8
Traditional	45.1	4.55	7.75
All category	44.9	4.73	7.60

TABLE 3
Educational attainment by category of respondents

Educational attainment	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Illiterate	0	0.0	6	30.0	5	25.0	11	18.3
Primary	1	5.0	4	20.0	3	15.0	8	13.3
Secondary	8	40.0	9	45.0	12	60.0	29	48.3
High school	11	55.0	1	5.0	0	0.0	12	20.0
Total	20	100	20	100	20	100	60	100

TABLE 4
Attendance and type of training by category of respondents

Type of training*	Intensive			Semi-intensive			Traditional			All categories		
	Duration (days)	No.	%	Duration (days)	No.	%	Duration (days)	No	%	Duration (days)	No	%
Government training	2.40	1	6.67	1.5	10	100	1.5	8	100	1.80	19	57.6
Private training	1.30	14	99.3							1.30	14	42.4
Total	1.85	15	100	1.5	10	100	1.5	8	100	1.62	33	100

*Government training: training courses offered by aquaculture extension agencies of governmental authorities; private training: training courses offered by feed and/or drug and chemical companies

Catfish culture has boomed and has recently attracted new investors. Sixty eight percent of the total number of respondents claimed that their major occupation prior to catfish culture was fish farming, while only 13 percent were involved in agricultural activities (Table 5). The new investors in some cases would hire either permanent or periodical/seasonal technicians that had experience in catfish farming.

TABLE 5
Occupation of catfish farmers by category of respondents

Occupation	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Fish farming	8	40	17	85	16	80	41	68.3
Fish trading	0	0	0	0	0	0	0	0.0
Agriculture	1	5	3	15	4	20	8	13.3
Housewife	3	15	0	0	0	0	3	5.0
No response	8	40	0	0	0	0	8	13.3
Total	20	100	20	100	20	100	60	100

3.3 General profile of the farm

FFish culture in the Mekong Delta is operated on a small scale. Catfish farming, especially catfish culture in ponds is operated individually, with the exception of a few large farms operated by companies. Table 6 shows that the average number of ponds for all categories was 2.37, which varied from 1.95 for intensive farmers to 2.65 for semi-intensive farmers. The total pond area for intensive farms was the highest (1.5 ha), which was about twice as large as the other categories. It was observed that intensive farmers had an average pond area 3 times larger than the others. The depth of catfish ponds was similar among all categories (averaging 3.23 m in dry season to 3.70 m in rainy season).

TABLE 6
Number and area of the ponds, and water depth

Item	Intensive	Semi-intensive	Traditional	All categories
Total no. of pond	1.95	2.65	2.50	2.37
Total area of pond (ha)	1.50	0.69	0.86	1.02
Average area of pond (ha)	0.77	0.27	0.34	0.44
Average water depth (m)				
Rainy season	3.52	3.80	3.79	3.70
Dry season	3.18	3.33	3.19	3.23

The survey also shows that catfish ponds in the studied areas were used exclusively for fish farming and no multipurpose use was recorded. The survey also showed that all of the studied catfish farmers were single owners. This is because catfish farmers use their private land to build ponds. Moreover, the catfish culture was also operated individually and is considered small-scale in terms of total culture area. However, there were exceptional cases where some catfish farms were operated under joint-ownership or by state-run companies.

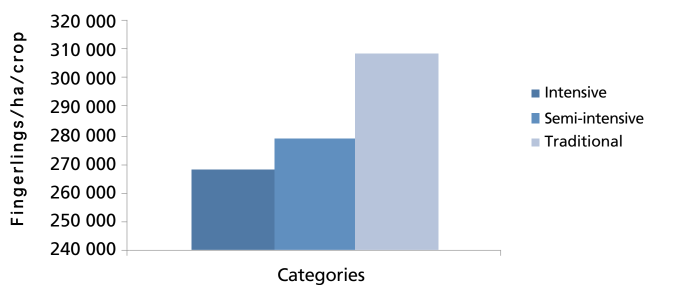
It is interesting to note that all respondents reported that profitability was the main influencing factor in prompting their decision to invest in catfish pond culture. This may support the reasons for the rapid expansion of catfish culture in general or catfish pond culture in particular in the Mekong delta during the last few years (Figure 2). Additionally, it should be noted that there are other factors considered in the selection of catfish culture for investment such as the excellent natural conditions, availability of culture techniques, processing factories and marketing (Le and Nguyen, 2005).

3.4 Farm production practices

3.4.1 Stocking strategies

All three categories applied single stocking. The average stocking density was 285 282 fingerlings per ha per crop. The average stocking densities were fairly similar, with a marginally lower density for intensive followed by semi intensive and traditional farms (Figure 3).

FIGURE 3
Average stocking density



3.4.2 Feeding practice

Feed types

There are two kinds of feed used in catfish culture; these are manufactured pelleted feed and farm-made feed. The manufactured pelleted feed is produced as floating types, while the farm-made feeds are sinking. There are a number of feed manufacturers involved in production of pelleted feeds for catfish. The total pelleted feeds produced from these companies were estimated from 100 000 to 150 000 tonnes in 2004. The nutritional quality of pellets (printed on the feed bag) is almost similar. The nutritional values, especially protein content, differ according to the fish sizes. Pelleted feeds for small size fish contained higher protein than that for larger fish sizes. However, Nguyen *et al.* (2003) reported that the protein contents of manufactured pelleted feed for catfish are lower than its requirement. Nguyen *et al.* (2003) also reported that the protein requirement to achieve the optimum growth for catfish fingerlings was from 32.7–36.1 percent for large fingerling sizes. The farm-made feed is prepared by cooking various feed ingredients such as rice bran, broken rice, trash fish and vegetables. This farm-made feed is usually produced in moisture form and has a low protein level of around 10.8 percent in dry weight basic (Table 7).

TABLE 7
Average proximate composition (percent dry matter basis) of feed types

Composition (%)	Manufactured pelleted feed	Farm-made feed
Moisture	10.60–11.00	60.0
Crude protein	23.10–24.90	10.8
Crude lipid	4.30–4.65	2.0
Ash	6.90–7.75	4.0
Crude fiber	5.60–7.30	-

Source: Values of the pellets are recorded from feed bag and that of the farm-made feed are from Tran (2005)

FIGURE 4
Feed application methods

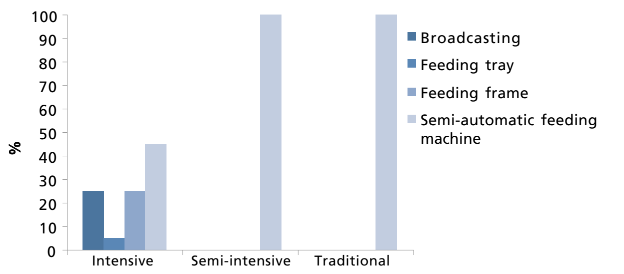
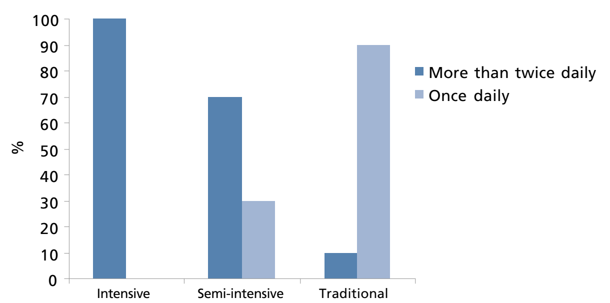


FIGURE 5
Feeding frequency



Feeding practices

Table 8 shows that the feeding practices differ according to feed forms, *i.e.* either manufactured pelleted or farm-made feeds. Broadcasting (25 percent of respondents), feeding frame (25 percent of respondents) and semi-auto feeding (45 percent of respondents) were the feeding methods practised by intensive farmers. Semi-automatic feeding was the only feeding method used for the other two categories (Figure 4). Manual feeding of farm-made feed, applied before the 1990s (Nguyen, 1998), is no longer used.

Feeding frequencies varied by feed types. Intensive farmers applied multiple feeding frequencies (100 percent of farms), while traditional farmers (90 percent), generally fed only once daily (Table 8 and Figure 5). Making farm-made feeds is considered very labour intensive (cooking, cooling, mixture, extruding), hence the lower frequency of feeding regime, thus saving on labour costs.

TABLE 8
Feed application method and feeding frequency

Feed application methods	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
1. Broadcasting	5	25	0	0	0	0	5	8.33
2. Feeding tray	1	5	0	0	0	0	1	1.67
3. Feeding frame	5	25	0	0	0	0	5	8.33
4. Semi-automatic feeding machine	9	45	20	100	20	100	49	81.70
Total	20	100	20	100	20	100	60	100
Feeding frequency								
1. More than twice daily	20	100	14	70	2	10	36	60
2. Once daily	0	0	6	30	18	90	24	40
Total	20	100	20	100	20	100	60	100

3.5 Fish production costs

3.5.1 Labour costs

Labour requirements for catfish pond culture included full-time, part-time and casual labour. Intensive farmers used less full-time labour (averaging 0.88 man-days per ha) compared to the other two categories (averaging 3.15 and 1.95 man days per ha for semi-intensive and traditional, respectively) (Table 9). The semi-intensive and traditional farmers required more full-time labour due to the high labour requirements for the daily preparation of farm-made feeds such as cooking and feeding. Therefore, the farm group with the highest labour cost was "traditional" and the lowest, "intensive".

TABLE 9
Average number of labour (man-days/ha) and cost (US$/ha)

Item	Intensive	Semi-intensive	Traditional	All categories
Full-time labour	0.88	3.15	1.95	1.99
Part-time labour	0.20	0.14	0.36	0.23
Casual labour	0.35	3.02	2.66	1.32
Average number of labour	0.48	2.10	1.66	1.18
Labour cost	288	389	218	298

US$1.00 = VND15 893

3.5.2 Fingerling costs

The fingerling unit prices differed slightly among farm categories. The unit price of fingerlings stocked in intensive systems was lower due to smaller size. The total fingerling cost per hectare depended on the stocking densities and farm size of each category (Table 10).

TABLE 10
Average quantity (number per ha) and cost of fingerlings

Categories	Number of fingerlings (pieces/ha)	Fingerling size (cm in length)	Price/piece (US$)	Total cost (US$/ha)
Intensive	285 213	2.35	0.032	9 084
Semi-intensive	295 157	3.21	0.044	13 106
Traditional	357 992	3.12	0.040	14 438
All categories	312 787	2.89	0.039	12 209

3.5.3 Feed costs

The unit cost of feeds varied by feed types particularly between manufactured pelleted (intensive) and farm-made feeds (traditional). The unit price for manufactured pelleted feeds depended on protein levels, which averaged US$0.34/kg (Table 11). Farm-made feed price was generally lower (US$0.18/kg) due to their low protein content and as well as the utilization of cheap feed ingredients such as rice bran, broken rice, trash fish and vegetables. However, it should also be noted that fluctuation in availability of these ingredients and increases in price could be a reflection of shortages of some of the raw materials. The average feed cost for all farm categories accounted for 84 percent of the total variable costs, varying from 74 percent for traditional farmers to 93 percent for intensive farmers. The lowest feed cost was noted amongst farmers using farm-made feed, but these farmers may switch to other feed types once the catfish industry continues to grow due to the increase of ingredient prices, shortage of supply and environmental pollution concern.

3.5.4 Miscellaneous input/other variable costs

Miscellaneous input costs included staff salaries, electricity and fuel. Miscellaneous input costs varied by feeding practices (Table 12). The average of miscellaneous input costs for catfish culture was US$1 303, US$1 202 and US$2 464/ha respectively for intensive, semi-intensive and traditional farms. Of these, fuel costs accounted for 64.6-81.1 percent, and staff salaries 18.9-25.4 percent, amounting to most of total miscellaneous input costs. Electricity was mostly used for lighting and living activities. Fuels were mainly used for water pumping and partly for feed preparation. Intensive systems required daily water pumping during the last two thirds of the production cycle resulting in a high expenditure (US$1 018/ha) on fuel per production cycle relative to the other two farm categories (US$975 and US$1 592 for semi-intensive and traditional farms, respectively).

TABLE 11
Quantity (kg/ha/year) and cost of feeds (US$)

Item	Intensive			Semi-intensive			Traditional		
	Quantity (kg/ha)	Price (US$/kg)	Total cost (US$/ha)	Quantity (kg/ha)	Price/ (US$/kg)	Total cost (US$/ha)	Quantity (kg/ha)	Price (US$/ kg)	Total cost (US$/ha)
Manufactured pelleted feed									
Feed for grow-out stage	327 248	0.34	110 006	22 783	0.32	7 189			
Feed for larger fingerling size	67 632	0.34	22 768						
Feed for small fingerling size	2 167	0.33	709						
Subtotal	397 177		133 483	22 783		7 189			
Farm-made feed				507 119	0.18	89 343	270 189	0.18	49 086
Total	397 177		133 483	529 982		96 532	270 189		49 086

TABLE 12
Average annual quantity and cost of miscellaneous inputs/other variables per hectare

Item	Intensive				Semi-intensive				Traditional			
	Quantity	Unit cost (US$)	Total cost (US$)	%	Quantity	Unit cost (US$)	Total Cost (US$)	%	Quantity	Unit cost (US$)	Total Cost (US$)	%
Salaries of staff (man-years)	1.55	183.73	285	21.9	2.22	102	227	18.9	3.95	159	626	25.4
Electricity (KWH)									4 111	0.06	247	10.0
Fuel (liters)	2 166	0.47	1 018	78.1	2 073	0.47	975	81.1	3 386	0.47	1 592	64.6
Total			1 303	100			1 202	100			2 464	100

3.5.5 Other input costs

Purchased cost items in this study included the costs of buying major equipment used in fish culture activities such as water pumps, feed cooking pans, auto-feeding machines and other minor equipment. The average fixed cost for all categories was estimated at US$4 161/ha. The fixed cost of farm-made feed categories was highest at US$452/ha/cycle, the lowest was manufactured pelleted feed (US$178/ha/cycle) (Table 13).

The table below shows purchase prices, the life span of the assets, the annualized costs and salvage values.

TABLE 13
Average purchase volume, life span, annualized cost and salvage value of fixed investment

Items	Value
Intensive	
Purchase value (US$/ha)	2 816
Life span (years)	15.5
Annualized cost (US$/ha)	178
Salvage value (US$/ha)	141
Semi-intensive	
Purchase value (US$/ha)	5 871
Life span (years)	12.8
Annualized cost (US$/ha)	380
Salvage value (US$/ha)	294
Traditional	
Purchase value (US$/ha)	3 796
Life span (years)	10.8
Annualized cost (US$/ha)	452
Salvage value (US$/ha)	190
All categories	
Purchase value (US$/ha)	4 161
Life span (years)	13
Annualized cost (US$/ha)	337
Salvage value (US$/ha)	208

3.5.6 Total production costs

Total production costs included major items such as the cost of labour, fingerlings, feeds and others (Figures 6–8). The total production cost per hectare per year varied from US$66 658/ha/cycle for traditional systems to US$144 338/ha/cycle for intensive systems (Table 14). The high level of investment in intensive farming could not be followed by small-scale and less capital endowed farmers.

TABLE 14
Total costs by items (US$/ha/year)

Description	Intensive	Semi-intensive	Traditional	All categories
Total costs	144 338	111 614	66 658	107 537
Total fixed costs	178	380	452	337
Total variable costs	144 160	111 233	66 206	107 199
1. Labour costs	288	389	218	298
2. Fingerlings	9 084	13 106	14 439	12 209
3. Feeds	133 483	96 532	49 086	93 034
4. Other variables	1 303	1 202	2 464	1 659

FIGURE 6
Distribution of costs for farms using manufactured pelleted feed

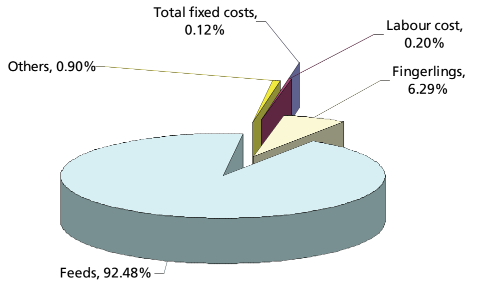


FIGURE 7
Distribution of costs for farms using farm-made and manufactured pelleted feed

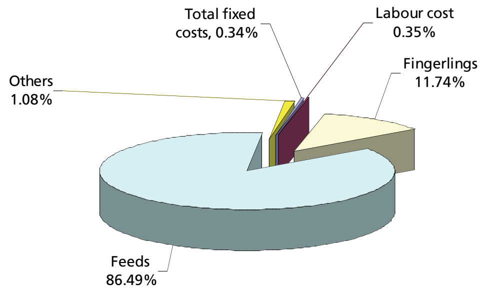
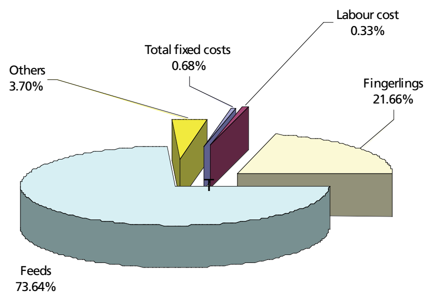


FIGURE 8
Distribution of costs for farms using farm-made feed



3.5.7 Gross revenues

Gross revenues

The average gross revenue of all farm categories was estimated at US$126 134/ha. Average gross revenues varied by category of respondents. Intensive farmers recorded the highest gross revenue US$158 531/ha, while the lowest return was recorded in traditional systems, US$88 173/ha. Variation in gross revenues was mainly due to the volume of fish harvested and the quality of fish. Catfish fed with manufactured pelleted feed has a brighter flesh. This appearance commands a higher price premium. Table 15 shows that the volumes of harvest fish increased from 157 452 kg/ha (traditional farming) to 243 887 kg/ha (semi intensive farming).

It is also indicated in Table 16 that the actual average selling prices of fish per kilogram differ by farm category. However, the actual average selling prices of catfish sold by traditional and semi intensive farmers are almost similar at US$0.54/kg and US$0.56/kg, respectively. Intensive farmers reported the highest average actual selling price (US$0.66/kg). In addition to flesh quality, fish farmers also indicated that price variables included harvesting seasons, fish size, and international market demand. Prices used in the report are the prices at the time of the survey.

TABLE 15
Summary of major findings by farm category (ha/year)

Items	Intensive	Semi-intensive	Traditional
No. of fingerling stocked	285 213	295 157	357 992
Amount of feed (kg)	564 089	529 982	270 189
Production/volume of fish harvested (kg)	240 199	243 887	157 452
Feed conversion ratio	2.35	4.02	3.06

TABLE 16
Annual gross revenues per hectare

Items	Value
Intensive	
1. Volume of fish harvested (kg)	240 199
2. Price/kg (US$)	0.66
3. Gross revenue (US$)	158 531
Semi intensive	
1. Volume of fish harvested (kg)	243 887
2. Price/kg (US$)	0.54
3. Gross revenue (US$)	131 699
Traditional	
1. Volume of fish harvested (kg)	157 452
2. Price/kg (US$)	0.56
3. Gross revenue (US$)	88 173
All categories	
1. Volume of fish harvested (kg)	213 787
2. Price/kg (US$)	0.59
3. Gross revenue (US$)	126 134

Net return

The net return of catfish production also varies by farm category. Traditional farmers registered the highest net return of US$21 515/ha per year. This level of net return was higher than in both semi intensive and intensive systems (Table 17 and Figure 9). Feed costs were the most influential cost factor.

TABLE 17
Annual net returns by category

Category	Amount in US$/ha		
	Gross revenue	Total cost	Net return
Intensive	158 531	144 338	14 193
Semi-intensive	131 699	111 614	20 085
Traditional	88 173	66 658	21 515
All categories	126 134	107 537	18 598

3.6 Comparative analysis of economic and financial indicators

3.6.1 Gross aquaculture margins

The annual average gross aquaculture margin per farm was highest in traditional farmers (US$21 967/ha) compared with intensive (US$14 371/ha) and semi intensive farmers (US$20 466/ha). For all farms categories, the annual average gross margin was US$18 935/ha (Table 18 and Figure 10). Feed cost was the main factor affecting the gross aquaculture margin for all farming categories.

FIGURE 9
Net return by category

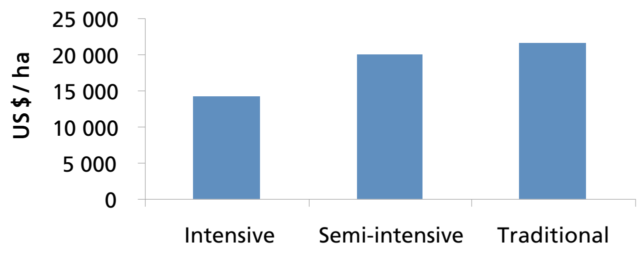


FIGURE 10
Gross aquaculture margin by category

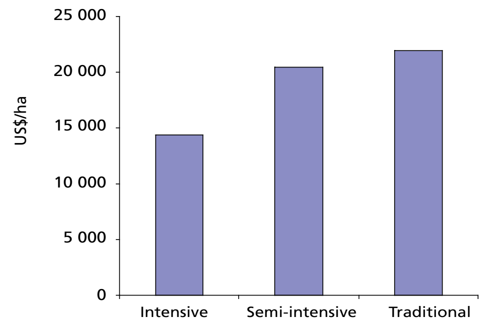


FIGURE 11
Net return to labour by category

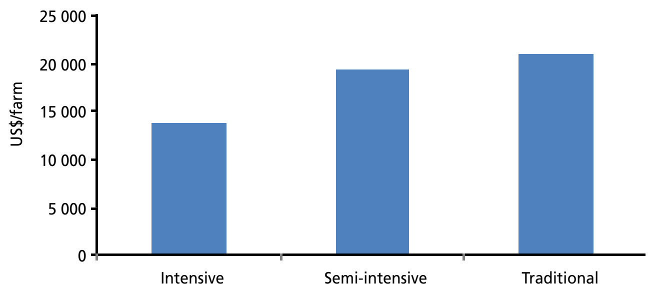


FIGURE 12
Net return to land, labour and capital by category

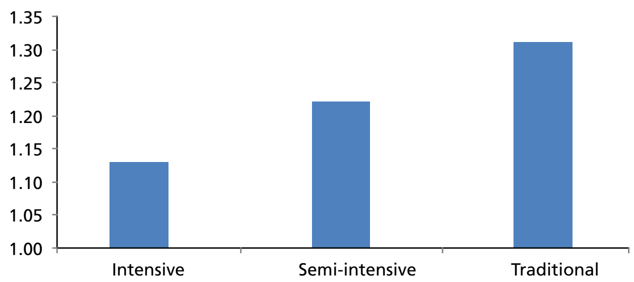
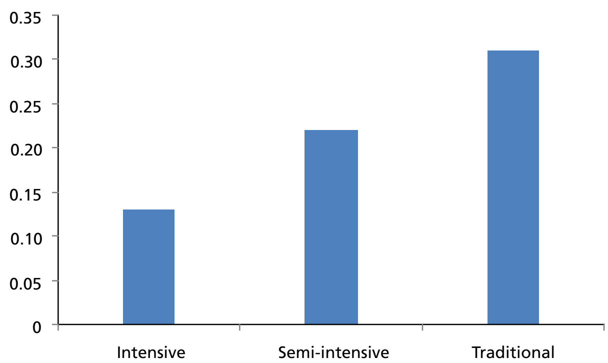


FIGURE 13
Gross total factor productivity by category



3.6.2 Net returns to labour

The net returns to labour for traditional farms was highest followed by semi-intensive and intensive farms (Table 18 and Figure 11). Net returns to labour for traditional, semi-intensive and intensive farms were estimated respectively at US$21 297, 19 696 and 13 905. For all farm categories, it was estimated at US$18 300.

3.6.3 Gross and net total factor productivity

Both gross and net total factor productivity were highest for traditional farmers at 1.31 and 0.31, respectively and lowest for intensive farmers. The average gross and net total factor productivities regardless of fish farm category were estimated at 1.22 and 0.22 respectively (Table 18, Figures 12 and 13). These figures imply that for one VND or US$ of expenditure made in catfish aquaculture production, the equivalent gross revenue of 1.22 VND or US$ or a net income of 0.22 VND or US dollar could be generated.

3.6.4 Break-even prices

The average break-even prices for traditional and semi intensive farmers were US$0.39 and US$0.32 respectively. The breakeven price for intensive farmers was much higher at US$0.87 (Table 18 and Figure 14).

3.6.5 Break-even production

Break-even production for all categories varied from 121 128 kg to 218 749 kg. Break even production was highest for intensive farmers (Table 18). The current productivity levels of all three fish farm categories were higher than their break-even levels. The figures represented 91 percent, 87 percent and 77 percent of the actual harvested volume for intensive, semi intensive and traditional farmers, respectively.

TABLE 18
Summary of assessed financial and economic indicators by farm category (per hectare)

	Item	Intensive	Semi intensive	Traditional	All categories
A	Total cost (US$)[1]	144 338	111 614	66 658	107 537
B	Total variable cost (US$)[2]	144 160	111 233	66 206	107 200
C	Total fixed cost (US$)[3]	178	380	452	337
D	Total gross revenue (US$)[4]	158 531	131 699	88 173	126 134
E	Gross margin (US$)[5]	14 371	20 466	21 967	18 935
F	Net margin/returns (US$)[6]	14 193	20 085	21 515	18 598
G	Net returns to labour (US$)[7]	13 905	19 696	21 297	18 300
H	Gross total factor productivity/benefit cost ratio[8]	1.13	1.22	1.31	1.22
I	Net total factor productivity[9]	0.13	0.22	0.31	0.22
J	Break-even price (US$)[10]	0.60	0.46	0.42	0.50
K	Break-even production (kg)[11]	218 749	210 913	121 128	183 596
L	Recovery rate (percent)[12]	82	76	70	76

[1] Total costs = variable costs + fixed costs
[2] Sum of costs of fertilizer, feeds, fingerlings, hired/family labour, electricity & other variable costs
[3] Sum of fees, lease, interest, rental, depreciation
[4] Value of aquaculture output
[5] Total gross revenue less total variable costs
[6] Total gross revenue less total cost
[7] Net margin/returns less cost of labour
[8] Gross revenue divided by total costs
[9] Net margin/returns divided by total costs
[10] Total costs divided by total production
[11] Total costs divided by average price
[12] (Number of pieces during harvest/number of pieces during stocking)*100

3.7 Production problems

3.7.1 Feed related problem

A small proportion (10 percent) of intensive farmers reported that the high price of manufactured pelleted feed was a major problem (Table 19). A much larger number of semi-intensive (65 percent) and traditional farmers (75 percent) were of the view that the high price of farm-made feed was problematic (Table 20).

FIGURE 14
Net total factor productivity by category

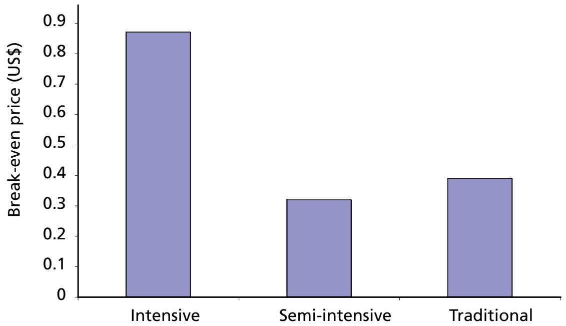


TABLE 19
Problems concerning manufactured pelleted feeds by category of respondents

Problem	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Procurement	0	0.00	0	0.0	0	0.0	0	0.00
Availability	0	0.00	0	0.0	0	0.0	0	0.00
Price	2	10.0	0	0.0	0	0.0	2	3.33
Total	2	10.0	0	0.0	0	0.0	2	3.33

TABLE 20
Problems concerning farm-made feed by category of respondents

Problem	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Procurement	0	0.00	1	5.00	1	5.0	2	3.33
Availability	0	0.00	2	10.0	1	5.0	3	5.00
Price	0	0.00	13	65.0	15	75.0	28	46.7

3.7.2 Enabling production factors

The study also indicated several enabling factors that could improve fish production. Technical factors included the increase of stocking density (36.7 percent), disease control (30 percent), more feed use or increased feeding rates (27 percent) and improvement of water quality (28 percent). The quality of fingerlings and better management practice were also mentioned by 16.7 percent of the respondents (Table 21).

TABLE 21
Enabling factors to increase catfish production by category of respondents

Enabling factors	Intensive		Semi intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
More feed	1	5	3	15.0	9	45	13	27
High stocking density	2	10	9	45.0	11	55	22	37
Quality of fry	1	5	6	30.0	3	15	10	17
Better management	1	5	4	20.0	5	25	10	17
Disease control	2	10	7	35.0	9	45	18	30
Improved water quality	1	5	6	30.0	10	50	17	28

*The question elicited multiple response answers and hence exceeded 100 percent

3.7.3 Disabling production factors

Regardless of farm category, the disabling factors mentioned by the respondents were market facilities (23 percent) (Table 22). These market problems have been caused by the periodical over production, trade barriers from importing countries and the increasing product quality standards. Moreover, constraints of technical factors have also occurred due to disease, seed quality, water quality management and zoning for development

TABLE 22
Disabling factors to increase catfish production by category of respondents

Disabling factors	Intensive		Semi-intensive		Traditional		All categories	
	No	%	No.	%	No.	%	No.	%
Lack of money	0	0	2	10	5	25	7	11.7
Limited feed availability	0	0	0	0	1	5	1	1.67
Lack of market facilities	0	0	8	40	6	30	14	23.3
Limited knowledge of farmers	0	0	2	10	3	15	5	8.33
Other 1 - very high stocking density	2	10	0	0	0	0	2	3.33
Other 2 - farmers' limited ability	13	65	0	0	1	5	14	23.3
Other 3 - degradation of water quality	0	0	1	5	0	0	1	1.67
Total	15	75	13	65	16	80	44	73.3

3.8 Statistical analysis

Multiple regression models using the Cobb-Douglas production function was built for the effects of independent variables on the yield of Pangasius catfish. Four independent variables affecting the fish yield at a significant level of $p \leq 0.01$ are total feed use per ha, proportion of farm feed to total feed, stocking rate, and total fixed costs. The education variable also has a significant level of $p \leq 0.074$. If the stepwise method is used, with level of $p \leq 0.10$, then all of the first 4 variables are included in the model, however, the education variable is replaced by number of ponds which yielded a significant level of $p \leq 0.064$. The stepwise regression model used in estimating fish yield is summarized as in the following table.

TABLE 23
Results of the regression analysis (Dependent variable: yield of fish/ha_ln, stepwise method, stopped at step 5)

Model	Model summary			
	R	R Square	Adjusted R Square	Standard error of the estimate
1	0.959	0.919	0.918	0.350
2	0.968	0.938	0.936	0.309
3	0.973	0.947	0.944	0.288
4	0.976	0.953	0.949	0.275
5	0.978	0.956	0.951	0.269

ANOVA of Model (step 5)	Sum of squares	df	Mean square	F	Level of significance
Regression	83.803	5	16.761	232.40	0.00
Residual	3.894	54	0.072		
Total	87.698	59			

Coefficients (step 5, final step)	Unstandardized coefficients		Standardized coefficients	t	Level of significance
	B	Standard error	Beta		
(Constant)	0.743	0.452		1.642	0.106
Total feed/ha ln	0.710	0.044	0.735	16.082	0.000
Total fixed costs/ha_ln	0.300	0.051	0.390	5.937	0.000
Stocking rate_ln	0.067	0.019	0.114	3.611	0.001
Proportion of farm feed_ln	-0.074	0.023	-0.133	-3.229	0.002
No. of ponds_ln	0.185	0.098	0.084	1.888	0.064

The final model of regression analysis is written in the following form:

Ln (fish yield/ha) = 0.743 + 0.710 Ln (total feed/ha) + 0.300 Ln (total fixed costs/ha) + 0.067 Ln (stocking rate) - 0.074 Ln (proportion of farm-made feed to total feed use) + 0.185 Ln (number of ponds)

Therefore, it can be concluded that the total quantity of feed and the proportion of farm-made feed (or in another way, manufactured feed) significantly affect the yield of Pangasius catfish fish cultured in pond in the Mekong Delta of Viet Nam. An increase in total feed with a regard given to reduce the proportion of farm-made feed should be considered in association with the stocking rate.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Catfish pond culture in the Mekong delta, Viet Nam is largely operated by family farmers. Governmental authorities together with private companies provided technical training for these farmers.

Farm size varies from 0.86 to 1.5 hectares. Fish production is different among three categories of farms. The combined use of manufactured pelleted and farm-made feeds (semi-intensive) yields the highest production (243 887 kg/ha) followed by manufactured pelleted feed (intensive) (240 199 kg/ha). The lowest production was recoded in farm-made feed (traditional) (157 452 kg/ha).

Feed costs account for the highest portion of the total variable cost for all three categories (varying from 73.6 percent to 92.5 percent of total production costs). The net returns in traditional category is highest (US$21 515/ha) as a result of the low cost of farm-made feeds.

The net total factor productivity is highest for traditional farmers (0.31) relative to other categories (semi-intensive group is 0.22 and intensive group is 0.13). Traditional farmers obtain the highest return to labour.

Manufactured pelleted feed has the lowest FCR (2.35) due to the high nutritional values. However, manufactured pelleted feed is higher in unit price and higher in total feed cost per hectare. The use of this feed type leads to high level of investment.

The results of statistical analysis indicate that total feed/ha, proportion of farm feed to total feed, stocking rate, total fixed costs, and number of ponds are the five independent variables affect significantly the fish yield (Figures 15–20).

FIGURE 15
Relationship between total feed (kg/ha) and fish yield (kg/ha)

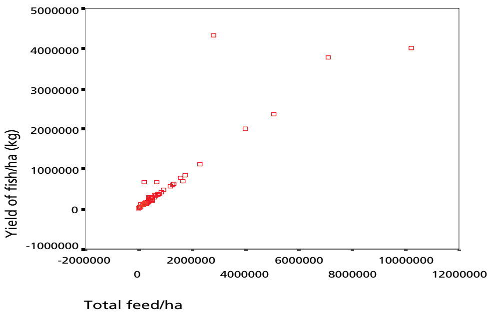


FIGURE 16
Relationship between proportion of farm-made feed to total feed (percent) and fish yield (kg/ha)

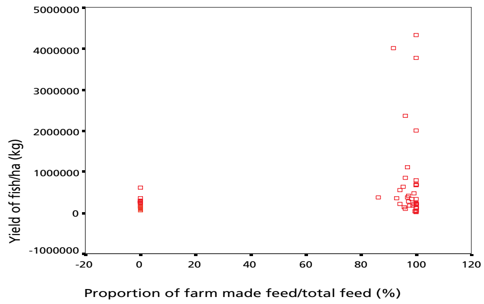


FIGURE 17
Relationship between stocking rate (no. of fish/ha) and fish yield (kg/ha)

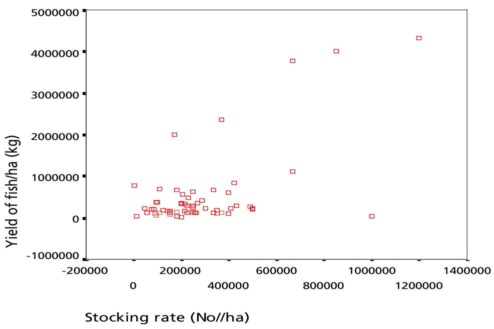


FIGURE 18
Relationship between total fixed costs (US$/ha) and fish yield (kg/ha)

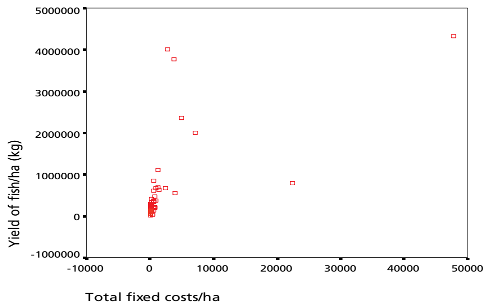


FIGURE 19
Relationship between number of ponds and fish yield (kg/ha)

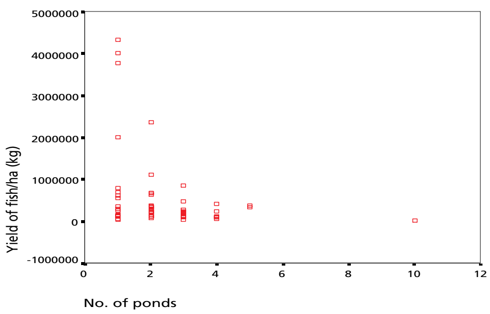
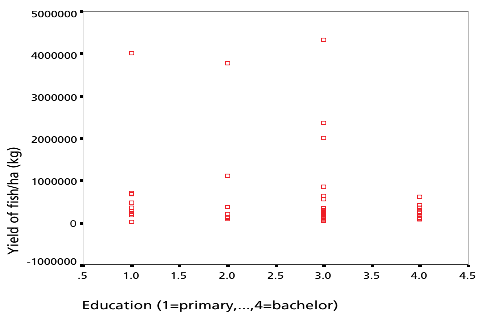


FIGURE 20
Relationship between educational level and fish yield (kg/ha)



4.2 Recommendations

Traditional farm-made feeds are still important to catfish farming due to their low cost and higher net return. However, it is important to assess the environmental impact of continuous use of these feed and to find ways of mitigating the impact of environmental pollution.

It is also important to study the relationship between stocking density and feeding practices in order to improve the profitability.

ACKNOWLEDGEMENTS

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APPENDIX

Appendix A: Multiple regression models

Dependent variable: yield of fish/ha_ln (ENTER METHOD)

Model summary

Model	R	R square	Adjusted R square	Standard error of the estimate
1	0.981	0.962	0.949	0.275

ANOVA

Model		Sum of squares	df	Mean square	F	Level of significance
1	Regression	84.37324	15	5.624883	74.451	0.000
	Residual	3.324264	44	0.075551		
	Total	87.6975	59			

Coefficients

	Unstandardized coefficients		Standardized coefficients	t	Level of significance
	B	Std. Error	Beta		
(Constant)	1.182	0.725		1.631	0.110
Ownership (1= single, 0=shared/joint)	–0.019	0.273	–0.003	–0.070	0.944
No. of ponds_ln	0.220	0.135	0.100	1.621	0.112
Ave. area of a pond_ln	0.073	0.112	0.050	0.651	0.518
Total feed/ha_ln	0.664	0.068	0.687	9.715	0.000
Proportion of farm feed_ln	–0.095	0.031	–0.170	–3.027	0.004
Ave. water depth_dry season_ln	–0.306	0.255	–0.069	–1.197	0.238
Ave. water depth_rainy season_ln	0.374	0.274	0.068	1.364	0.180
Age of the owner_ln	–0.139	0.154	–0.049	–0.902	0.372
Household size_ln	–0.086	0.137	–0.022	–0.625	0.535
Education_ln	–0.197	0.108	–0.079	–1.828	0.074
No. of years in fish farming_ln	0.029	0.060	0.021	0.479	0.634
No. of trainings_ln	–0.066	0.095	–0.023	–0.690	0.494
Stocking rate_ln	0.118	0.035	0.200	3.335	0.002
Total fixed costs/ha_ln	0.343	0.074	0.446	4.617	0.000
Labour costs/ha_ln	0.015	0.069	0.017	0.212	0.833

DEPENDENT VARIABLE: YIELD OF FISH/HA_LN (STEPWISE METHOD)

Model summary

Model	R	R square	Adjusted R square	Standard error of the estimate
1	0.959	0.919	0.918	0.350
2	0.968	0.938	0.936	0.309
3	0.973	0.947	0.944	0.288
4	0.976	0.953	0.949	0.275
5	0.978	0.956	0.951	0.269

ANOVA

Model (step 5)	Sum of squares	df	Mean square	F	Level of significance
Regression	83.803	5	16.761	232.40	0.00
Residual	3.894	54	0.072		
Total	87.698	59			

Coefficients (step 5)	Unstandardized coefficients		Standardized coefficients	t	Level of significance
	B	Std. Error	Beta		
(Constant)	0.743	0.452		1.642	0.106
Total feed/ha_ln	0.710	0.044	0.735	16.082	0.000
Total fixed costs/ha_ln	0.300	0.051	0.390	5.937	0.000
Stocking rate_ln	0.067	0.019	0.114	3.611	0.001
Proportion of farm feed_ln	–0.074	0.023	–0.133	–3.229	0.002
No. of ponds_ln	0.185	0.098	0.084	1.888	0.064

Correlation (step 5)	Total feed/ha_ln	Total fixed costs/ha_ln	Stocking rate_ln	Proportion of farm feed_ln	No. of ponds_ln
Total feed/ha_ln	1	–0.69	–0.32	0.21	–0.22
Total fixed costs/ha_ln	–0.69	1	0.37	–0.62	0.67
Stocking rate_ln	–0.32	0.37	1	–0.11	0.13
Proportion of farm feed_ln	0.21	–0.62	–0.11	1	–0.63
No. of ponds_ln	–0.22	0.67	0.13	–0.63	1

Coefficient correlations

	Labour costs/ha	No. of trainings	Stocking rate	Average depth-rainy	Household size	Education	No. of years in farming	Owner-ship	percent of farm feed	No. of ponds	Age of the owner	Average depth-dry	Average area/ pond	Total feed/ ha	TFC/ha
Labour costs/ha_ln	1	–0.07	–0.10	–0.16	0.04	–0.04	–0.15	–0.01	0.12	0.46	0.04	0.12	0.25	–0.65	–0.02
No. of trainings_ln	–0.07	1	0.10	0.09	0.03	–0.15	–0.23	0.29	–0.21	–0.11	–0.15	–0.20	–0.17	–0.14	0.04
Stocking rate_ln	–0.10	0.10	1	0.28	0.10	–0.44	0.01	–0.09	–0.08	0.11	–0.61	–0.34	0.33	–0.29	0.47
Average water depth_ rainy season_ln	–0.16	0.09	0.28	1	–0.05	–0.21	–0.01	–0.08	–0.13	–0.05	0.07	–0.72	0.15	0.00	0.15
Household size_ln	0.04	0.03	0.10	–0.05	1	–0.10	–0.31	0.30	–0.15	0.04	–0.37	–0.01	–0.14	0.02	–0.02
Education_ln	–0.04	–0.15	–0.44	–0.21	–0.10	1	0.11	–0.18	0.40	–0.12	0.42	0.10	–0.17	0.27	–0.28
No. of years in fish farming_ln	–0.15	–0.23	0.01	–0.01	–0.31	0.11	1	–0.33	–0.01	–0.22	0.06	0.10	0.27	0.17	0.02
Ownership (1=single, 0=shared/joint)	–0.01	0.29	–0.09	–0.08	0.30	–0.18	–0.33	1	–0.37	0.18	–0.32	–0.24	–0.15	–0.09	0.11
Percent of farm feed_ln	0.12	–0.21	–0.08	–0.13	–0.15	0.40	–0.01	–0.37	1	–0.22	0.20	0.09	0.29	0.08	–0.24
No. of ponds_ln	0.46	–0.11	0.11	–0.05	0.04	–0.12	–0.22	0.18	–0.22	1	–0.07	–0.06	0.44	–0.48	0.63
Age of the owner_ln	0.04	–0.15	–0.61	0.07	–0.37	0.42	0.06	–0.32	0.20	–0.07	1	–0.02	–0.09	0.20	–0.22
Average water depth_ dry season_ln	0.12	–0.20	–0.34	–0.72	–0.01	0.10	0.10	–0.24	0.09	–0.06	–0.02	1	–0.19	0.07	–0.24
Average area of a pond_ln	0.25	–0.17	0.33	0.15	–0.14	–0.17	0.27	–0.15	0.29	0.44	–0.09	–0.19	1	–0.31	0.63
Total feed/ha_ln	–0.65	–0.14	–0.29	0.00	0.02	0.27	0.17	–0.09	0.08	–0.48	0.20	0.07	–0.31	1	–0.49
Total fixed costs/ha_ln	–0.02	0.04	0.47	0.15	–0.02	–0.28	0.02	0.11	–0.24	0.63	–0.22	–0.24	0.63	–0.49	1

Covariances

	Labour costs/ha	No. of trainings	Stocking rate	Average depth-rainy	Household size	Education	No. of years in farming	Owner-ship	percent of farm feed	No. of ponds	Age of the owner	Average depth-dry	Average area/ pond	Total feed/ ha	TFC/ha
Labour costs/ha_ln	0.005	0.000	0.000	–0.003	0.000	0.000	–0.001	0.000	0.000	0.004	0.000	0.002	0.002	–0.003	0.000
No. of trainings_ln	0.000	0.009	0.000	0.002	0.000	–0.002	–0.001	0.007	–0.001	–0.001	–0.002	–0.005	–0.002	–0.001	0.000
Stocking rate_ln	0.000	0.000	0.001	0.003	0.001	–0.002	0.000	–0.001	0.000	0.001	–0.003	–0.003	0.001	–0.001	0.001
Average water depth_ rainy season_ln	–0.003	0.002	0.003	0.075	–0.002	–0.006	0.000	–0.006	–0.001	–0.002	0.003	–0.050	0.005	0.000	0.003
Household size_ln	0.000	0.000	0.001	–0.002	0.019	–0.001	–0.003	0.011	–0.001	0.001	–0.008	0.000	–0.002	0.000	0.000
Education_ln	0.000	–0.002	–0.002	–0.006	–0.001	0.012	0.001	–0.005	0.001	–0.002	0.007	0.003	–0.002	0.002	–0.002
No. of years in fish farming_ln	–0.001	–0.001	0.000	0.000	–0.003	0.001	0.004	-0.005	0.000	–0.002	0.001	0.002	0.002	0.001	0.000
Ownership (1=single, 0=shared/joint)	0.000	0.007	–0.001	–0.006	0.011	–0.005	–0.005	0.074	–0.003	0.007	–0.013	–0.017	–0.005	–0.002	0.002
Percent of farm feed_ln	0.000	–0.001	0.000	–0.001	–0.001	0.001	0.000	–0.003	0.001	–0.001	0.001	0.001	0.001	0.000	–0.001
No. of ponds_ln	0.004	–0.001	0.001	–0.002	0.001	–0.002	–0.002	0.007	–0.001	0.018	–0.001	–0.002	0.007	–0.004	0.006
Age of the owner_ln	0.000	–0.002	–0.003	0.003	–0.008	0.007	0.001	–0.013	0.001	–0.001	0.024	–0.001	–0.002	0.002	–0.003
Average water depth_ dry season_ln	0.002	–0.005	–0.003	–0.050	0.000	0.003	0.002	–0.017	0.001	–0.002	–0.001	0.065	–0.005	0.001	–0.005
Average area of a pond_ln	0.002	–0.002	0.001	0.005	–0.002	–0.002	0.002	–0.005	0.001	0.007	–0.002	–0.005	0.013	–0.002	0.005
Total feed/ha_ln	–0.003	–0.001	–0.001	0.000	0.000	0.002	0.001	–0.002	0.000	–0.004	0.002	0.001	–0.002	0.005	–0.002
Total fixed costs/ha_ln	0.000	0.000	0.001	0.003	0.000	–0.002	0.000	0.002	–0.001	0.006	–0.003	–0.005	0.005	–0.002	0.006