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Economics of aquaculture feeding practices in selected Asian countries

Cover photos:
Left top to bottom: Bag feeding method practised in carp farms in Andhra Pradesh, India (courtesy of J.K. Jena). Sea trawlers' bycatch consisting of unwanted small fish, shrimp and squids, mixed with rice bran and minced into a paste to be fed to African catfish raised in earthen ponds in Phuket, Thailand (courtesy of Wing-Keong Ng). Industrially manufactured pelleted feed for sutchi catfish, Bangladesh (courtesy of Nesar Ahmed).
Right: Sun-drying of farm-made aquafeed in Bangladesh (courtesy of Mohammad R. Hasan).

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Improved feed management strategy including the use of optimal combinations of fertilizers, feed ingredients and manufactured feeds has been advocated to be a prioritized area of study for small-scale aquaculture to lower feed cost and to optimize production of aquatic species during different stages of their life cycles. Increased understanding on the economics and cost-benefit analysis of these practices is one of important pre-requisites for development of an improved feed management strategy. With this objective in view, the Aquaculture Management and Conservation Service (FIMA) of the FAO commissioned the implementation of six (6) case studies in selected countries in Asia (Bangladesh, China, India, The Philippines, Thailand and Viet Nam) to have a clear understanding on these practices as a part FIMA's regular work programme on "Study and analysis of feed and nutrients (including fertilizers) for sustainable aquaculture development" under the programme entity "Monitoring, Management and Conservation of Resources for Aquaculture Development". In addition, and as part of the FIMA work programme, a targeted training workshop on "Data processing and analysis on the economic and bioeconomic assessments of aquaculture feeding systems" was organized in Bangkok, Thailand, 25– 27 April 2006 to review and analyze critical issues related to the conduct of appropriate economic assessments of aquaculture feeding systems. The workshop was jointly organized by FIMA of FAO and the Network of Aquaculture Centres in Asia-Pacific (NACA).

Six country case study reports from Asia and a regional synthesis prepared based on six country case studies are included in this document. The manuscripts contained in this technical paper were reviewed and technically edited by Mohammad R. Hasan. English editing was done by Mr. Richard Banks and Tim Huntington of Poseidon. For consistency and conformity, scientific and English common names of fish species were used from FishBase (http://www.fishbase.org/home.htm). Most of the photographs in the manuscripts were provided by the authors. Where this is not the case, due acknowledgements are made to the contributor(s).

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Abstract

This technical paper provides an analysis of the economic implications of, and the reasons for, adopting various feeding practices for different fish species and aquaculture systems in Asia. It comprises of six selected country case study reports from Asia (Bangladesh, China, India, the Philippines, Thailand and Viet Nam) and an overall synthesis ending with conclusions and recommendations.

Field survey for the case studies was carried out between 15 October 2005 and 14 February 2006 and three hundred and fourty Asian fish farmers were interviewed about their fish feeding practices. In India and China selected farmers were engaged in carp polyculture, in Bangladesh and Viet Nam they raised sutchi catfish (*Pangasianodon hypophthalmus*) and pangasiid catfish (*Pangasianodon hypophthalmus* and *Pangasius bocourti*) respectively, in Thailand hybrid catfish (*Clarias gariepinus* x *C. macrocephalus*). In the Philippines those undertaking polyculture of giant freshwater prawn and milkfish participated. Prior to the random selection of farmers each national group of farmers had been stratified according to three broad categories of feeding practices. These were (i) use of industrially produced pelleted feed (intensive farmers), (ii) use of industrial and farm-made feed mixes (semi-intensive), and (iii) use of on-farm feeds consisting of a mixture of locally available feed ingredients (traditional/ extensive). The 340 respondents represent these three feeding categories in about equal proportions, and include 60 farmers by country with the exception of India in which 40 farmers were interviewed.

After completion of the field survey and the preliminary analyses, the researchers involved in the case studies met to agree on methods and an outline for country reports. After agreeing on the methodology and outline of the country reports, the authors of the case studies, for each feeding strategy and farming system, analyzed demographic factors (including age and marital status, education and ownership structure), physical characteristics (average number of ponds and average pond size), and other input features (stocking strategies, feeding practices, types of feed, frequency and intensity of feeding and labour utilization).

The case studies also identified the principal input costs, assessed the economic rates of return (gross and net margins), returns to labour, land and capital, gross and net total factor productivity, break-even prices and production and returns on capital for each feeding strategy. Problem areas were identified for the different farming systems. A statistical analysis using either regression analysis or the Cobb Douglas production function established the existence, or non-existence, for each feeding strategy of the relationships between aquaculture production and or profit as the dependent variable and a number of independent factors.

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ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
BCR	Benefit Cost Ratio
BFAR	Bureau of Fisheries and Aquatic Resources, the Philippines
CNY	Chinese Yuan
Danida	Danish International Development Assistance
DAP	Di-Ammonium Phosphate
FC	Fixed Cost
FCR	Food Conversion Ratio
MAEP	Mymensingh Aquaculture Extension Project, Bangladesh
MOFI	Ministry of Fisheries, Viet Nam
MP	Muriate of Potash
MRD	Mekong River Delta
NGO	Non-Governmental Organization
PCMARD	Philippine Council for Marine and Aquaculture Research and Development
PRA	Participatory Rural Appraisal
SFP	Stochastic Frontier Production
SRS	Stratified Random Sampling
TC	Total Cost
TE	Technical Efficiency
TSP	Triple Super Phosphate
US$	United States Dollar
VC	Variable Cost
VND	Vietnamese Dong

Economics of aquaculture feeding practices: a synthesis of case studies undertaken in six Asian countries

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SUMMARY

Objective of the study: The general objective of the study is to assess the economic implications of, and the reasons for, adopting various feeding practices in aquaculture in Bangladesh, China, India, the Philippines, Thailand and Vietnam.

Methodology: Three categories of feeding practices were studied: extensive/traditional, semi-intensive and intensive through interviews with 340 randomly selected fish farmers. In each of the six countries, with the exception of India, twenty respondents were interviewed for each feeding practice. In India forty farmers were interviewed as only two feeding practices (extensive/traditional and semi-intensive) were studied. The type of species varied by country and included sutchi catfish (*Pangasianodon hypophthalmus*) (Bangladesh), pangasiid catfish (*Pangasianodon hypophthalmus* and *Pangasius bocourti*) (Viet Nam), hybrid catfish (*Clarias gariepinus* x *C. macrocephalus*) (Thailand), carps (India and China), and prawn and milkfish (the Philippines). It should be noted that the analyses and findings presented in this report concern only these species or species-groups and hence do not necessarily reflect economic consequences of feeding practices in other aquaculture sectors in these six countries, or elsewhere in Asia.

Results: production, profitability and feeding regimes. In order to establish the nature and strength of the relationship between feeding practices and economic results the authors of the case studies have estimated and reviewed benefit-cost ratios, break-even prices and break even production.

The combined results of the six case studies do not fully support the hypothesis of a direct relationship between growing intensity of feeding on the one hand and an improving benefit cost ratio (BCR) on the other. The positive relationship between commercial feeding and a relatively high BCR is supported

by the data from Thailand and the Philippines. However, data from Bangladesh and Viet Nam does not support this hypothesis as their best BCR performers are in fact the traditional farms. Data from China and India did not show any conclusive pattern as the BCRs estimated for these two countries do not differ much from one feeding practice to another.

The lower the break-even price, in comparison to the market price, the better off is the producer. In this sense aquaculture farms from Bangladesh and India are the most efficient as their break-even prices are the lowest, expressed as a percentage of the prevailing market or actual prices. The study reveals that aquaculture farms in these two countries can afford to absorb a 43 percent reduction of market prices and still break even. Aquaculture farms based in China, Thailand and the Philippines are somewhat more vulnerable to output price changes than they are in Bangladesh and India. Aquaculture farms in China, Thailand and the Philippines would break even given a 31 to 32 percent reduction in output prices. The most vulnerable farms in terms of output price decrease are those in Viet Nam. They cannot afford to absorb a decrease exceeding 15 percent.

Often farmers gauge their skills and resilience to production failures by comparing the productivity of their ponds with that needed to cover costs (break-even production levels) - the smaller the break-even production as proportion of the production achieved, the better. The estimated break-even production levels per hectare vary widely in absolute figures amongst the farmers interviewed in the six case studies in large part due to the differences of fish species produced. For all farm categories, the study reveals that China yielded the most favorable proportion of break-even production to actual production: 35 percent. This implies that overall production levels in China could fall by up to 65 percent before the average Chinese carp farm reaches its break-even production level. Aquaculture farmers in Bangladesh, India, Thailand and the Philippines likewise performed credibly with break-even proportions of 56, 58, 68 and 69 percent thus achieving production levels which were comfortably above the estimated break-even production levels. The most vulnerable farms in terms of yield fluctuations are those from Viet Nam where the break-even production level is 86 percent indicating that the average Vietnamese catfish farmer produces at only 14 percent above their break-even production level.

In respect of the connection between feeding and economically sound aquaculture the case studies did not reveal a very clear pattern. While data from China, the Philippines and Thailand supports the argument that intensified feeding shall result in more efficient aquaculture farming, data from Bangladesh and Viet Nam demonstrated the reverse, that is, intensified feeding seem to result in less efficient performances. In the case of India no clear pattern emerged.

Results: use of feeds and their cost. The share of feed in total costs varied from a low 25.0 percent in China to a high of 86.5 percent in Viet Nam. For the six case studies combined, cost of feeds accounted for an average of 58 percent, being the largest individual cost item, while fingerling acquisition and labour costs represented 15.5 and 14.4 percent respectively of the total. Overall, combining the results from the 340 farms, variable costs accounted for 94.2 percent of the total cost the remaining 5.8 percent being fixed costs.

In China intensive farms were major users of industrially manufactured feeds. On the average, for the sixty Chinese farms such feeds accounted for 75 percent of the total feed consumption. On aquaculture farms in Bangladesh and the Philippines, respectively, industrial feeds accounted for 54 and 49 percent of total feed consumption. In Thailand, and Viet Nam industrial feeds accounted for 35 percent of the total while India was the least user at only 31 percent. In terms of absolute volume of industrially manufactured feed utilization however, Viet

Nam and Thailand were the largest users while the Philippines and India used the smallest quantities.

Results: what promotes what hinders the use of a feeding strategy? Farmers reported that the most important enabling factors were improved water quality, intensified commercial feeding and increased rate of stocking. While water quality issues can be addressed both on and off the farm, intensified commercial feeding and increased stocking rate can be addressed rapidly if aquaculture farmers have access to cheap credit. According to the analysis, other enabling factors are: effective disease control, better farm management, and improved quality of fry.

Farmers differ in what they consider to be important for increased production according to the feeding strategies they use. Among intensive farmers, improved water quality, disease control and better management are identified as the most important factors. For semi-intensive farms, high stocking of fry, more commercial feeds and improved water quality are priorities. As could be expected, the most important enabling production factor reported by the traditional farmer is intensified commercial feeding.

Regardless of farm category, however, farmers have reported lack of capital to be the most important obstacle to increased aquaculture production. This may not be surprising as easy access to capital is required if farmers are to intensify use of commercial feeds and increase stocking rates.

Intensive (70 percent), semi-intensive (80 percent) and traditional farmers (78 percent) share concerns about the high cost of acquiring commercially or industrially manufactured feeds. While traditional farmers readily recognize the importance of commercial feeding, its high cost per unit has discouraged them from purchasing these types of feeds. Limited technical know-how was also mentioned as a disabling factor.

As many as 92 percent of the respondents say they started fish farming because they expected to make large profits. Farmers using intensive feeding strategies are generally more educated than those using the other two feeding strategies. So, educational attainment appears to be correlated with the feeding practices that farmers adopt.

Recommendations: Four major recommendations are made to stakeholders: (i) consider a larger range of non-economic factors in future economic studies of feeds in aquaculture; (ii) lobby for easy access to credit by small-scale aquaculturists: (iii) governments should design and implement capacity building in farm management; and, (iv) implement action oriented research about the use of farm-made and industrial feeds and devise ways to spread research findings to those concerned.

1. INTRODUCTION

1.1 RATIONALE

Aquaculture today comprises several different types of production systems. Many different practices and technologies co-exist in prevailing production systems. These systems are not static, they change over time. They change as most fish farmers, wishing to make profit, try to optimize their production systems by modifying what they do. Such changes of practices and technologies, e.g. from extensive to intensive feeding strategies, in fact can be seen as a technological innovations at least at the local level

A very important component of any aquaculture production system is the feeding strategy used and the various technologies that this strategy relies on. But different feeding strategies co-exist within the same production system. This fact is common in Asian aquaculture and exemplified in this study. Are these feeding strategies all equally profitable in any one fish production system or do results depend significantly on the surroundings in which they are used?

The six case studies presented in this report are expected to shed light on the extent to which economic considerations drive the use of three feeding practices in six fish farming systems in six Asian countries.

1.2 Objectives of the study

The objective of the study is to assess the economic implications of adopting various feeding practices in aquaculture production in six selected Asian countries.

Specifically, this synthesis report aims to:

(i) review the case study reports on the "Economics of aquaculture feeding practices" that were undertaken in Bangladesh, China, India, the Philippines, Thailand and Viet Nam;

(ii) process and analyse the assembled data to arrive at an integrative comparative analysis of the different farm categories and countries:

(iii) prepare a consolidated report of the six country case studies highlighting the following:

a) production (including feeding) practices,
b) production costs,
c) gross factor productivities or benefit cost ratio;
d) production problems,
e) break-even analyses (break-even price, break-even production), and
f) conclusions and recommendations.

2. GENERAL APPROACH AND METHODOLOGY

2.1 Comparative analysis

The case study provides a comparative analysis of three (3) different categories of feeding systems/practices; namely: (1) extensive/traditional; (2) semi-intensive; and (3) intensive. However, in order to enhance comparability of results obtained in different countries only one fish farming system was studied in each country. Three of these farming systems are polyculture systems, the other monoculture of various types of catfish.

The case study in China focused on polyculture of carps, including silver, bighead, grass, black and crucian carps as well as Wuchang fish. The Bangladesh and Viet Nam case studies specifically focused on the monoculture of sutchi catfish (*Pangasianodon hypophthalmus*) and pangasiid catfish (*Pangasianodon hypophthalmus* and *Pangasius bocourti*), respectively, while the Philippine case assessed the feeding practices used in the polyculture of milkfish (*Chanos chanos*) and giant freshwater prawn (*Macrobrachium rosenbergi*) aquaculture. The case study in India looked at the feeding practices in the polyculture of Indian major carps (catla *Catla catla*, rohu *Labeo rohita*, mrigal *Cirrhinus cirrhosus*), Chinese carps (silver carp, grass carp) and common carp (*Cyprinus carpio*). In Thailand the study concerned monoculture of hybrid clariid catfish (*Clarias gariepinus* and *C. macrocephalus*).

In the context of the study, traditional practice refers to a feeding practice in which the feeds utilized in the fish farms are sourced or developed on-farm or locally and are not being sold or distributed commercially. Fish farms based on traditional feeding practice generally use farm-made aquafeed and/or supplementary diets consisting of a mixture of locally available feed ingredients. Farms with intensive feeding practice depend largely on commercially manufactured pelleted feeds while a semi-intensive category refers to a feeding practice that combines the two with at least 25 percent of either one being utilized. Although the three farming systems in this report and elsewhere are often categorized into traditional, semi-intensive and intensive based on their stocking density and feeding intensity and type of feed, it must noted that intensity of farming and so the feeding intensity vary widely between countries. For example, in the traditional farming in Thailand, which uses locally sourced feed ingredients (e.g., poultry by-products), the fry stocking density is higher and the amount of feed used is much larger than what is commonly found in many other countries of Asia. Similarly, in Viet Nam the stocking density and feeding intensity (i.e., amount of feed) used is similar for three feeding systems (e.g., locally sourced home-made feed, mixture of home-made and pellet feed and industrially manufactured pelleted feed) and consequently stocking density and feeding intensity often are higher than those used in other countries. These differences have to be taken into consideration when anaysing the case studies.

2.2 Assessment indicators

This synthesis assesses the impacts of the various feeding practices in terms of: (i) gross revenues; (ii) gross margin/profit; (iii) net returns; (iv) break-even price levels; (v) break-even production levels; (vi) gross total factor productivity; and (vii) net total productivity. These indicators were estimated based on cost and returns tables derived from survey questionnaires.

2.3 Sampling technique

Each country case study includes three representative feeding practices or systems, with the exception of the Indian carp culture, which only provides an analysis of the semi-intensive and traditional aquaculture farms. Each feeding practice was analysed based on a survey of 20 replicate farms. A total of 60 fish farms represented the sample size for each country case study with the exception of India which had 40 respondents. The stratified random sampling (SRS) technique was utilized in selecting the individual sample farm. The SRS was directly applied on a general listing of fish farms obtained from the study sites of the six countries.

2.4 Data processing and analysis

In general, a tabular analysis was employed to develop the cost and returns tables for the various feeding practices observed in the study sites. The cost and returns analysis indicated the variable cost categories included feeds, fingerlings, fertilizers, labour and other miscellaneous inputs. The fixed costs and capital investments were also determined. Gross revenues and net revenues were also identified. A cross sectional analysis using graphs, percent changes and relative proportions were adopted to determine the relationship of feeding practices with selected impact indicators.

The various authors utilized regression analysis. They applied the Linear Profit Function models, Cobb Douglas Production and Profit Function models and Technical Efficiency analysis to determine the statistical significance and the nature and extent of the relationships between aquaculture production and profit levels as the dependent variables and the factors (independent variables) that would explain their behavior. This synthesis integrates the results of the country level statistical analyses done.

2.5 Scope and duration of the study

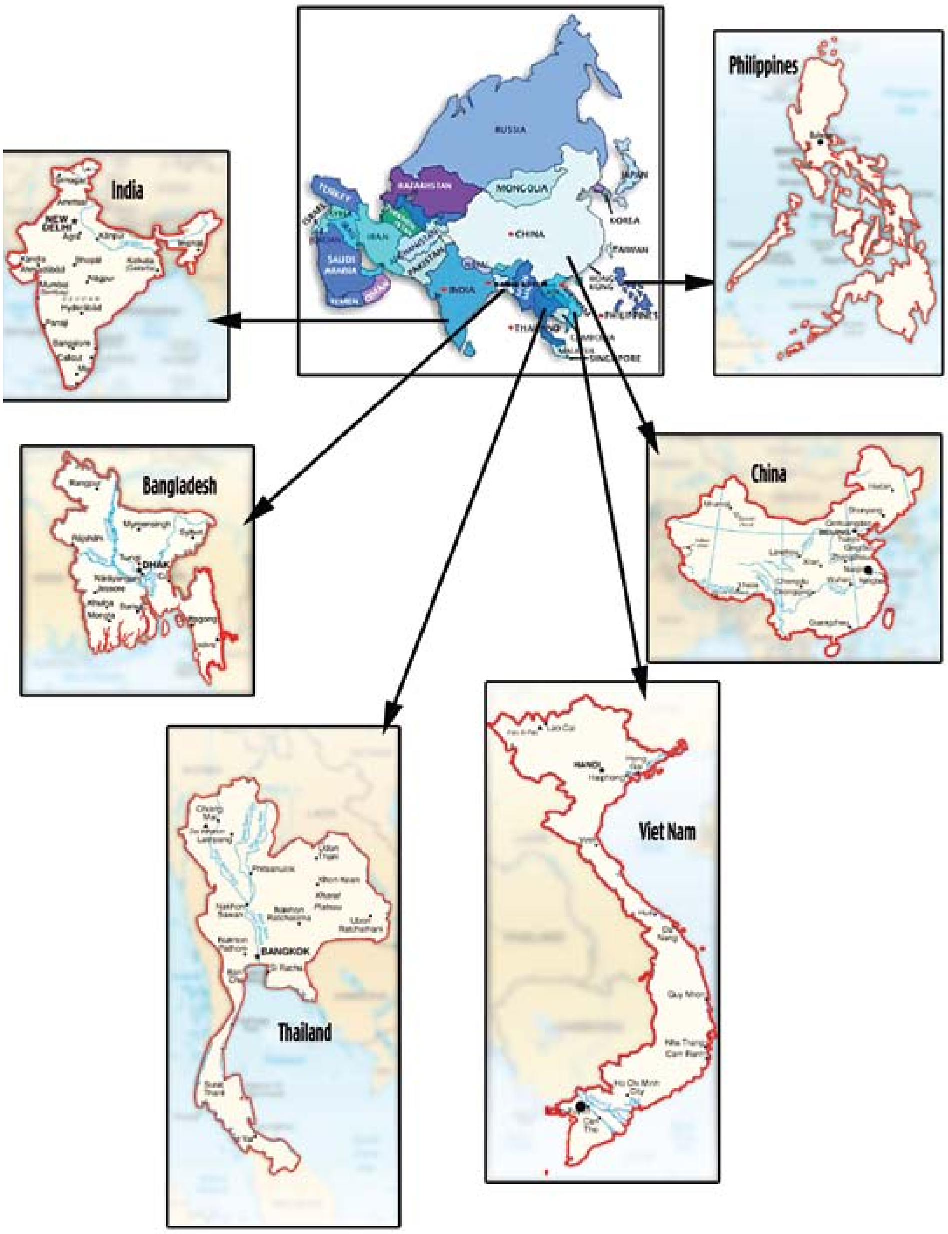
The study was conducted between 15 October 2005 and 14 February 2006. The study sites are indicated in Figure 1. The sample sites included ten counties in the province of Jiangsu in China; municipality of Hagonoy in the province of Bulacan in the Philippines; Bhaluka Upazila, Mymensingh district in Bangladesh; An Guiang Province in Viet Nam; Ludhiana, Gurudaspur, Patiala and Jalandhar districts in Punjab, India; and the provinces of Khon Kaen, Kalasin, Saraburi, Nakorn Sawan, Suphan Buri, and Pathum Thani in Thailand.

3. RESULTS AND DISCUSSION

3.1 Description of the study areas

The study covered six countries in Asia: Bangladesh, China, India, the Philippines, Thailand and Viet Nam. Bhaluka upazila was chosen as the study site in Bangladesh

FIGURE 1
Map of the study sites



being an important area for sutchi catfish aquaculture due its proximity to hatcheries, availability of ponds, low lying agricultural lands, warm climate, abundance of cheap labour and favourable socio-economic conditions. In the case of China, Jiangsu province was selected as the study site due to its long history in aquaculture production. It is known as the cradle land for aquaculture farming in China. The province is located at the lower stream of the Yangtze River and the Huai River. It is rich in natural water resources with a total pond area of 167 000 hectares. The study sites in Thailand are located in six provinces, of which three are located in the central plain region; two are in the north eastern region and one in the northern region. The study site for the Philippine case study is located in the municipality of Hagonoy, Province of Bulacan. The province is located in Region III among the eleven regions of the Government of the Philippines. Of the total aquaculture production of the Philippines, the province of Bulacan accounted for about 5 percent. The study sites in Viet Nam included four districts of An Giang province. This province is located along the branches of Mekong River in Viet Nam. As in China, the study sites have the longest history of catfish culture which started as cage culture during the 1960s. The Mekong River Delta (MRD) in the southern part of Viet Nam covers 12 percent of the total area of the country and has a huge potential for increasing aquaculture production in the country. The MRD comprises approximately 650 000 ha of freshwater bodies; the freshwater surface area potentially expands to 1.7 million has during flooding periods. Ludhiana, Gurudaspur, Patiala and Jalandhar districts in Punjab, India, having major areas of carp aquaculture, were chosen as the study sites.

3.2 Description of the respondents

Respondents have an average age of 46 years. Aquaculture farmer respondents from the Philippines were the oldest at 51 years while those from Bangladesh were the youngest at 39. Respondents representing traditional farms have an average age of 47 years while intensive farm and semi-intensive farm respondents were younger with an average age of 45 and 46 years, respectively (Table 1). Respondents from the traditional farm category have average household size of 5.2 while intensive and semi-intensive farmers reported slightly lower household sizes of 5.0 and 4.8, correspondingly. Respondents from Bangladesh reported the largest household size at about six while China has the smallest household size at 4.4. Philippine respondents have an average household size of 5 while Viet Nam, Thailand and India reported average household sizes of 4.7, 4.6 and 5.7 respectively (Table 2). In terms of aquaculture farming experience, intensive and traditional farm respondents reported being in the profession for about 9 and 8 years, correspondingly. Respondents using semi-intensive feeding practices were slightly more experienced with 10.8 years. Respondents from China and the Philippines were the more experienced with 12.7 and 12.3 years in aquaculture farming while respondents from Thailand and India were less experienced with only 7.3 and 7.9 years of aquaculture farming, respectively (Table 3).

TABLE 1
Average age of respondents by category and country

Country	Farm category			All categories
	Intensive	Semi-intensive	Traditional	
Bangladesh	40	39	38	39
China	49	49	52	50
Philippines	49	52	52	51
Viet Nam	44	46	45	44
Thailand	45	48	46	46
India	*	43	44	44
All countries	45	46	47	46

Note: case study carried out in India did not have intensive feeding practice

TABLE 2
Average household size of respondents by category and country

Country	Farm category			All categories
	Intensive	Semi-intensive	Traditional	
Bangladesh	5.8	5.9	6.0	5.9
China	4.8	3.7	4.7	4.4
Philippines	5.0	5.0	5.0	5.0
Viet Nam	4.4	5.2	4.6	4.7
Thailand	4.9	3.8	5.1	4.6
India	*	5.3	6.1	5.7
All countries	5.0	4.8	5.2	5.1

Note: case study carried out in India did not have intensive feeding practice

TABLE 3
Average years in farming of respondents by category and country

Country	Farm category			All categories
	Intensive	Semi-intensive	Traditional	
Bangladesh	8.3	8.9	7.4	8.2
China	13.7	12.2	12.4	12.7
Philippines	15.0	14.0	8.0	12.3
Viet Nam	3.2	11.8	7.8	7.6
Thailand	4.5	9.6	7.7	7.3
India	*	8.4	7.5	7.9
All countries	8.9	10.8	8.4	9.4

Note: case study carried out in India did not have intensive feeding practice

A majority of the respondents had completed primary (34 percent) and secondary education (38 percent). Only 16 percent had completed tertiary education. Eleven percent of the respondents did not attend primary education (Table 4 and Figure 2). Table 4 also indicates that intensive farmers were more educated than semi-intensive and traditional farmers. Only two percent of intensive farmers did not complete primary education compared with 14 and 18 percent of semi-intensive and traditional farmers, respectively. In addition, 48 percent of intensive farmers completed secondary education compared to 32 and 34 percent for the semi-intensive and traditional farmers, respectively. The above statistics on educational attainment appear to have a degree of correlation with the feeding practices adopted by the respondents. The more formally educated respondents had practised intensive and semi-intensive feeding practices in favour of the traditional method of aquaculture farming.

Aside from aquaculture farming, the respondents also engage in other economic activities particularly agricultural crop production (23 percent) and other business enterprises (7 percent). It is interesting to note that a larger proportion (36 percent) of traditional farmers were simultaneously engaged in agricultural crop production activities compared with semi-intensive (21 percent) and intensive (6 percent) aquaculture farmers (Table 5). These findings suggest that traditional farmers do not solely rely on incomes derived from aquaculture business but tend to augment their incomes by engaging in other economic activities particularly agricultural crop production.

3.3 General profile of the farms

Three hundred of the farmers who participated in this study on the average each used three and one third ponds with a combined area just below three hectares. The forty Indian farmers operated much larger farms. They averaged about 50 ponds with a combined area just above 100 hectares (Table 6).

Excluding the Indian farmers from the analysis, respondents from Thailand used the largest number of ponds – six. They were followed by the Chinese respondents who were operating an average of four ponds. Respondents from Bangladesh had the smallest number of ponds - one.

Again considering only respondents outside India, aquaculture farmers from the Philippines reported the largest combined pond area of 8.77 ha while Bangladesh respondents reported the least at only 0.28 ha. By farm category, intensive farmers reported the largest number of ponds (3.8) while traditional farms had the least at 2.75. Similarly, intensive farms have the largest area for aquaculture production (4.51 ha) compared with semi-intensive (2.41 ha) and traditional farms (2.01 ha).

TABLE 4
Educational attainment of respondents by category and country

Country	Farm category/level of education															All categories				
	Intensive					Semi-intensive					Traditional									
	NE	P	S	T	Total	NE	P	S	T	Total	NE	P	S	T	Total	NE	P	S	T	Total
Bangladesh	0	40	60	0	100	55	35	10	0	100	70	30	0	0	100	42	35	23	0	100
China	0	30	45	25	100	0	35	40	25	100	0	50	40	10	100	0	38	42	20	100
Philippines	10	20	20	50	100	0	25	30	45	100	10	30	35	25	100	7	25	28	40	100
Viet Nam	0	5	95	0	100	30	20	50	0	100	25	15	60	0	100	18	13	68	0	100
Thailand	0	65	20	15	100	0	90	10	0	100	0	75	20	5	100	0	77	17	6	100
India						0	5	50	45	100	0	30	50	20	100	0	18	50	32	100
All	2	32	48	18	100	14	35	32	19	100	18	38	34	10	100	11	34	38	16	100

Note: Case study carried out in India did not have intensive feeding practice; NE = No Education, P = Primary, S = Secondary, T = Tertiary

TABLE 5
Major occupation of the farmers by category of respondents and country

Country	Farm category/type of occupation																		All categories					
	Intensive						Semi-intensive						Traditional											
	F	CP	B	FT	O	Total*	F	CP	B	FT	O	Total*	F	CP	B	FT	O	Total*	F	CP	B	FT	O	Total*
Bangladesh	100	10	30	0	0	140	100	25	10	0	0	135	100	45	5	0	0	150	100	27	15	0	0	142
China	100	10	0	10	5	125	100	35	0	0	5	140	100	35	0	0	0	135	100	27	0	3	3	133
Philippines	100	0	35	0	0	135	100	0	15	0	0	115	100	0	15	0	5	120	100	0	22	0	2	123
Viet Nam	100	8	0	0	25	133	100	15	0	0	0	115	100	20	0	0	0	120	100	14	0	0	8	123
Thailand	100	0	0	0	0	100	100	0	0	0	15	115	100	70	0	0	0	170	100	23	0	0	5	128
India							100	50	5	5	0	160	100	45	0	0	0	145	100	47	3	3	0	100
All	100	6	13	2	6	127	100	21	5	1	3	130	100	36	3	0	1	140	100	23	7	1	3	125

Case study carried out in India did not have intensive feeding practice; Note: F = fish farming, CP = crop production, B = own business, FT = fish trading, O = others

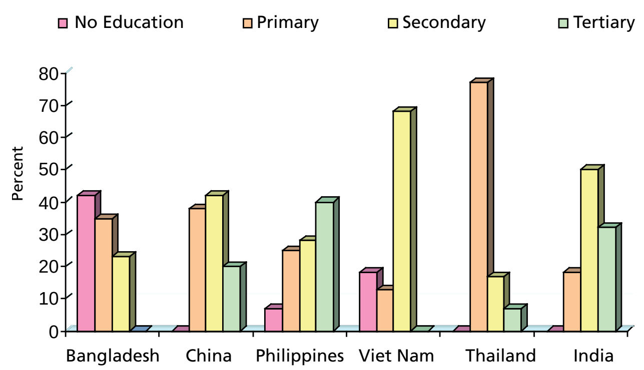
*Total exceeds 100 due to multiple responses

TABLE 6
Total number and area of ponds by farm category and country

Country	Farm category: Intensive – Total number of ponds	Intensive – Total pond area (ha)	Semi-intensive – Total number of ponds	Semi-intensive – Total pond area (ha)	Traditional – Total number of ponds	Traditional – Total pond area (ha)	All categories – Total number of ponds	All categories – Total pond area (ha)
Bangladesh	1.35	0.49	1.05	0.22	1.00	0.12	1.13	0.28
China	2.90	2.70	4.50	2.65	4.85	6.23	4.08	3.86
Philippines	3.95	16.88	2.75	7.28	2.05	2.16	2.92	8.77
Viet Nam	1.95	1.50	2.65	0.69	2.50	0.86	2.37	1.02
Thailand	9.00	0.96	6.10	1.19	3.35	0.68	6.15	0.94
All five	3.83	4.51	3.41	2.41	2.75	2.01	3.33	2.97
India*			64.00	144.70	40.00	67.50	52.00	104.00

*Case study carried out in India did not have intensive feeding practice

FIGURE 2
Educational attainment of respondents by country



The average area of a pond was 1.21 ha, which ranged from a low of 0.15 ha in Thailand to a high of 2.53 ha in the Philippines. Viet Nam and Bangladesh reported an average pond area of less than one hectare while respondents from the India and the Philippines reported respective average pond sizes of 2 and 2.5 ha. Average pond sizes in Bangladesh, India, Viet Nam and the Philippines showed that average pond area increases as the aquaculture farms progress from traditional to intensive feeding practices (Table 7).

Table 8 indicates that single ownership of ponds generally prevails in the study sites (63 percent). The other types of ownership reported were singly leased (26 percent), multiple ownerships (8 percent) and jointly leased (3 percent).

TABLE 7
Average area of ponds and water depth by category of respondents and country

Country	Intensive: Average area of one pond	Intensive: Average water depth (m) Rainy	Intensive: Dry	Semi-intensive: Average area of one pond	Semi-intensive: Average water depth (m) Rainy	Semi-intensive: Dry	Traditional: Average area of one pond	Traditional: Average water depth (m) Rainy	Traditional: Dry	All categories: Average area of one pond	All categories: Average water depth (m) Rainy	All categories: Dry
Bangladesh	0.36	1.83	1.24	0.21	1.54	1.03	0.12	1.65	1.19	0.23	1.67	1.15
China	1.27	2.27	1.88	0.74	2.50	1.89	3.96	2.49	2.01	1.87	2.42	1.93
Philippines	4.18	1.47	0.98	2.38	1.41	0.99	1.02	1.43	0.88	2.53	1.44	0.95
Viet Nam	1.42	3.52	3.18	0.27	3.80	3.33	0.25	3.79	3.19	0.44	3.76	3.23
Thailand	0.12	1.80	1.50	0.11	1.90	1.72	0.23	1.76	1.52	0.15	1.80	1.55
India				2.26	2.17	1.94	1.69	1.68	1.46	2.04	1.94	1.71
All	1.47	2.18	1.76	0.99	2.22	1.82	1.21	2.13	1.71	1.21	2.17	1.75

TABLE 8
Type of pond ownership of respondents by category and country

Country	Farm category/type of ownership															All categories				
	Intensive					Semi-intensive					Traditional									
	SO	MO	SL	JL	Sum	SO	MO	SL	JL	Sum	SO	MO	SL	JL	Sum	SO	MO	SL	JL	Sum
Bangladesh	55	25	20	0	100	75	15	10	0	100	80	20	0	0	100	70	20	10	0	100
China	20	0	80	0	100	25	15	60	0	100	35	5	55	5	100	27	7	65	2	100
Philippines	50	20	20	10	100	75	10	15	0	100	45	10	45	0	100	57	13	27	3	100
Viet Nam	100	0	0	0	100	100	0	0	0	100	100	0	0	0	100	100	0	0	0	100
Thailand	100	0	0	0	100	100	0	0	0	100	35	0	65	0	100	78	0	22	0	100
India*						30	15	35	20	100	65	0	25	10	100	48	7	30	15	100
All	65	9	24	2	100	68	9	20	3	100	60	6	32	2	100	63	8	26	3	100

*Case study carried out in India did not have intensive feeding practice; SO = single ownership, MO= multiple ownership, SL = singly leased, JL = jointly leased

Seventy-two percent of the respondents reported that they use the fish farms exclusively for fish culture while the rest of the respondents were using the fish farms for other purposes. Amongst such purposes are: as the raising of ducks and chickens on the pond dikes in China and washing of clothes and dishes, for bathing and as a source of irrigation water for home gardening in Bangladesh. A higher percentage of intensive farmers (74 percent) used the fish farms exclusively for fish production than did semi-intensive (71 percent) and traditional farmers (68 percent) (Table 9).

TABLE 9
Pond utilization of respondents by category and country

Country	Farm category									All categories		
	Intensive			Semi-intensive			Traditional					
	FC	MP	Total	FC	MP	Total	FC	MP	Total	FC	MP	Total
Bangladesh	70	30	100	40	60	100	5	95	100	38	62	100
China	85	15	100	70	30	100	75	25	100	77	23	100
Philippines	15	85	100	20	80	100	45	55	100	27	73	100
Viet Nam	100	0	100	100	0	100	100	0	100	100	0	100
Thailand	100	0	100	100	0	100	100	0	100	100	0	100
India				95	5	100	80	20	100	88	12	100
All	74	26	100	71	29	100	68	32	100	72	28	100

Note: FC = fish culture only; MP = multipurpose

The major factor considered for engaging in fish farming was the expectation of large profits, as cited by 92 percent of the respondents. This expectation of high profits caused a rapid expansion of catfish pond culture in Viet Nam during the last few years. The dramatic increase in inland aquaculture production in Bangladesh is also a reflection of the expectation of high profits. An average annual growth rate of nearly 20 percent was reported for this activity (Muir, 2003). All respondents from Viet Nam, India and Thailand considered profitability to be the only factor that made them decide to pursue the business while more than 75 percent of the farmer respondents from China, the Philippines and Bangladesh cited the same reason for going into the fish farming business. The other factors considered included access to fish culture technology and availability of fingerlings each reported by 10 percent of farmers (Table 10).

TABLE 10
Main factors considered by farmers in undertaking fish farming country

Factor	Country						
	Bangladesh	China	Philippines	Viet Nam	Thailand	India	All Countries
Profitability	90	78	83	100	100	100	92
Own consumption	8	3	10	0	0	0	4
Access to fish culture technology	0	10	48	0	0	0	10
Feed availability	0	7	15	0	0	0	4
Fingerling availability	2	2	22	33	0	0	10
Total*	100	100	178	133	100	100	118

*Total exceeds 100 percent due to multiple responses, specifically from the Philippines

Table 11 shows the average number and type of farm labourers employed by country and farm category. Irrespective of farm category, an average of 11 workers was employed per farm. China reported the highest number of average fish farm workers at 15 while Philippine respondents employ an average of 12 workers. Viet Nam and Thailand employed the least number of workers at 8. Irrespective of farm category, average employments of full time, part time and occasional labourers were estimated at 2, 3 and 6, respectively. Intensive, semi-intensive and traditional farms generated an average employment of 11, 13 and 10 workers respectively. In general labourers are hired for pond preparation, dike repair, pre-stocking activities, procurement of feeds, feeding and marketing related activities.

3.4 Farm production practices

3.4.1 Stocking strategies

Stocking rates by aquaculture farmers varied by country, fish species and type of farm. Overall, stocking rates are generally higher on intensive and semi-intensive farms than on traditional farms regardless of species. The main reason for these differences in stocking rates by farm category is the relatively better financial capabilities of semi-intensive and intensive farmer. The trend of stocking rates by species in the region did not demonstrate a clear pattern as indicated in Table 12.

TABLE 11
Average number of farm labourers employed by category of respondents and country

Country	Farm category												All categories			
	Intensive				Semi-intensive				Traditional							
	Full-time	Part-time	Occasional	Total	Full-time	Part-time	Occasional	Total	Full-time	Part-time	Occasional	Total	Full-time	Part-time	Occasional	Total
Bangladesh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
China	2	2	6	10	3	3	12	18	3	3	12	18	2	3	10	15
Philippines	3	6	6	13	2	4	11	17	1	2	2	5	2	4	6	12
Viet Nam	2	4	4	10	3	2	4	9	3	2	4	9	2	2	4	8
Thailand	2	4	3	9	4	4	0	8	1	4	4	9	2	4	2	8
India					-	-	-	-	-	-	-	-	-	-	-	
All	2	4	5	11	3	3	7	13	2	3	5	10	2	3	6	11

* Note: India and Bangladesh case studies did not have the data to quantify type of farm labourers employed

TABLE 12
Average stocking rate (no./ha/year) by species, country and farm category

Countries & species	Farm category			All categories
	Intensive	Semi-intensive	Traditional	
Bangladesh				
Pangas	35 900	23 575	12 065	23 847
China				
Grass carp	10 678	5 323	4 553	6 851
Black carp	752	541	441	578
Crucian carp	14 604	16 966	11 039	14 203
Bighead carp	2 393	2 160	1 365	1 973
Wuchang fish	3 145	2 604	2 689	2 813
Silver carp	15 653	5 652	7 285	9 583
Other fishes	2 068	1 414	53	1 178
Philippines				
Milkfish	7 826	4 348	2 923	5 032
Prawn	27 798	26 329	26 500	26 876
Viet Nam				
Hybrid catfish	268 257	278 805	308 783	285 282
Thailand				
Pangasiid catfish	453 546	231 302	266 198	317 015
India*				
Rohu		6 820	6 518	6 669
Catla		2 713	4 179	3 446
Mrigal		6 190	4 607	5 398
Common carp		5 368	3 121	4 203
Silver carp, grass carp, etc.		3 894	2 511	3 202

*Note: Case study carried out in India did not have intensive feeding practice

3.4.2 Stocking strategy/frequency

Regardless of farm category, 65 percent of the respondents practised a single stocking strategy and the remainder adopted multiple stocking. The majority of traditional farmers (78 percent) claimed that they practiced single stocking. On the other hand, single stocking was being practised by 56 and 59 percent of semi-intensive and intensive farmer respondents (Table 13). The data revealed that as aquaculture farming intensified, multiple stocking increasingly became a common practice as farm operators were able to finance stocking and harvesting - particularly the cost of acquisition of fish stocks.

Amongst those undertaking multiple stockings, the most widely practised stocking frequency reported were two (35 percent) and three (51 percent) times a year. Only a small number of farmers reported stocking frequencies of more than 3 times a year. Low stocking frequencies were used largely to reduce the cost of harvesting and for marketing of fish.

TABLE 13
Stocking strategy and frequency by farm category, all countries

Strategy/frequency	Farm category				
	Intensive	Semi-intensive	Traditional	All	Percent
Strategy					
Single stocking	59	68	94	221	65
Multiple stocking	41	52	26	119	35
All	100	120	120	340	100
Frequency					
2x per year	10	23	9	42	35
3x per year	28	23	10	61	51
4x per year	2	6	2	10	9
Continuous	1	0	5	6	5
Total	41	52	26	119	100

3.4.3 Feeding practice

Feeding rates

The average annual feeding rates per hectare by type of feeds are shown in Table 14. Aquaculture farms from China were major users of industrially manufactured feeds accounting for 75 percent of the total feed consumption regardless of farm category (Figure 3). They are followed by aquaculture farms from Bangladesh and the Philippines where industrially manufactured feeds respectively account for 54 and 49 percent. On aquaculture farms in Thailand and Viet Nam the same type of feed accounted for 35 percent of the total while India was the least user at only 31 percent. In terms of absolute volume of industrially manufactured feed utilization however, Viet Nam and Thailand were the largest users while the Philippine and India-based farms were the lowest. Among intensive farms, industrially manufactured feeds were the only feed used except in the Philippines and China. In the Philippines, about 65 percent of the volume of feeds used, were industrially manufactured while in China only 7 percent of total volume of feeds were of farm-made origin and the remaining 93 percent were industrial feeds. It was also noted that semi-intensive farms in Bangladesh resorted to full utilization of farm-made feeds at an average of 13 010 kg per ha per year. On the average, annual feeding rates among traditional farms in Bangladesh per ha were estimated at 2 054 kg of rice bran, 2 071 kg of wheat bran and 1 665 kg of oil cake; for an aggregate annual feeding rate per ha of 5 790 kg. The use of farm-made and supplementary feeds is likewise high on semi-intensive farms in Viet Nam (96 percent), the Philippines (72 percent) and Thailand (67 percent).

Among semi-intensive farms, use of industrially manufactured feeds is dominant in India (74 percent), and China (46 percent). On semi-intensive farms in Viet Nam and in the Philippines industrially manufactured feeds occupy a lower proportion of total feed at 4 and 28 percent, respectively.

Frequency and intensity of feeding

A summary of data on feeding frequency is shown in Table 15. For all farm categories, the most widely practised feeding frequency was "once a day" as reported by 68 percent of the respondents. Feeding frequencies of "more than once a day" and "once or twice a week" were observed by 16 percent and 12 percent of the respondents, respectively, while an irregular feeding frequency was only noted among four (4) percent of the respondents. It is noted that frequency of feeding increases as the fish pond operation becomes more intensive. Only seven percent of traditional farms practised a feeding frequency of "more than once a day" compared with 20 and 21 percent among semi-intensive and intensive farms. These findings may imply that feed management is of least importance among traditional farmers. However, these farmers may be guided by their limited capability to supply the feed more frequently as well as their difficulties in sustaining the larger expenditures associated with an increase in feeding.

3.5 Regional comparative analysis of production costs

3.5.1 All farms

The percentage distribution of aquaculture farm production cost by item for all farm categories are shown in Table 16 and illustrated in Figure 4. Feeds accounted for the largest percentage of the total cost at 58 percent while fingerling acquisition and labour costs represented 15.5 and 14.4 percent of the total, respectively. "Other variable cost" accounted for only 4.9 percent while the cost of fertilizer represented 1.3 percent. Variable costs accounted for 94.2 percent of the total cost while the remaining 5.8 percent are classified as fixed costs. The percentage distribution of feed costs among all farm categories varied from a low 25 percent in China to a high of 86.5 percent in

Viet Nam. In regard to the percentage cost distribution of fry/fingerlings a high of 42.2 percent was noted in China compared to a low 6.2 percent in Bangladesh and Thailand. As a proportion of the total, labour cost has been high in the Philippines (34.2 percent) compared to Viet Nam (0.30 percent). The labour cost in Viet Nam, considering the huge amount of feed handled due to the high feeding rate (as high as 1.47 tonnes/ha/day in some cases), is unusually low and deserve special mention. These statistics illustrate the very important role of feeds in the total cost of production in aquaculture farms. As such, decision-making in terms of the quality and quantity of feed is a major aspect of the production process.

TABLE 14
Feeding rate (kg/ha/year) by type of feeds, farm category and country (as fed basis except for China and the Philippines where feeding rates are shown on dry matter basis)

Country/type of feed	Farm category							
	Intensive	%	Semi-intensive	%	Traditional	%	All	%
Bangladesh								
Industrial feed	22 370	100	0	0	0	0	7 457	54
Farm-made feed	0	0	13 010	100	5 970	100	6 327	46
Total	22 370	100	13 010	100	5 790	100	13 723	100
China								
Industrial feed	14 202	93	3 621	46	0	0	5 941	75
Farm-made feed	1 078	7	4 296	54	1 500	100	1 932	25
Total	15 280	100	7 917	100	1 500	100	7 873	100
Philippines								
Industrial feed	2 950	65	391	28	0	0	1 114	49
Farm-made feed	1 615	35	1 316	72	844	100	1 158	51
Total	4 565	100	1 707	100	844	100	2 272	100
Thailand								
Industrial feed	92 160	100	64 903	33	2 516	2	53 078	35
Farm-made feed	0	0	134 779	67	155 984	98	96 921	65
Total	92 160	100	199 682	100	158 500	100	149 999	100
Viet Nam								
Industrial feed	397 177	100	22 783	4	0	0	139 987	35
Farm-made feed	0	0	507 119	96	270 189	100	259 102	65
Total	397 177	100	529 902	100	270 189	100	399 089	100
India*								
Industrial feed			6 494	74	0	0	3 247	31
Farm-made feed			2 313	26	12 322	100	7 318	69
Total			8 806	100	12 322	100	10 565	100

*Note: Case study carried out in India did not have intensive feeding practice; farm-made feed include feed prepared on-farm as well as supplementary feed consisting of mixture of feed ingredients and/or single feed ingredient.

TABLE 15
Feeding frequency by farm category, all countries

Feeding frequency	Farm category				
	Intensive	Semi-intensive	Traditional	All	Percent
Once a day	55	79	98	232	68
More than once a day	21	24	8	53	16
Once/twice a week	24	15	1	40	12
Irregular feeding	0	2	13	15	4
Total	100	120	120	340	100

Note: The data for intensive feeding included five countries only as India case study did not include intensive feeding practice.

TABLE 16
Relative proportion (in percent) of aquaculture production cost by cost item, all farm category

Cost item	Country						All countries
	Bangladesh	China	India	Philippines	Viet Nam	Thailand	
A. Variable cost							
1. Labour cost	8.1	24.1	14.4	34.2	0.3	5.5	14.4
2. Fertilizer	1.9	0.1	4.8	0.2	0.0	0.6	1.3
3. Fry/fingerlings	6.2	42.2	11.2	15.7	11.4	6.2	15.5
4. Feeds	71.8	25.0	47.0	36.3	86.5	81.4	58.0
5. Miscellaneous			0.3	0.0	0.0	0.2	0.1
6. Other variable/ miscellaneous input costs	5.5	7.6	9.6	2.8	1.5	2.1	4.9
Subtotal	93.7	99.0	87.8	89.2	99.7	96.0	94.2
B. Fixed costs	6.3	1.0	12.2	10.8	0.3	4.0	5.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

FIGURE 3

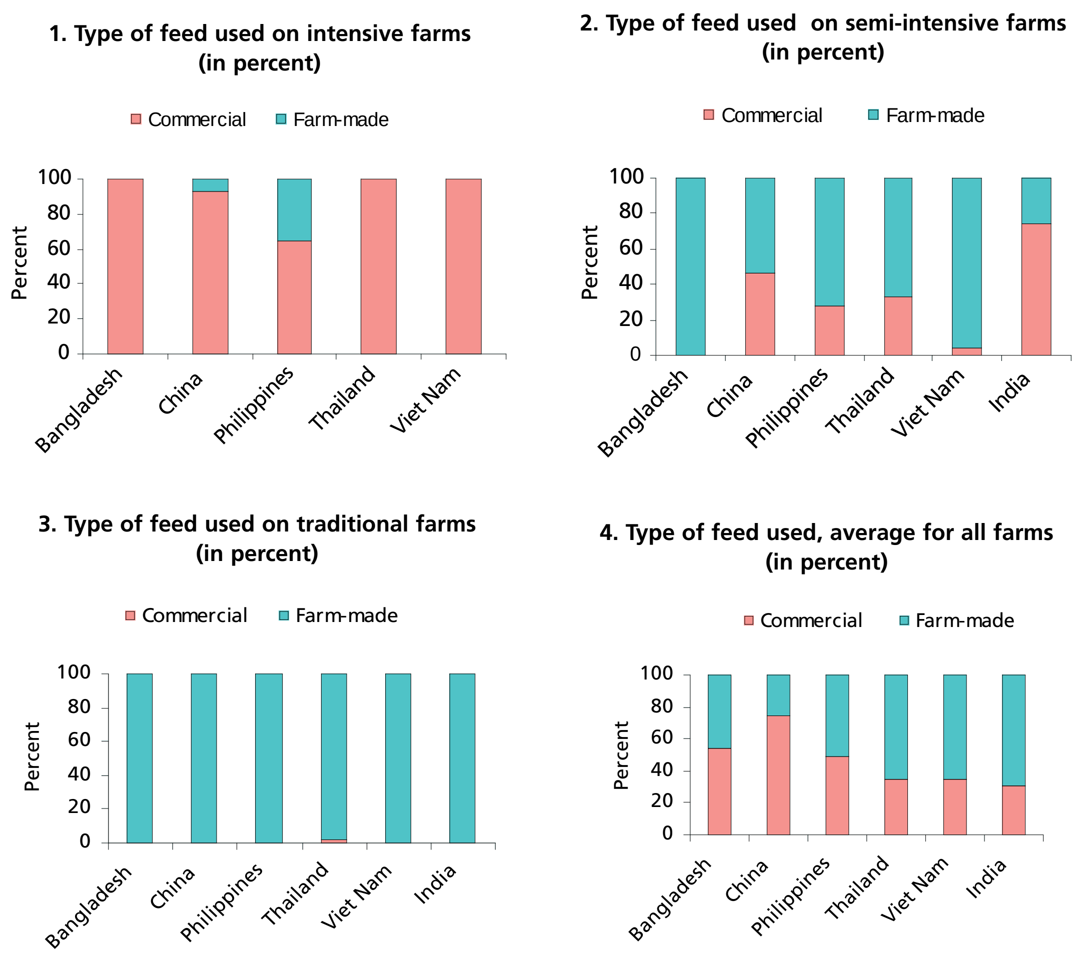
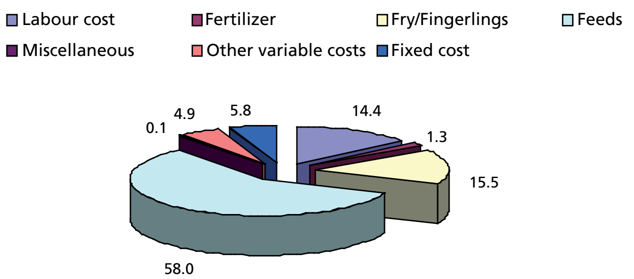


FIGURE 4
Relative proportion (percent) of aquaculture production cost by item, all farm categories and all countries



3.5.2 Intensive farms

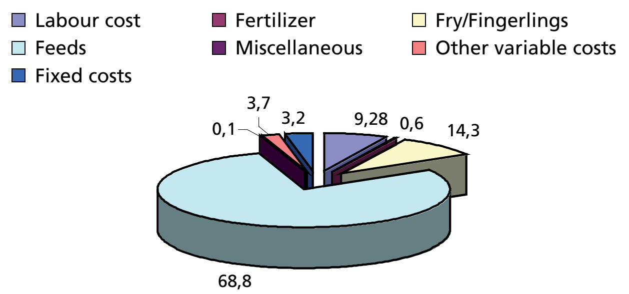
At the regional level, intensive farms have allocated 68.8 percent of the total production budget on feeds alone. Costs of fry/fingerlings and labour respectively accounted for 14.3 and 9.3 percent of the total while fertilizer cost only represented 0.6 percent of the total (Table 17 and Figure 5). These findings indicate that feed cost has been a major cost item among intensive farms and should require careful management. The high proportion of feed costs to total production costs has been particularly noted in Viet Nam, Thailand and Bangladesh. Intensive farms in China and the Philippines have reported relatively lower proportions of feed costs to total production costs. China and the Philippines have invested relatively higher proportions on fry/fingerlings and labour costs. Variable and fixed costs accounted for 96.8 and 3.2 percent of the total costs, correspondingly.

TABLE 17
Relative proportion of aquaculture production cost (in percent) by cost item and country, intensive farms

Cost Item	Country					All countries
	Bangladesh	China	Philippines	Viet Nam	Thailand	
A. Variable cost						
1. Labour cost	6.9	18.8	15.6	0.2	4.8	9.3
2. Fertilizer	2.2	0.2	0.1	0.0	0.5	0.6
3. Fry/fingerlings	5.3	38.7	16.4	6.3	4.6	14.3
4. Feeds	75.8	32.4	56.2	92.5	87.2	68.8
5. Miscellaneous	-	-	-	-	0.2	0.1
6. Other variable/ miscellaneous input costs	4.3	8.8	3.9	0.9	0.8	3.7
Subtotal	94.5	98.9	92.6	99.9	98.0	96.8
B. Fixed costs	5.4	1.1	7.4	0.1	2.0	3.2
Total	100.0	100.0	100.0	100.0	100.0	100.0

Note: Case study carried out in India did not have intensive feeding practice

FIGURE 5
Relative proportion (percent) of aquaculture production cost by item, intensive farms, all countries



3.5.3 Semi-intensive farms

At the regional level, semi-intensive farms have allocated 55.5 percent of the total budget on feed acquisition. This proportion is about 13 percent lower than the share of feed expenditure in intensive farms. Costs of fry/fingerlings and labour among semi-intensive farms have been estimated at 16.7 and 15.8 percentage of the total, respectively. Semi-intensive farms started to confront some financial difficulties and hence lesser proportions are spent on feed. However, variable costs remained very important at 94.5 percent of the total production costs (Table 18 and Figure 6). Over 68 percent of the total costs have been spent on feed by semi-intensive farms in Viet Nam, Thailand and Bangladesh. Semi-intensive farms in China and the Philippines had the least percentage spent on feed at 21 and 28 percent, correspondingly.

TABLE 18
Relative proportion (in percent) of aquaculture production cost by cost item, semi-intensive farms

Cost Item	Country						All countries
	Bangladesh	China	India	Philippines	Viet Nam	Thailand	
A. Variable cost							
1. Labour cost	8.9	25.3	13.9	42.3	0.3	4.3	15.8
2. Fertilizer	2.0	0.1	4.8	0.5	-	0.7	1.5
3. Fry/fingerlings	6.7	45.4	12.1	18.9	11.7	5.8	16.7
4. Feeds	68.8	21.0	47.6	28.4	86.5	81.2	55.5
5. Miscellaneous		-	-	-	-	0.1	0.1
6. Other variable/ miscellaneous input costs	6.5	7.4	9.4	2.8	1.1	3.0	4.9
Subtotal	92.9	99.2	87.3	92.9	99.7	95.0	94.5
B. Fixed costs	6.9	0.8	12.7	7.1	0.3	5.0	5.5
Total	100	100	100	100	100	100	100.0

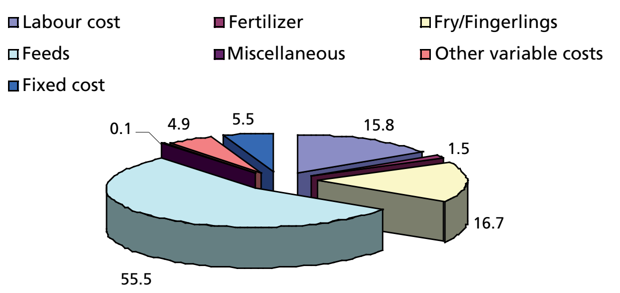
3.5.4 Traditional farms

The cost of feeds on traditional farms has been estimated at 45.2 percent of total production costs. Among the three farm categories this is, not unexpectedly, the lowest share. The second most important cost item among traditional farmers is labour which accounted for 21.6 percent of the total. A moderate percentage proportion of 18.4 percent has been defrayed on purchases of fry/fingerlings. Part of the cost of labour is for unpaid family labour. The time spent by family labour has been monetized in the analysis. So the relatively higher use of family labour among traditional farms may imply that they are low on cash. The proportion of labour costs among traditional farms in the Philippines and China have been respectively estimated at 56.5 and 36.9 percent, respectively (Table 19 and Figure 7).

TABLE 19
Relative proportion of aquaculture production cost (in percent) by cost item, traditional farms

Cost Item	Country						All countries
	Bangladesh	China	India	Philippines	Viet Nam	Thailand	
A. Variable cost							
1. Labour cost	12.6	36.9	14.9	56.5	0.3	8.6	21.6
2. Fertilizer	0.5	-	4.8	-	-	0.8	1.1
3. Fry/fingerlings	9.5	47.0	10.4	12.1	21.7	9.6	18.4
4. Feeds	58.5	10.7	46.4	11.2	73.6	72.2	45.2
5. Miscellaneous	0.0	-	0.6	-	-	0.3	0.4
6. Other variable/ miscellaneous input costs	9.7	4.7	9.9	1.0	3.7	3.0	5.4
Subtotal	91.0	99.3	88.4	80.8	99.3	94.3	92.1
B. Fixed costs	9.0	0.7	11.6	19.2	0.7	5.7	7.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	99.8

FIGURE 6
Relative proportion (percent) of aquaculture production cost by item, semi-intensive farms, all countries



3.6 Regional comparative analysis of economic indicators

3.6.1 Gross factor productivities (benefit cost ratio)

The region-wide summary of gross factor productivities or benefit cost ratios (BCRs) by country and farm categories is shown in Table 20. The region-wide average benefit-cost ratio for all farm categories has been estimated at 1.59 which implies an income of US$1.59 for a dollar of expenditure in aquaculture production. BCR estimates were highest among intensive farms (1.70) and lowest among traditional farms (1.46) which indicates that in general and throughout the region all three (3) farm categories have been able to generate benefits from their investments in aquaculture production. High BCRs were recorded for the average aquaculture farms in both the Philippines and Bangladesh. Viet Nam and China reported the lowest BCRs at 1.22 and 1.34, respectively.

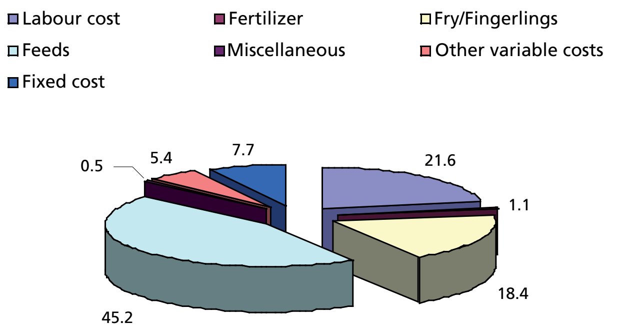
The best performers among intensive farms are those based in the Philippines (2.66) and Thailand (1.71). Among semi-intensive farms high BCRs of 2.01, 1.81 and 1.76 are respectively generated by aquaculture farms from the Philippines, India and Bangladesh. In the case of traditional farms, Bangladesh has recorded the highest BCR of 2.12 while India has provided a respectable BCR of 1.75. The Philippine based traditional farms only were able to break even.

The findings at the regional level do not fully establish the direct relationship between intensified feeding practice and the BCR coefficient. The positive relationship has been supported by the data from Thailand and the Philippines. However, data from Bangladesh and Viet Nam did not support this hypothesis as their best BCR performers are the traditional farms. Data from China and India were inconclusive as BCRs estimated for these two countries under different feeding practices were very similar. It is interesting to note that while the individual country reports indicate relatively low absolute incomes among traditional farms, their high BCR values imply that their low cost of production makes them viable.

3.6.2 Break-even prices

The break-even price measures the price level(s) by which an enterprise is able to recover its production costs. For most farms the break-even price level lower than the actual prices received for fish and thus can be expressed as a proportion, or percentage, of the latter. Break-even prices were calculated based on a combined average of prices for all species produced on the farms[1].

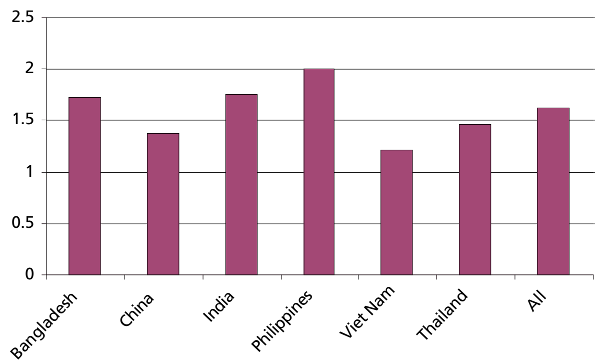
FIGURE 7
Relative proportion (percent) of aquaculture production cost by item, traditional farms, all countries



The performance of the farmers by farm category and by country can be assessed by examining the proportion of the market price that corresponds to the estimated break-even price. A comparison of break-even prices relative to actual prices is presented in Table 21 and Figures 10–13.

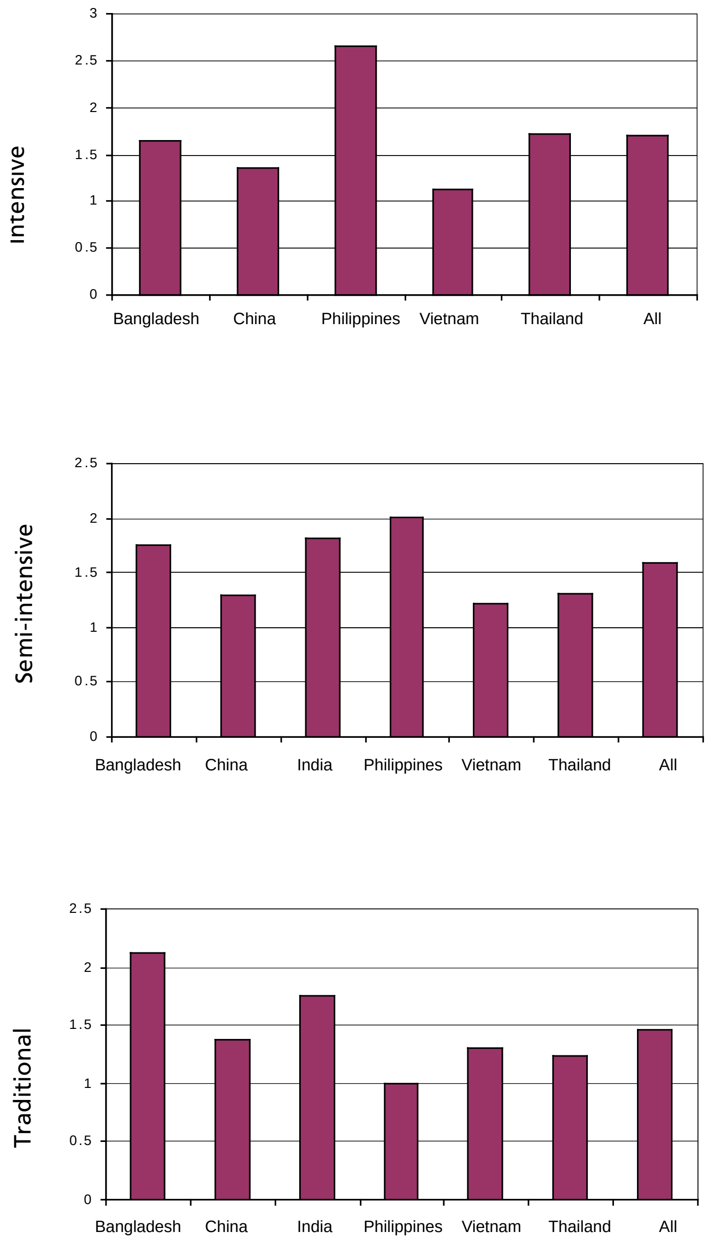
The overall break-even price level for all countries was estimated at US$0.53 per kg which amounts to 67 percent of the actual market price of US$0.78 per kg. The break-even prices recorded by aquaculture farms in Bangladesh and India appeared to be the most efficient of those studied. In these two countries they amount to only 57 percent of the market price. Likewise aquaculture farms in China, Thailand and the Philippine appear to be less vulnerable to output price changes given that their respective break-even prices amount to about 68 and 69 percent of prevailing market prices. Viet Nam is the least performer. For the average Vietnamese fish farmer in this study the break-even price (at 85 percent) is just below the market price. These price relationships indicate that aquaculture farms in Bangladesh can afford to absorb a 43 percent reduction in market prices and still break even. Aquaculture farms from China, Thailand and the Philippines can still break even if

FIGURE 8
Benefit cost ratios: all farm categories



1 In order to facilitate comparisons authors used one currency for both inputs and outputs. Local currencies were converted into their US$ equivalents.

FIGURE 9
Benefit cost ratios by country



exposed to a 31-32 percent reduction in output prices. The most vulnerable farmers in terms of output price decreases were those from Viet Nam who can only afford to absorb a 15 percent output price decrease and still break even.

Considering intensive farms only, the estimated break-even price was US$0.54/kg, and the observed average market price was US$0.84/kg. This break-even price represents 65 percent of the actual market price. These figures imply that on the average intensive farms can absorb significant price changes and still achieve profitability. Looking at intensive farms by country the result is almost the same. The exception is farms in Viet Nam. In Viet Nam the break even price was only 9 percent below the market price. However, in general intensive farms in the region can absorb even a significant reduction in their output prices.

In the case of semi-intensive farms, the break-even price at US$ 0.55/kg was almost identical to that recorded for intensive farmers, while the average market price was considerably lower at US$ 0.76/kg. This implies that the situation of semi-intensive farmers is somewhat worse than that of intensive farmers, the break-even price reaching 72 percent of the market price.

But the situation varied considerably amongst the semi-intensive farms. Farms in India and Bangladesh were well off recording break-even prices amounting to as little as 55and 57 percent, respectively of market prices. The semi-intensive farms most vulnerable to output price fluctuations were those in Viet Nam and China where farms would just cover costs if output prices rose by 17 and 19 percent respectively.

While traditional farmers achieved as high prices for their fish (US$ 0.75/kg) as did farmers using semi-intensive feeding strategies, their costs per kg produced were higher reaching US$ 0.59/kg. This means the average traditional farmer could afford a drop in fish prices of 23 percent and still cover his costs. The study thus indicates that the traditional farms were more vulnerable to decreases in output prices than either intensive or semi-intensive aquaculture farms. But, differences amongst countries are large. If fish prices were to fall generally for fish from traditional farms the least affected would be farms in Bangladesh for which the break-even price reaches only 47 percent of the market price. The most vulnerable traditional farms are those based in the Philippines where fish prices have to increase for farmers to break even.

Overall, the 100 farmers using intensive feeding strategies seem more able to cover their costs than do the 120 using semi-intensive feeding strategies. These in turn appear better at this than do the 120 farmers using traditional feeding strategies. While this is true when comparing these three groups it is not always true when making this same comparison on a case study basis. While the 20 intensive farms based in the Philippines and the 20 intensive farms in Thailand have stronger break-even price structure then do their co-nationals who use semi-intensive and traditional feeding practices, traditional farmers in Bangladesh, China and Viet Nam have a better break-even price situation than their compatriots using more modern feeding practices.

TABLE 21
Comparative analysis of actual price and break-even price by country, all species (US$/kg)

Country	Category									All categories		
	Intensive			Semi-intensive			Traditional					
	Actual price	Break-even price	Proportion of break-even with actual price (%)	Actual price	Break-even price	Proportion of break-even with actual price (%)	Actual price	Break-even price	Proportion of break-even with actual price (%)	Actual price	Break-even price	Proportion of break-even with actual price (%)
Bangladesh	0.62	0.37	60	0.62	0.35	57	0.62	0.29	47	0.62	0.35	57
China	1.11	0.73	66	0.98	0.79	81	1.02	0.61	60	1.04	0.71	68
Philippines	0.93	0.51	55	0.94	0.72	77	0.95	1.22	128	0.93	0.64	69
Viet Nam	0.66	0.60	91	0.54	0.45	83	0.56	0.42	75	0.59	0.50	85
Thailand	0.88	0.51	58	0.75	0.57	76	0.67	0.55	82	0.79	0.54	68
India*				0.74	0.41	55	0.72	0.42	58	0.73	0.42	57
All Countries	0.84	0.54	65	0.76	0.55	72	0.76	0.59	77	0.78	0.53	67

* Note: India did not have intensive feeding practice in its study sites

3.6.3 Break-even production

The break- production level is the volume of production needed to recover total production costs at the prevailing output prices. A comparative analysis of break-even production levels by country and feeding strategy is presented in Table 22 and Figure 14.

The estimated break-even production levels per hectare for each country vary widely in absolute figures due to the differences in size and metabolisms of the farmed fish species. Comparing farmers in the six countries, without considering fish feeding strategies, the study reveals that Chinese farmers were most successful as 35 percent actual production would enable the average farmer to break even. This implies that the overall current aquaculture production levels in China could fall by up to 65 percent before the average farm reaches a break-even production level. Aquaculture farmers from India, Bangladesh, Thailand and the Philippines likewise performed credibly having break-even production levels of 56, 58, 68 and 69 percent. All are production levels that are comfortably above estimated break-even production. The most vulnerable farms in terms of yield fluctuations are those in Viet Nam as their production volumes on the average are only 14 percent above break-even volumes.

The results differ somewhat when each of the three feeding strategies is analyzed separately. However, Chinese farmers remain the most secure. The intensive, semi-intensive and traditional farms in China have break-even production levels well below 50 percent of recorded production volumes (respectively 29 and 43 and 44 percent). Amongst other groups of farmers (see table 22) only traditional farmers in Bangladesh reach a similar level (47 percent). The most exposed and probably least efficient farms are the traditional farms in the Philippines. In fact, these farms are unlikely to continue for long unless economic and/or technical conditions change as recorded production levels were below break-even volumes.

FIGURE 10
Actual and break-even prices of all farm categories by country

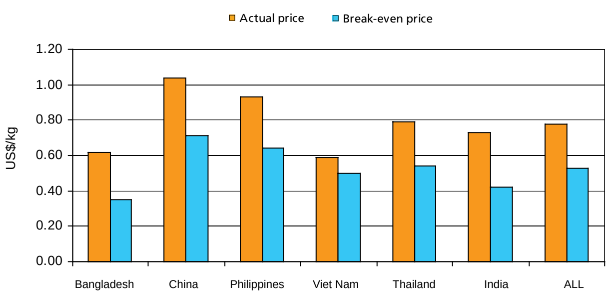
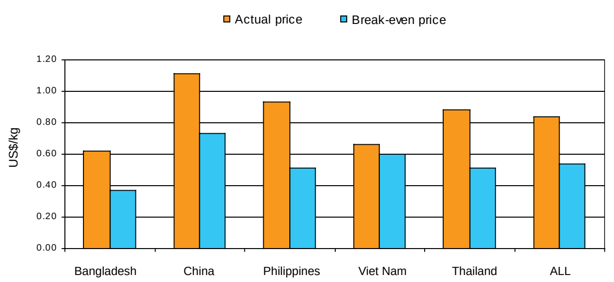


FIGURE 11
Actual and break-even prices of intensive farm category by country



Among intensive farms, only the Viet Nam-based farms can be considered as highly vulnerable to significant drops in their production levels. Intensive farms in the other five countries exhibited production levels showing significant margins to break-even production implying that they are capable of handling also drastic reductions in production.

In regards to semi-intensive farms, those in China, India and Bangladesh can afford to absorb significant reductions in productivity levels and still break even, while farms in Philippines and Thailand can not afford to lower their production levels by more than 24 percent. It is not only in the Philippines that traditional farmers are vulnerable to downward fluctuations in production. This also applies in Thailand (break-even production amounting to 81 percent of production) and Viet Nam (77 percent).

A review of break-even production data from the six countries and the three feeding strategies does not exhibit a clear pattern. On the one hand, data from China, Thailand and the Philippines supports the argument that intensified feeding shall result in more efficient aquaculture farming in this case illustrated by large production volumes relative to break-even estimates. On the other hand, data from Bangladesh and Viet Nam demonstrate the reverse - intensified feeding result in less efficient performances.

3.7 Production problems

3.7.1 Enabling production factors

The respondents cited several factors that contribute to efficient aquaculture production. The most important enabling factors and reported by about 25 percent of the 340 respondents were good water quality, intensified feeding with commercially manufactured feeds, and, high rates of stocking (Table 23). While water quality issues can be addressed both on and off the farm, increased use of commercial manufactured feeds and higher stocking rates often require that farmers have access to cheap credit. Other factors which farmers reported would contribute to efficient production were: effective disease control (23 percent of respondents), better management (19 percent), and use of good quality fish fry (13 percent).

Among intensive farmers, improved water quality (31 percent), disease control (28 percent) and better management (19 percent) are identified as the most important factors in any strategy intending to in increase productivity. In particular, Chinese farmers have reported their inability to focus on these factors as their major problem. For semi-intensive farmers, higher stocking rates for fry, more commercial feeds and improved water quality are their priorities for increasing aquaculture production. These problems have been more pronounced in Viet Nam and China. As perhaps could be expected, amongst traditional farmers as many as 35 percent of respondents reported that the most important enabling production factor is intensified commercial feeding. This is a likely consequence of the fact that the average traditional aquaculture farmer lacks the

FIGURE 12
Actual and break-even prices of semi-intensive farm category by country

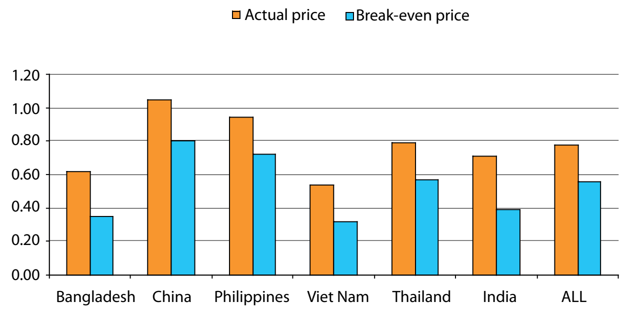


FIGURE 13
Actual and break-even prices of traditional farm category by country

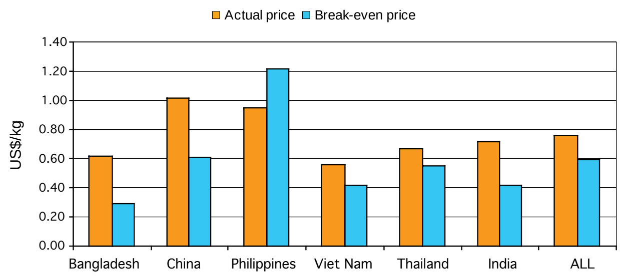


FIGURE 14
Proportion (in percent) of break-even production to actual production by farm category and country

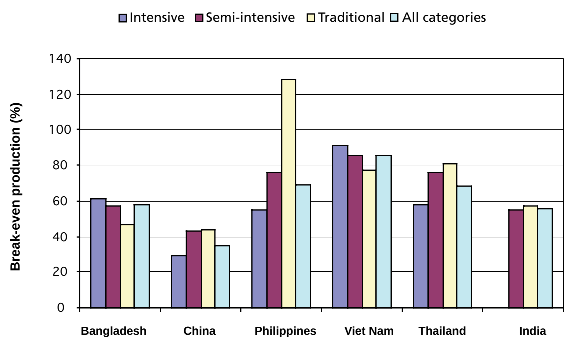


TABLE 22
Comparative analysis of actual production and break-even production (kg/ha/year) by country and farm category

Country	Category									All categories		
	Intensive			Semi-intensive			Traditional					
	Actual production (A)	Break-even production (B)	% of B to A	Actual production (A)	Break-even production (B)	% of B to A	Actual production (A)	Break-even production (B)	% of B to A	Actual production (A)	Break-even production (B)	% of B to A
Bangladesh	13 945	8 478	61	7 705	4 377	57	3 380	1 593	47	8 343	4 816	58
China	38 251	11 085	29	16 111	6 891	43	9 343	4 132	44	21 235	7 369	35
Philippines	3 012	1 669	55	882	674	76	578	742	128	1 491	1 027	69
Viet Nam	240 199	218 749	91	243 887	210 913	86	157 452	121 128	77	213 846	183 596	86
Thailand	108 943	63 457	58	82 904	63 280	76	62 182	50 633	81	84 676	57 895	68
India*	-	-	-	5 699	3 151	55	5 853	3 353	57	5 772	3 252	56

*Note: Case study carried out in India did not have intensive feeding practice

TABLE 23
Enabling factors to increase production by farm category, all countries

Enabling factor	Farm category							
	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
More commercial feeds	16	20	27	34	28	35	71	30
High stocking of fry	13	16	29	36	22	28	64	27
Quality fry	13	16	14	18	5	6	32	13
Better management	19	24	16	20	10	13	45	19
Disease control	22	28	15	19	17	21	54	23
Improved water quality	31	39	25	31	26	33	82	34

Analysis only included data from China, the Philippines, Thailand and Viet Nam financial capacity to purchase commercial feeds. Region-wide, one third of traditional farmers also consider that improved water quality would contribute much to enhance their production. This is a problem common to all farm categories.

3.7.2 Disabling production factors

Table 24 summarizes information on disabling factors, that is those factors that create obstacles for farmers who want to increase production. Irrespective of the feeding strategy one quarter of the farmers reported that lack of capital was the most important obstacle to increased aquaculture production. It is clear that without access to capital farmers will not be able to improve their production by using commercial feeds and increased stocking rates. The second largest obstacle for the 240 respondents is limited technical know-how. Almost one of every five farmers considered their relative technical ignorance as a disabling factor.

The importance of obstacles is not much changed when looked at by country or by feeding strategy. But, again, perhaps not unexpectedly, lack of capital was reported more frequently as an obstacle among traditional farmers (43 percent) than among farmers using more sophisticated feeding strategies. In respect of technical knowledge the situation is reverse. It is more common that farmers using intensive feeding strategies find that they are lacking in technical know-how (21 percent) than that the traditional farmer does so (15 percent). Poor market facilities have discouraged 5, 15, and 18 percent of the intensive, semi-intensive and traditional aquaculture farms respectively, to increase their aquaculture production.

3.7.3 Other problems

The high cost of commercially/industrially manufactured feeds is a major concern among all farm categories as reported by 61 percent of the respondents (Table 25). Intensive (58 percent), semi-intensive (64 percent) and traditional farmers (62 percent) share such concerns. While traditional farmers readily recognized the importance of commercial feeding, its high cost per given unit prevented them from purchasing these types of feeds. Likewise it appears that the high cost of feeds has made both intensive and semi-intensive farmers decide not to buy optimum quantities.

As generally is the case farmers (in this case 55 percent of all respondents) have the view that low prices for cultured fish prevent them from achieving higher returns (Table 26). This problem has been consistently cited by respondents, and seem to be a particular concern of those who live in the Philippines, China and Bangladesh. High cost of transportation, poor market facilities and intermediary influence are considered minor marketing problems by all respondents.

TABLE 24
Disabling factors to increase production by farm category, all countries

Disabling factor	Farm category							
	Intensive		Semi-intensive		Traditional		All	
	No.	%	No.	%	No.	%	No.	%
Lack of capital	11	14	14	18	34	43	59	25
Limited seed availability	1	1	3	4	7	9	11	5
Limited feed availability	0	0	1	1	4	5	5	2
Limited fertilizer	1	1	4	5	5	6	10	4
Poor market facility	4	5	12	15	14	18	30	13
Limited knowledge	17	21	14	18	12	15	43	18
Poor water quality	9	11	4	5	0	0	13	5

Analysis only included data from China, the Philippines, Thailand and Viet Nam

TABLE 25
Problems concerning industrially manufactured feeds by farm category, all countries

Problem	Farm category							
	Intensive		Semi-intensive		Traditional		All	
	No.	%	No.	%	No.	%	No.	%
High price	58	58	64	64	62	62	184	61
Procurement/availability	22	22	5	5	6	6	33	11
Affects small fishes	0	0	2	2	5	5	7	2

Analysis only included data from Bangladesh, China, the Philippines, Thailand and Viet Nam

TABLE 26
Constraints in aquaculture marketing by category of respondents, all countries

Problems/constraints	Farm category							
	Intensive		Semi-intensive		Traditional		All	
	No.	%	No.	%	No.	%	No.	%
Low product price	48	60	39	49	46	58	133	55
High transport costs	5	6	7	9	7	9	19	8
Poor market facilities	9	11	5	6	2	3	16	7
Intermediary influence	5	6	5	6	5	6	15	6

Analysis only included data from Bangladesh, China, the Philippines and Thailand.

3.8 Statistical analysis

Table 27 provides a summary of the results of the statistical analysis by country. The statistical analysis establishes the existence or non existence of the relationships between aquaculture production and or profit as the dependent variables and the factors that affect their behavior such as feed cost, labour cost, stocking rate, survival rate, and fertilizer cost as the independent variables. The table also includes regression coefficients which measure the nature and extent of relationships between these variables.

Each country author selected a regression model based on which model provided the “best fit” in terms of the values of F and R^2. High R^2 values, for instance, imply that the variation in the dependent variable is largely explained by the independent variables (called predictors in the regression model). In addition the standardized coefficient (*Beta*) provides a measure of the direction (sign) and extent (value) of the effect of a predictor on the dependent variable. The table likewise shows the existence and or non existence of each predictor at a given level of significance.

The Cobb Douglas Production Function was used in Bangladesh, Viet Nam, India and Thailand while the Profit Function models were utilized in China and the Philippines. In addition authors of the China report provided an analysis of the technical efficiency of aquaculture production. Except for the Bangladesh case, where the model was run for each aquaculture farm category, the other country papers report on the results of regression analysis for all farm categories combined. The Thailand model used a dummy variable (Di) to indicate the impact of management by using farm category as the indicator.

Results of the statistical analysis shows a low adjusted R^2 value of 0.54 in India implying that the predictors included in the Indian model accounted for only 54 percent in the variation of the dependent variable. Results of the statistical analysis in the other countries indicated high adjusted R^2 values ranging from 0.800 to 0.995 suggesting that the predictors included in their models have largely (e.g. at least 87 percent) explained the behavior of the aquaculture production or gross profit/income. Likewise the values of the F statistic for all the models are at least significant at 5 percent level.

Results from the Bangladesh study indicated that among intensive farms, size of the farm, stocking cost, and feed cost yielded highly significant t values. However, the signs of the beta coefficients for stocking, fertilizer cost and feed cost are negative which would run counter with theoretical expectations. In the case of semi-intensive farms, the beta coefficients for the above variables yielded positive signs and are consistent with theoretical expectations. Among intensive Bangladesh farms, farm size was the only important predictor of aquaculture production both in terms of the sign and value of the beta coefficient as well as the value of t which is significant at 5 percent level. The regression results suggest that increasing farm size by one (1) percent can contribute 0.68 percent to an increase in output. Among semi-intensive farms, farm size, stocking cost, feed cost, and fertilizer cost, yielded positive beta coefficients whose t values are significant at 1 to 5 percent levels. In addition the values of the beta coefficients of 0.12 to 0.39 implying that these predictors significantly influence the increase in output of the semi-intensive aquaculture farms in Bangladesh. It is also interesting to note that since the sum of the beta coefficients (bi's) is greater than 1 (one), it suggests that the function exhibits increasing returns to scale, that is if a all the predictors are increased by one (1) percent, aquaculture output would increase by more than one (1) percent. In the case of traditional farms, farm size, stocking cost, feed cost, and fertilizer cost, likewise yielded positive beta coefficients whose t values are significant at 5 to 10 percent levels. It is interesting to point out that feed cost and seed cost are the most important predictor of output behavior among traditional aquaculture farms in Bangladesh.

Results of the statistical analysis in Viet Nam suggests that feed quantity, fixed cost, stocking rate, farm feed to total feed ratio, and number of ponds are excellent predictors of aquaculture output variation as exhibited by signs of the beta coefficients and t values that are significant at 1 to 5 percent levels. Among the predictors, feed quantity had the highest value at 0.735. This finding supports the hypothesis that intensified feeding shall result in increased aquaculture production.

Results of the statistical analysis from Thailand yielded consistent signs of the beta coefficients whose t values for feed cost, seed cost, labour cost, survival rate are all significant at one (1) percent level. The most important predictors in terms of the value of the beta coefficients are survival rate (b=0.71) and seed cost (b=0.55). Labour and feed cost can be considered as moderate predictors of aquaculture production in Thailand. Fertilizer cost, fuel cost and size of the fingerling yielded theoretically correct signs of the beta coefficients but did not pass the test of significance.

Results of the regression analysis using a profit function in China identifies feed cost as a significant predictor of profit in aquaculture production given its high beta coefficient of 0.594. Seed cost was also a major explanatory variable of aquaculture profit with a beta coefficient of 0.394 while labour cost has a relatively lower coefficient. These variables have t values that are significant at one (1) percent level. Fertilizer cost, training days and educational level provided insignificant values of their respective t statistics. Aside from the profit function, the China study likewise provided a technical efficiency analysis using the general stochastic frontier production function to express the relationship between inputs and aquaculture output. The results indicate that all the cost items had significant effects on aquaculture productivity in China. In addition, pond number, average water area and experience in fish farming are positively correlated with technical efficiency of production while pond size, average pond water depth, marital status, family size, education, and training had negative relationships with technical efficiency. By farm category, the highest average technical efficiency was reported in intensive fish farms at 0.82, while the lowest was estimated in semi-intensive fish farms at 0.769. Traditional or extensive fish farms had a technical efficiency coefficient of 0.8. The variations in technical efficiencies by farm groups have been related to feed management efficiency.

The regression results of the profit function model in the Philippines tried to explain the variation in aquaculture profits using the variables such as stocking rate, recovery or survival rate and total feed cost. Results of the analysis indicate that stocking rate was the most important predictor of aquaculture profit based on a very high value of its beta coefficient at 0.924. Recovery rate yielded a relatively lower beta coefficient at 0.225. The t values of these predictors are significant at 1 to 5 percent levels. Feed cost has a theoretically correct sign of coefficient but failed to pass the test of significance.

Results derived from applying the Cobb Douglas profit function model to the data from Indian farms indicate that the t values of cost of feeds and the cost of organic fertilizer as predictors of gross revenues are statistically significant at 1 percent level. Likewise cost of feeds yielded a high beta coefficient of 0.494 while a beta coefficient of 0.319 has been estimated for the cost of organic fertilizer. These imply the relative importance of feeds and organic fertilizer as major factors for profitability of carp farms in India.

The statistical analyses in the six study sites were all based on best fit models, which allow identification of the various predictors of profit and production. In general, the important predictors were labour cost, feed cost, feeding rate, stocking rate, recovery or survival rate, and fertilizer cost. This suggests that projects or programs aimed at enhancing productivity and profit should focus on the above mentioned variables as the major points of intervention. The results also imply that technical efficiencies can be addressed by enhancing the feed management capabilities of aquaculture farms.

TABLE 27
Summary of results of statistical analysis by country

Country/variable name	Regression model	Adjusted R^2	F value	Level of significance (%)	Standardized coefficient (*B*)	t-value	Level of significance (%)
Bangladesh							
Intensive farms		0.995		5			
Y-intercept	Cobb-Douglas production power function				2.37	na	1
Farm size					0.681	na	5
Stocking cost			1 696.06		-0.081	na	5
Feed cost					-0.191	na	1
Fertilizer cost					-0.169	na	10
Labour cost					0.58	na	NS
Semi-intensive farms		0.926	1 934.80	5			
Y-intercept					3.125	na	1
Farm size					0.391	na	1
Stocking cost					0.382	na	1
Feed cost					0.231	na	1
Fertilizer cost					0.115	na	5
Percent cost					0.092	na	NS
Traditional farms		0.993	1 433.82	1			
Y-intercept					2.58	na	1
Farm size					0.284	na	10
Stocking cost					0.557	na	5
Feed cost					0.365	na	5
Fertilizer cost					0.434	na	5
Labour cost					0.041	na	NS
China		0.882	102.6	1			
Y-intercept	Profit function					0.449	5
Labour cost					0.182	3.592	1
Seed cost					0.370	6.908	1
Feed cost					0.607	11.163	1

TABLE 27
Continued

Country/variable name	Regression model	Adjusted R^2	F value	Level of significance (%)	Standardized coefficient (B)	t-value	Level of significance (%)
Fertilizer cost					0.047	0.980	NS
Age					-0.121	-2.436	5
Educational level					-0.006	-0.111	NS
Training days					-0.016	-0.328	NS
Philippines		0.869	46.32	1			
Y-intercept	Profit function					-2.829	1
Stocking rate/seed					0.924	7.586	1
Recovery rate					0.225	2.250	5
Total feed cost					0.163	1.595	NS
Viet Nam	Cobb-Douglas production function	0.951	232.4	1			
Y-intercept						1.642	NS
Feed quantity					0.735	16.082	1
Fixed costs					0.390	5.937	1
Stocking rate					0.114	3.611	1
Farm-made feed/total feed ratio					-0.133	-3.229	1
Number of ponds					0.084	1.888	5
Thailand		0.800	40.971	1			
Y-intercept	Cobb-Douglas production function		27.214		2.5204	2.9887	1
Feed cost					0.2359	3.4714	1
Fertilizer cost					0.0743	1.9305	NS
Fingerling/seed cost					0.4865	7.4956	1
Fuel cost					-0.0069	-0.876	NS
Labour cost					0.2715	2.6570	1
Fingerling size					0.0750	0.4654	NS
Survival rate					0.7078	5.9571	1
D1 (Dummy variable)					0.5325	3.2510	1
D2 (Dummy variable)					0.4375	2.8990	1
India		0.538					
Y-intercept						4.002	1
Cost of labour					-0.107	-0.917	NS
Cost of inorganic fertilizer	Cobb-Douglas profit function				0.138	1.148	NS
Cost of organic fertilizer					0.319	2.661	1
Cost of fingerlings					0.082	0.560	NS
Cost of feed					0.580	4.157	1
Cost of electricity/fuel					0.059	0.494	NS
Other variable cost except electricity/fuel					-0.014	-0.115	NS

NS = not significant; na = not analysed

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

The expectation of large profits had caused most of the respondents to start fish farming and this irrespective of the culture systems and feeding regimes that they use. There is no clear link between any of the three feeding regimes and the demographic characteristics of respondents with one exception: farmers with higher educational attainment use industrially manufactured feeds more often than do farmers with less education.

High benefit cost ratios were not found exclusively among intensive farms in response to intensive feeding regimes but were also identified among farm-made feed users in traditional and semi-intensive practices in Bangladesh and Viet Nam. Break-even price indicators pointed to a high degree of efficiency on farms in Bangladesh and India followed by China, Thailand and the Philippines. Break-even production coefficients identified farmers in China, India and Bangladesh as the most efficient. However, no matter how measured the farming systems used in Viet Nam were found to be the least efficient.

As is usually the case stocking rates were generally highest among intensive farms, moderate among semi-intensive farms and lowest among traditional farms. In Chinese carp farms industrially manufactured feeds accounted for a larger proportion of feeds used than in any of the other culture systems studied. However, farms in Viet Nam and Thailand used larger quantities of industrial feeds, measured in absolute terms, than did respondents in the other four countries.

The share of feed in total costs varied from a low 25 percent in China to a high of 86.5 percent in Vietnam. As an average for all culture systems and feeding regimes feeds accounted for more than half (58 percent) of total input costs. Taken together purchases of fingerlings and wages to farm worker accounted for about one third of the total. Variable costs accounted for 94.2 percent of the total cost the remaining 5.8 percent being fixed costs. Variable costs account for a remarkably high proportion of the total. In part this has come about as many farmers have managed to initiate the culture systems reviewed in this study without having to construct ponds. They have used already existing structures.

Farmers reported that to improve operations the most important factors are improved water quality, intensified commercial feeding and increased rate of stocking. According to the analysis, other enabling factors are: effective disease control, better farm management, and improved quality control. Regardless of farm category, lack of capital was reported to be the greatest obstacle to increased aquaculture production. In respect of feeding strategies, the surveys show that industrially manufactured feeds would be much more common on the farms if they were less expensive.

As ex-farm prices generally are not within the control of the respondents, feed cost, feeding rate, stocking rate, recovery or survival rate, and fertilizer cost are the most important determinants of the outcome of their fish farming. This suggests that projects or programs aimed at enhancing productivity and profit in the studied farming systems should focus on the above mentioned variables. The results also imply that technical efficiencies can be addressed by enhancing the feed management capabilities of fish farmers.

4.2 Recommendations

Four key recommendations have been derived. They are addressed to governments, industry, farmer organizations, research and development organizations and development agencies. The recommendations are as follows:

1. Non-economic variables (such as water quality and seed quality) should be explicitly considered in future economic studies of fish feeding practices.
2. Lobby for the provision of credit assistance tailored to the circumstances of small-scale fish farmers using traditional and semi-intensive feeding practices.
3. Urge relevant government agencies to implement capacity building programmes in farm management with particular emphasis on feeding rates, stocking density and fingerling survival.
4. Urge governments to implement area specific, action-research types of programs that integrate institutional-technical and socio-economic aspects of fish farming and include post harvest and marketing aspects. The purpose of such programmes

is to devise effective ways to make to farmers benefit from innovation including those concerning farm-made and/or commercially manufactured feeds.

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Economics of aquaculture feeding practices: Bangladesh

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SUMMARY

This case study was conducted to assess the economics of sutchi catfish, *Pangasianodon hypophthalmus* (locally known as pangas) monoculture in Bhaluka *upazila* (sub-district), Mymensingh, a district of north-central Bangladesh. The analysis examined three different categories of feeding practice: (1) intensive, (2) semi-intensive, and (3) traditional.

Fish farms based on traditional feeding practice use supplementary diets consisting of a mixture of locally available feed ingredients. Farms with intensive feeding practice depend solely on commercially manufactured pelleted feeds while the semi-intensive category refers to the feeding practice of using farm-made aquafeed. A total of 60 fish farms (20 from each feeding practice) were surveyed via interviews using a structured questionnaire and the Rapid Rural Appraisal method. The stratified random sampling technique was used in selecting the sample farms.

Based on the survey of 60 farmers from three different feeding practices, the average area of pangas pond was 0.23 ha, varying from 0.12 ha in traditional farms to 0.21 ha in semi-intensive and 0.36 ha in intensive farms. In general, the culture period is typically 9 to 12 months. The majority of fish farmers stocked their ponds from as early as March to May and harvested their fish at least after 3 months and the multiple stocking and the staggered harvesting were practised at similar intervals until the end of the year. The average annual stocking density of fingerlings for intensive, semi-intensive and traditional farms were estimated at 35 900, 23 575 and 12 065 per ha, respectively. On average, the quantity of feed used per ha per annum were 22 370 kg, 13 010 kg and 5 790 kg in intensive, semi-intensive and traditional feeding practices, respectively. Survey results showed that almost all intensive and semi-intensive farmers used fertilizers (mainly cow dung, urea and triple super phosphate) at varying frequencies and rates. The highest average annual production of pangas per ha was calculated in intensive farming (13 945 kg), as compared with semi-intensive (7 705 kg), and traditional (3 380 kg). The difference in fish yields was attributed to the differences in farm size, feed and seed inputs as well as management skill.

Feed costs generally constitute the highest single operational cost, accounting for 76 percent, 69 percent and 59 percent of total costs in intensive, semi-intensive and traditional feeding practices, respectively. Although all farmers in the three different feeding practices made profits, considerable variation in production costs and profitability was observed in the different feeding practices. The total costs of pangas farming of all sample farmers averaged US$2 964 per ha per year, varying from US$5 217 in intensive farming to US$2 694 in semi-intensive and US$981 in traditional farming. Despite higher production costs per ha, the average annual net return was higher in intensive farming (US$3 364) compared with semi-intensive (US$2 048) and traditional farming (US$1 099). The higher profits were as a result of higher production. The highest average gross margin per ha was found in intensive farms (US$3 649) compared with semi-intensive (US$2 235) and traditional (US$1 188) farms. The Cobb-Douglas production function model indicates that there is enough scope to increase the production and income from pangas farms in semi-intensive and traditional feeding practices by applying more seed, feed and fertilizer. However, intensive feeding exhibits decreasing return to scale.

The commercially manufactured pelleted feed is the most effective way to cultivate fish, although feed costs are extremely high. However, statistical analysis indicated that inputs are inefficiently used in intensive feeding. The highest benefit-cost ratio is found in traditional feeding at 2.12, compared with 1.76 in semi-intensive and 1.64 in intensive feeding. It is therefore suggested that the semi-intensive system may be preferable with the option of decreasing production costs by using farm-made quality feed in order to increase profits. Thus, development of feed based on low-cost locally produced ingredients would help improve farmer's declining profit margins. In addition, training and extension services would help to improve profitability and reduce risks. Most of the poor framers (traditional farmers) reported that higher production costs as well as lack of money was the most important constraint for pangas farming. Thus, adequate bank credits with low interest would provide the basis for a change in practices from traditional to semi-intensive feeding.

1. INTRODUCTION

1.1 Rationale

Aquaculture production comprises different systems depending upon the applied level of technology. 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.

Farmers' adoption of technology such as industrially produced complete feed for aquaculture production result in higher outputs, higher costs and improved financial returns. Other farmers may be constrained through factors such as a lack of capital or a lack in education, and will adopt lower cost input systems including traditional or semi intensive farming. The proposed case study is expected to shed light on the economics of the various feeding practices as applied in Bangladesh. The case study provides a comparative analysis of three different categories of feeding practices, namely: (1) intensive, (2) semi-Intensive, and (3) traditional.

1.2 Aquaculture in Bangladesh

Over the last decade, there has been a dramatic increase in inland aquaculture production, an average annual growth rate of nearly 20 percent (Muir, 2003). Around 400 000 ha of freshwater ponds and more than 900 000 households are involved in aquaculture (ADB, 2005). Conditions are highly favourable for the rapid expansion of aquaculture, as the quantity of seed produced has risen rapidly in recent years. The total fish production in Bangladesh was estimated at 2.21 million tonnes in 2004–05[1] of which 0.88 million tonnes were obtained from closed-water culture fisheries, contribution about 40 percent of the total fish production (DoF, 2006). Value added from aquaculture was estimated to total US$643 million. Pond carp polyculture accounts for 80 percent of the total freshwater aquaculture production in Bangladesh. The remaining 20 percent were mainly from pangas and tilapia culture and integrated rice-fish farming (ADB, 2005). A current focus is on promoting pangas farming with important local food supply benefits, and increasing income of the poor farmers.

With the increasing demand for food fish and the decline in capture fisheries production (currently 39 percent of the total fish production), pangas monoculture in Bangladesh is heading towards intensification. This shift from low density to high density culture i.e. traditional to semi-intensive or intensive culture is consequently leading to an unprecedented rise in the demand for feeds over and above other inputs (fingerlings, fertilizers). The success of intensive and semi-intensive fish culture depends to a large extent on the application of suitable feeds. Because faster growth rates and higher returns on capital, farmers are gradually shifting from farm-made aquafeed, to industrially manufactured pelleted feed. However, the main constraints to expansion in uptake are lack of money and inadequate technical knowledge.

Sutchi catfish (*Pangasianodon hypophthalmus*) is an indigenous fish species of Thailand, living in the Mekong River (Roberts and Vidthayanon, 1991). This species is particularly important for their fast growth, lucrative size and high market demand. This species can also be stocked at a much higher density in ponds compared to other cultivable species. It was introduced in Bangladesh from Thailand in 1989 (Banglapedia, 2006) and has become an important source of food fish for the country. Pangas farming began in Bhaluka *upazila*[2], Mymensingh, in 1998.

1.3 Objectives of the study

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

Specifically, the case study is aimed at:

(i) conducting a survey of three feeding practices in sixty (60) aquaculture farms, twenty (20) per category;

(ii) processing and analysing the data to arrive at a comparative analysis of the farms highlighting the following:
- a) general profile,
- b) production (including feeding) practices,
- c) production problems,
- d) production costs (fixed investment as well as maintenance and operating costs),
- e) income (gross margin and net margin/return),
- f) returns on investments (labour, land and capital),
- g) break-even analyses (break-even price and production), and
- h) recommendations;

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

[1] Bangladesh fiscal year: 1 July –30 June

[2] An *upazila* is an administrative government unit in Bangladesh consisting of unions, each of which consists of a number of villages.

2. GENERAL APPROACH AND METHODOLOGY

2.1 Comparative analysis

To minimize variation in terms of fish species being produced, a comparative analysis of various feeding practices was undertaken for the same species in the country. The species and aquaculture system selected for Bangladesh was monoculture of sutchi catfish, *P. hypophthalmus,* henceforth referred to as pangas.

In the context of the study, traditional systems refers to a feeding practice where the feeds utilized in the fish farms are sourced or developed locally and are not sold or distributed commercially. Fish farms based on traditional feeding practice generally use supplementary diets consisting of mixture of locally available feed ingredients such as rice bran, wheat bran or oil cake. Farms with intensive feeding practice depend solely on commercially manufactured pelleted feeds while a semi-intensive category refers to a feeding practice using on farm-made aquafeed which comprises rice bran, wheat bran, oil cake, fishmeal, flour, dried fish, oyster shell, salt and vitamins.

2.2 Assessment indicators

The case study assessed the impacts of the various feeding practices in terms of: (i) gross margin, (ii) net margin/return, (iii) benefit cost ratio (BCR), (iv) returns on investment, (v) returns to labour and land, (vi) break-even price coefficients and (vii) break-even production coefficients. The basis of estimating the above indicators were cost and earnings tables developed from the questionnaire results.

2.3 Sampling technique

The case study represent examination of three feeding practices in the three different aquaculture farm systems: traditional, semi intensive and intensive. A total of 60 fish farms were surveyed. Sample farms comprised 20 farms in each feeding practice. The selection technique of stratified random sampling[3] (SRS) was used to select the farms using the following approach:

Step 1: A listing of fish farms was collated for Bhaluka *upazila* (subdistrict), Mymensingh, derived from data provided by the Department of Fisheries (DoF) and relevant non-government organizations (NGOs).

Step 2: The country author in association with government fisheries officers and/or members of existing farmers association, identified the different farming systems used.

Step 3: From a sublisting of the categorized fish farms, 20 farms were selected at random from each category. Sixty farms were identified for analysis.

2.4 Data processing and analysis

Tabular analyses were used to develop the costs and returns tables for the various feeding practices observed in the study area. The costs and returns analysis contained the variable cost items: fingerlings, feeds, fertilizers, labour and miscellaneous. The fixed costs and capital investments such as depreciation (i.e. water pump, net and feeding machines), permanent staff salary including caretaker and guard, land use cost (or lease money) and interest on operating capital were also determined. Farm gross revenues were also identified based on farm-gate prices of harvested fish and current local market prices. A cross sectional analysis using graphs and percentage changes are used to determine the differences between the feeding practices.

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[3] A stratified sample is one obtained by separating the population elements into non-overlapping groups, called strata, and then selecting a sample from each stratum (Scheaffer *et al*., 1990). Arens and Loebbecke (1981) noted that stratification is used for most common reason is that reduces the sample size needed to achieve a desired level of precision and reliability.

Multiple regression analyses using economic and bioeconomic models relating to gross revenue derived from pangas production was undertaken. Regression runs comprised the profit function related to gross revenue and input and output prices. Likewise bioeconomic models relating gross revenue with economic variables (e.g. input and output prices) and non-economic variables (e.g. stocking rates, quantity of feeds and size of ponds) were analysed to determine the existence of statistical relationships.

2.5 Scope and duration of the study

The case study was conducted for a period of four months from 15 October 2005 to 15 February 2006. A total of 60 farmers were analysed where 20 respondents were interviewed for each of the three feeding categories. General descriptions of some of the activities are indicated as follows:

2.5.1 Background information

A literature review was undertaken to establish the aquaculture feed management practices used in the country and sector's contribution to the economic development of the fishery sector in general and the aquaculture sector in particular. This section also includes a discussion on the background information of the selected area under study.

2.5.2 Rapid appraisal of the survey area

The SRS was validated using participatory rapid rural appraisal (RRA) in order to substantiate the authenticity of the farms identified for survey. This also insured consistency in the type of species produced by the respondents so as to allow meaningful comparative analysis. RRA was undertaken using local officials from the relevant government and private organizations.

2.5.3 Finalization of draft questionnaire

Part of the rapid appraisal activity was used to validate the survey questionnaire approach in six test farms; two from each feeding practice. This led to redesigning the questionnaire to suit the field conditions in the study area.

2.5.4 Field survey

The field survey of 60 farms was undertaken based on the revised questionnaire over a period of seven weeks.

2.5.5 Data processing and analysis

Collected data were coded and entered into a Microsoft Excel database. Some data were collected in local units such as *bigha*[4], *maund*[5] due to familiarity for respondents. These were converted into international units before transfer to computer. SPSS (Statistical Package for Social Science) was used to analyse the data.

2.6 Limitations/problems encountered

The following problems and difficulties were noted during the survey work:

1. A significant amount of effort had to be devoted to convincing the respondents as to the legitimacy of the survey.
2. The respondents suspected the interviewees were acting as agents for the tax office, police department or other government agency.

[4] A unit of land is equivalent to 0.13 ha in the study area.
[5] A unit of weight measure equivalent to approximately 37.4 kg.

3. Most farmers and associated groups did not keep records of income and expenditure. Even if some farmers provided financial data, this was based on their best estimates. Extra attention had to be paid to validating financial information using different data collection methods (i.e. questionnaire interviews, RRA and cross-check interviews with key informants).

The interviewers had to have on hand support from DoF fisheries inspectors before commencing the survey work.

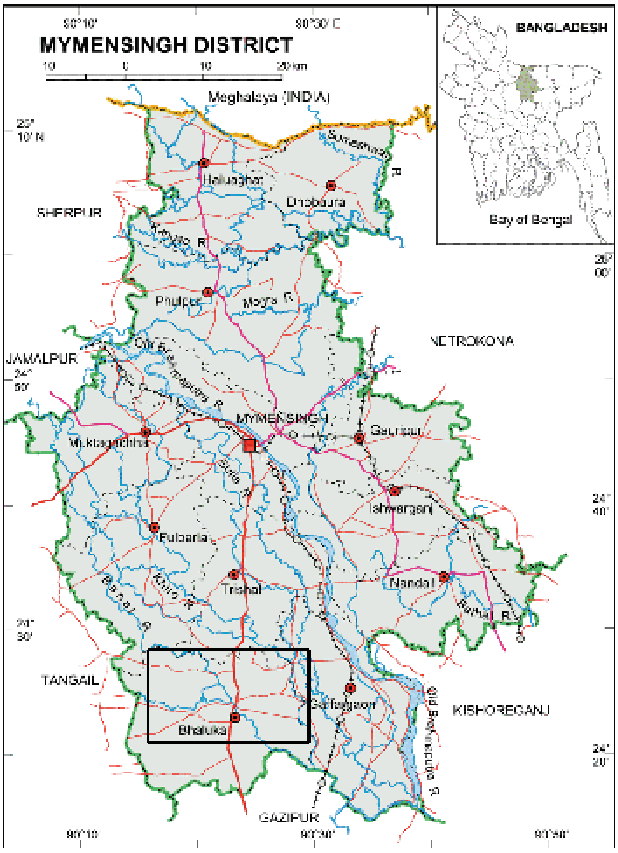
3. RESULTS AND DISCUSSION

3.1 Description of the study area

The area for the study was Bhaluka *upazila*, Mymensingh, in the north-central Bangladesh (Figure 1). Mymensingh district is divided into 12 *upazilas*[6]. Bhaluka *upazila* was selected for this study because of its importance in pangas farming. This is largely determined a combination of: the availability of hatchery-produced fry; the availability of ponds; warm climate (24 to 32°C); cheap and abundant labour. In addition, farmers in this area received training on pangas farming with the help of the Mymensingh Aquaculture Extension Project (MAEP), funded by Danish International

FIGURE 1
Map of Mymensingh District

Source: Banglapedia (2006)



[6] Mymensingh district is divided into 12 *upazilas* namely: 1) Mymensingh Sadar, 2) Trishal, 3) Bhaluka, 4) Gaffargaon, 5) Nandail, 6) Ishwarganj, 7) Gauripur, 8) Phulpur, 9) Muktagacha, 10) Phulbaria, 11) Haluaghat and 12) Dhobaura.

Development Assistance (Danida). As a result, there has been a dramatic increase in pangas production over the last few years. Carp farming[7], which represents the main freshwater aquaculture production system in Bangladesh, is not suited to this site because of the lower soil fertility.

3.2 Description of the respondents

3.2.1 Development in pangas activities

Only ten percent of farmers had started pangas farming by 1999, 27 percent in 2000, and the remaining 63 percent thereafter (Table 1). The highest number of farmers started pangas farming in 2000 as a result of MAEP training; varying from 40 percent in traditional farming to 25 percent in intensive and 15 percent in semi-intensive farming. Before pangas farming, most farmers were involved in integrated rice-fish farming, fry rearing, tilapia farming and a few were involved in carp polyculture, although this area is reported as not suitable for carp farming due to lower soil fertility.

TABLE 1
Starting year of pangas farming by category of respondents

Starting year	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
1998	1	5	0	0	1	5	2	3.3
1999	0	0	1	5	3	15	4	6.7
2000	5	25	3	15	8	40	16	26.7
2001	1	5	3	15	4	20	8	13.3
2002	5	25	7	35	3	15	15	25.0
2003	7	35	6	30	1	5	14	23.3
2004	1	5	0	0	0	0	1	1.7
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**

3.2.2 Reasons for farming pangas

The vast majority of respondents (90 percent) produced pangas for income generation, although 8.3 percent cultured for own consumption and a further 1.7 percent for availability of seed (Table 2). All intensive farmers produced pangas for income generation, compared with semi-intensive (95 percent) and traditional (75 percent) farming. It is widely known among the fish farmers that intensive pangas farming provides a high return on investment.

TABLE 2
Reasons for pangas farming by category of respondents

Reasons	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Income generation	20	100	19	95	15	75	54	90.0
Own consumption	0	0	1	5	4	20	5	8.3
Seed availability	0	0	0	0	1	5	1	1.7
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**

3.2.3 Farmer age structure

Most farmers were quite young, with an average age of 39 ranging from 29 to 50. There was very little difference in farmer's age by different culture systems (Table 3). The

[7] Popular species are indigenous Indian major carps: catla (*Catla catla*), rohu (*Labeo rohita*), and mrigal (*Cirrhinus cirrhosus*); and exotic species such as: silver carp (*Hypophthalmicthys molitrix*), grass carp (*Ctenopharyngodon idella*), and common carp (*Cyprinus carpio*).

highest percentage of farmers were found between 31 to 40 age group, semi-intensive farmers having the highest (70 percent) and intensive framers the lowest (60 percent).

TABLE 3
Distribution of pangas farmers' age group by category of respondents

Age group	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Up to 30	1	5	1	5	0	0	2	3.3
31 to 40	12	60	14	70	13	65	39	65.0
41 to 50	7	35	5	25	7	35	19	31.7
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**
Average age	**40**		**39**		**38**		**39**	

3.2.4 Gender and marital status
All interviewed farmers (head of the households) were male. Of the total (60) interviewed, 59 (98.3 percent) farmers were married and one (1.7 percent) was widowed (Table 4). Pangas farming was a male dominated activity. In general, women provided partial assistance to men in the supervision and management of ponds, particularly in applying feed, lime and fertilizers. The daily harvesting of fish for family consumption is performed by women with the help of the children. Women's activities are reported to have increased in pangas production.

TABLE 4
Marital status of the farmers by category of respondents

Marital status	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Married	19	95	20	100	20	100	59	98.3
Widowed	1	5	0	0	0	0	1	1.7
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**

3.2.5 Household size
The respondent households had an average family size of 5.9. There was little difference in this characteristic among the farmers from all the groups (Table 5). The respondents reported that all of the family members above 12 years were directly engaged in a combination of activities to supplement the household income, including: pangas farming; gardening; and poultry and livestock rearing.

TABLE 5
Distribution of farmer's family size by category of respondents

Family size	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Less than 5	2	10	0	0	1	5	3	5.0
5 to 7 persons	15	75	19	95	18	90	52	86.7
More than 7	3	15	1	5	1	5	5	8.3
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**
Average	**5.8**		**5.9**		**6.0**		**5.9**	

3.2.6 Occupation
Pangas farmers typically pursue more than one occupation to earn their livelihood. These can be classified into two groups on the basis of their relative importance (income and time spent):

1) **Main occupation:** Fifty-eight percent of respondents stated that their primary occupation was fish farming, while 26.7 percent and 15 percent were occupied in agriculture and small business activities, respectively (Table 6). The highest

percentage of farmers involvement in fish farming was noted among semi-intensive farmers (65 percent) followed by intensive (60 percent) and traditional (50 percent). On the other hand, the highest percentage of farmers involvement in agriculture was observed among traditional farmers (45 percent) compared with semi-intensive (25 percent) and intensive (10 percent) farmers.

TABLE 6
Main occupation of farmers by category of respondents

Main occupation	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Fish farming	12	60	13	65	10	50	35	58.3
Agriculture	2	10	5	25	9	45	16	26.7
Petty business	6	30	2	10	1	5	9	15.0
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**

2) **Secondary occupation:** Forty one percent of respondents stated that their secondary occupation was fish farming, while 38.3 percent, 6.7 percent, 6.7 percent, 5.0 percent and 1.7 percent were occupied in agriculture, livestock rearing, small business activity, day labouring and fish trading, respectively (Table 7). The numbers of traditional, semi-intensive and intensive farmers who consider fish farming as their secondary occupation are respectively estimated at 50 percent, 35 percent and 40 percent.

TABLE 7
Secondary occupation of fish farmers by category of respondents

Secondary occupation	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Fish farming	8	40	7	35	10	50	25	40.7
Agriculture	7	35	12	60	4	20	23	38.3
Livestock rearing	1	5	1	5	2	10	4	6.7
Petty business	3	15	0	0	1	5	4	6.7
Day labour	0	0	0	0	3	15	3	5.0
Fish trading	1	5	0	0	0	0	1	1.7
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**

3.2.7 Literacy and education

The reported literacy rate was found to be 58.3 percent. This is slightly higher than the national the average adult literacy level of 55 percent (BBS, 2002). NGOs have been working with fish farmers to improve their literacy levels. Five categories were used to define education level for pangas farmers: 1) Primary level – 1 to 5 class education, 2) Secondary level – 6 to 10 class education, 3) SSC (Secondary School Certificate) – class 10 pass, 4) HSC (Higher Secondary Certificate) – class 12 pass, and 5) Bachelors. From the total (60) interviewed, 21 (35 percent) farmers had primary level education, 9 (15 percent) had secondary, and 5 (8.3 percent) had SSC level education (Table 8). None of the farmer respondents were found to be above SSC education level. The highest number of farmers with primary, secondary and SSC level education were observed among intensive farmers, followed by semi-intensive and traditional farmers. Statistical analysis shows that farmer's education levels were significantly and positively related to feeding practices they have adopted. The results show that educated respondents tended to practice the intensive and semi-intensive feeding practices. The correlation estimated at 0.67, statistically significant at the 0.001 level.

TABLE 8
Education level of pangas farmers by category of respondents

Education level	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
No formal education	0	0	11	55	14	70	25	41.7
Primary	8	40	7	35	6	30	21	35.0
Secondary	7	35	2	10	0	0	9	15.0
SSC*	5	25	0	0	0	0	5	8.3
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**

*Secondary School Certificate examination

3.2.8 Formal training

In recent years, DoF, MAEP, NGOs, and other institutes have been providing training to the pangas farmers. In particular, the Danida-funded MAEP worked with the pangas farmers in Bhaluka *upazila* and its surrounding areas. Training and technical assistance (e.g. rearing of fry, applying feed and fertilizers, maintaining water quality and disease control) were the main components of the project. Pangas farming technology had been introduced into the area initially through MAEP. However, according to the survey, only 33.3 percent of farmers received formal training on pangas farming (Table 9). The highest percentage of farmers who got training was found among the intensive farmers (75 percent) compared with semi-intensive farmers (25 percent). None of the traditional farmers had received any training. Neighbours and friends who received training in semi-intensive production were the main source of technical assistance for the traditional farmers. The length of training varied between 2, 3 and 7 days as reported by 17 (85 percent), 2 (ten percent) and 1 (one percent) of the trained respondents (n=20), respectively. Almost all respondents who got 2 days training reported that the training was not good enough for them to raise fish with confidence.

TABLE 9
Status of formal training by category of respondents

Attendance in training	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Yes	15	75	5	25	0	0	20	33.3
No	5	25	15	75	20	100	40	66.7
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**

3.3 Farm production practices

3.3.1 Pond features

Most fish culture takes place in ponds constructed as borrow pits, which were dug out to raise the level of land for village households and roads (ADB, 2005). Thus, the ponds were not deliberately built as fishponds, but as part of excavation works used to support for village and homestead development. The majority of households, including some of the landless (i.e. no agriculture land) and most of the marginal and small-scale farmers, had ponds (Figure 2). According to the survey, most of the households (86.7 percent) have a single pond, and the remainders (13.3 percent) have two ponds (Table 10). The average area of pond is 0.23 ha. There is a significant difference

FIGURE 2
Fish ponds for pangas farming in rural Bangladesh

(P<0.05) of pond size in the different feeding practices. The highest average pond size was found in intensive farming (0.36 ha) followed by semi-intensive (0.21 ha) and traditional (0.12 ha). The average water depth of a pond in the rainy season and in the dry season were estimated at 1.64 m and 1.15 m, respectively. The principal water sources for ponds are rainfall, ground water (i.e. through tube-wells), and sometimes river water, via canals.

TABLE 10
Number of farmer's pond, average size and water depth by category of respondents

No. of pond, size and water depth	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
1 pond	13	65	19	95	20	100	52	86.7
2 ponds	7	35	1	5	0	0	8	13.3
Total	20	100	20	100	20	100	60	100
Average pond size (ha)		0.36		0.21		0.12		0.23
Water depth, rainy season (m)		1.83		1.54		1.65		1.64
Water depth, dry season (m)		1.24		1.03		1.19		1.15

Most of the ponds are owned by the farmers themselves. Seventy percent of the respondents reported single ownership of ponds, while 20 percent were co-owners under a multiple ownership arrangement, and ten percent had user rights under lease arrangements. Annual leasing rates averaged US$138.5 per ha, ranging from US$92.3 to 230.8 per ha, for periods of 12 to 24 months. Lease value varied from one site to another depending on the locality, soil fertility, topography of the soil and distance from the road. Table 11 shows that the highest percentage of single lease ponds were noted among intensive farms (20 percent) compared with semi-intensive (10 percent) and traditional (0 percent). On the other hand, the highest percentage of single ownership ponds were reported in traditional farming (80 percent) followed by semi-intensive (75 percent) and intensive farming (55 percent). Seventy five percent of ponds had two owners and 25 percent had three owners.

TABLE 11
Ownership of ponds by farmers in different farming systems/feeding practices

Pond ownership	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Single ownership	11	55	15	75	16	80	42	70
Multiple ownership	5	25	3	15	4	20	12	20
Single lease	4	20	2	10	0	0	6	10
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**

The survey reveals that 38.3 percent of ponds were used only for fish culture and the remainders (61.7 percent) were used for multipurpose (Table 12) activities such as washing clothes and dishes, bathing water, homestead gardening, livestock watering and irrigating crops. The highest number of farmers using ponds only for fish culture was observed among intensive farmers (70 percent) compared with semi-intensive (40 percent) and traditional (5 percent). In general, fish farming does not interfere with the multipurpose use of ponds, providing strong incentives for pond owners to safeguard the quality of pond water.

TABLE 12
Pond utilization by farmers in different farming systems/feeding practices

Pond utilization	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Fish culture only	14	70	8	40	1	5	23	38.3
Multipurpose	6	30	12	60	19	95	37	61.7
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**

3.3.2 Farm production

All interviewed farmers practised pangas monoculture. The peak season for pangas farming is from March to February. The majority of fish farmers stocked their ponds from as early as March to May and harvested their fish after three months, and subsequently at regular intervals until the end of the year. The culture period is from 9 to 12 months. Table 13 shows that around 40 percent cultured for 10 months, 38.3 percent of farmers for 11 months and the remainder cultured for nine (6.7 percent) and 12 (11.7 percent) months. The culture period of ponds in the study area is shorter than elsewhere in the country because of the 2–3 month cold and dry season (November–February) when the water temperature drops to less than 15°C. Lower temperatures reduce the pangas growth rates.

TABLE 13
Average culture period of pangas by different farming systems/feeding practices

Culture period	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
9 months	0	0	2	10	2	10	4	6.7
10 months	3	15	10	50	13	65	26	43.3
11 months	10	50	8	40	5	25	23	38.3
12 months	7	35	0	0	0	0	7	11.7
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**

3.3.3 Stocking strategies and rates

Farmers stock ponds with fingerlings distributed by itinerant seed traders. Pangas culture in ponds was fully dependent on hatchery produced fingerling. The most common stocking frequency in traditional farms was once per year (95 percent of respondents), with a small minority (5 percent of respondents) stocking twice. All intensive farmers, and 90 percent semi-intensive, reported multiple stocking, respectively (Table 14). About 15 percent, 80 percent and 5 percent of intensive farmers were observed to practise annual stocking frequencies of twice, three times and four times, respectively.

TABLE 14
Stocking frequency (no. per year) by different farming systems/feeding practices

Stocking frequency	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Single	**0**	**0**	**2**	**10**	**19**	**95**	**21**	**35.0**
Twice	3	15	15	75	1	5	19	31.7
3 times	16	80	3	15	0	0	19	31.7
4 times	1	5	0	0	0	0	1	1.7
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**

The average annual stocking density of fingerlings was estimated at 23 847 per ha, varying from 12 065 in traditional systems to 23 575 in semi-intensive and 35 900 in intensive systems (Table 15). There was a significant difference ($P<0.05$) in stocking densities in different culture systems. The average size of fingerlings stocked at 6.0 cm in length and 11.6 g in weight. There was little difference between average sizes of fingerlings stocked by farming system.

3.3.4 Fertilization

All intensive and semi-intensive farmers used fertilizers for grow out (Table 16). However, only 35 percent of traditional farmers used fertilizer, mainly cow dung which is relatively cheap and abundant in the study area while the rest (65 percent), did not use fertilizer due to lack of money and poor knowledge on fish farming. The use of fertilizers has influenced the increase in the growth of pangas. The purpose of using fertilizers in the pond is to create conditions which help to increase the growth of good quality natural food (e.g. phytoplankton and zooplankton) thereby increasing fish production.

TABLE 15
Mean stocking rate, size and weight of fingerlings by different farming systems/feeding practices

Fingerlings	Intensive	Semi-intensive	Traditional	All categories
Stocking rate (No./ha/year)	35 900	23 575	12 065	23 847
Size (cm)	6.0	6.0	5.9	6.0
Weight (g)	12.5	11.5	10.7	11.6

TABLE 16
Use of fertilizers by farmers in different farming systems/feeding practices

Use of fertilizers	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Yes	20	100	20	100	7	35	47	78.3
No	0	0	0	0	13	65	13	21.7
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**

Fish farmers use two types of fertilizer namely: organic (mainly cow dung) and inorganic [urea and triple super phosphate (TSP)]. The most widely used fertilizers were cow dung (60 percent), urea (57 percent) and TSP (43 percent) at varying frequencies and rates. On average, annual fertilization rates were pegged at 903 kg/ha of cow dung, 259 kg/ha of urea and 192 kg/ha of TSP (Table 17). Cow dung is relatively cheaper and easily accessible in the study area.

Intensive farmers used more fertilizers than the other two groups. Table 17 also shows that the average annual fertilization rates were 970 kg/ha of cow dung, 288 kg/ha of urea and 180 kg/ha of TSP. In case of semi-intensive farming, the average annual fertilization rates were 811 kg/ha of cow dung, 218 kg/ha of urea and 233 kg/ha of TSP. It is interesting to note that only cow dung was used in traditional farming with an average annual fertilization rate of 650 kg/ha.

3.3.5 Feeds and feeding rates

Supplementary feeds were used by all of the traditional farmers for pangas farming. In general, farmers were using a mixture of rice bran, wheat bran and oil cake (Figure 3). Among traditional farmers, ten percent of respondents applied feed once daily while 25 percent applied twice a week and 65 percent at irregular intervals (Table 18). On the average, annual feeding rates per ha were estimated at 2 054 kg of rice bran, 2 071 kg of wheat bran and 1 665 kg of oil cake; for an aggregate annual feeding rate per ha of 5 790 kg. As this type of feed is slow sinking, almost all farmers resorted to the broadcast method of feeding. The average composition of supplementary feed is as follows: 15 percent moisture, 18 percent protein, 10 percent lipid, 21 percent ash, 18 percent fiber and 18 percent nitrogen free extract (NFE) (Table 19).

FIGURE 3
Application of supplementary feed by broadcasting

TABLE 17
Frequency and rate of fertilization by different farming systems/feeding practices

Frequency and rate of fertilization	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Cow dung								
Never	0	0	11	55	13	65	24	40.0
Daily	0	0	0	0	0	0	0	0
Weekly	0	0	0	0	0	0	0	0
Bi-weekly	9	45	0	0	0	0	9	15.0
Monthly	11	55	9	45	0	0	20	33.3
Irregular	0	0	0	0	7	35	7	11.7
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**
Rate (kg/ha/year)	**970**		**811**		**650**		**903**	
Urea								
Never	0	0	6	30	20	100	26	43.3
Daily	0	0	0	0	0	0	0	0
Weekly	0	0	0	0	0	0	0	0
Bi-weekly	17	85	4	20	0	0	21	35.0
Monthly	3	15	10	50	0	0	13	21.7
Irregular	0	0	0	0	0	0	0	0
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**
Rate (kg/ha/year)	**288**		**218**		**0**		**259**	
TSP								
Never	0	0	14	70	20	100	34	56.7
Daily	0	0	0	0	0	0	0	0
Weekly	0	0	0	0	0	0	0	0
Bi-weekly	9	45	2	10	0	0	11	18.3
Monthly	11	55	4	20	0	0	15	25.0
Irregular	0	0	0	0	0	0	0	0
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**
Rate (kg/ha/year)	**180**		**233**		**0**		**192**	

TABLE 18
Feeding frequency and rate by different farming systems/feeding practices

Feeding frequency and rate	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
More than once daily	20	100	1	5	0	0	21	35.0
Once daily	0	0	19	95	2	10	21	35.0
Twice/week	0	0	0	0	5	25	5	8.3
Irregular	0	0	0	0	13	65	13	21.7
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**
Rate (kg/ha/year)	**22 370**		**13 010**		**5 790**		**13 723**	

In semi-intensive farms, feeds were used to supplement the natural food produced in the pond through fertilization. All respondents in semi-intensive farming were using home/farm-made aquafeed for pangas farming (Figure 4). The feed ingredients that were mainly used included; rice bran, wheat bran, oil cake, fishmeal, flour, dried fish, oyster shell, salt and vitamins. This feed was prepared by a machine mixing of 30 percent rice bran and wheat bran, 30 percent mustard oil cake, 15 percent fishmeal, and 25 percent others. The average proximate composition of farm-made aquafeed is: 14 percent moisture, 22 percent protein, 12 percent lipid, 19 percent ash, 12 percent fiber and 18 percent NFE (Table 19). According to the survey of 20 respondents, 95 percent of farmers applied feed once daily while only five percent applied more than once daily (Table 18). On average, annual feeding rate was 13 010 kg/ha.

Pangas growth in intensive farming is primarily dependent upon an adequate supply of commercial fish feeds (Figure 5), both in terms of quality and quantity. There are about 25 commercial fish feed producers in Bangladesh (Kader, 2003). There was a significant difference ($P<0.05$) of feeding rates by culture systems. The average annual feeding rate in intensive farming was 22 370 kg/ha. All farmers applied feed more than once daily. As these types of feed are of slow sinking, feeds were applied by broadcasting (Figure 6). The composition of commercial feed is: 11 percent moisture, 30 percent protein, 15 percent lipid, 15 percent ash, 8 percent fibre and 21 percent NFE. The protein and lipid levels of industrially manufactured pelleted feeds are higher than farm-made aquafeed and supplementary feed (Table 19).

TABLE 19
Average proximate composition (percent of dry matter basis) of different feeds used for pangas farming

Nutrients	Industrially manufactured pelleted feed*	Farm made aquafeed**	Supplementary feed**
Moisture	11	14	15
Crude protein	30	22	18
Crude lipid	15	12	10
Ash	15	19	21
Crude fiber	8	12	18
Nitrogen free extract	21	18	18

*Values of the industrially manufactured pelleted feed are recorded from feed bag; ** Values of farm- made aquafeed and supplementary feed are from Kader (2003).

3.3.6 Fish yield

According to the survey, the average annual yield of pangas was estimated at 8 343 kg/ha in 2005. Table 20 shows that the highest average annual pangas production per ha pond was observed in intensive farming (13 945 kg) followed by semi-intensive (7 705 kg) and traditional (3 380 kg) farming. There was a significant difference ($P<0.05$) of fish yields in different farming systems, because of the differences of farm size, feed and seed inputs and management skill. Yields were a function of stocking density used in different farming systems. A lower FCR (feed conversion ratio) obtained in intensive farming was primarily a result of fertilization. Intensive farmers also produced more fish due to a combination of higher input of feed and seed, larger pond size and higher investment. However, the FCR was lower in intensive practice due to use of quality pelleted feed. Fertilizers whilst not common in pangas farming, were used to maintain water quality to enhance the flavor of pangas to counteract the bad flavor due to high stocking and the high feeding rate.

A number of interdependent factors affected growth rates and production. These included stocking rate, the quality and quantity of feed supply, water quality, and other aspects of pond management. The size of fish at stocking, the duration of culture[8], mortality and the size at which the fish are harvested also influence total yield. The current production level suggests that the average production of pangas has increased in the study area over recent years. The production of pangas of the surveyed farms was significantly higher than carp farming in other parts of the Mymensingh area. Pangas farming allows for very high densities resulting in much higher production as compared with carp. The annual yields of carps in the Greater Mymensingh area averaged 3 300 kg/ha (Winrock International, 2004) or 3 100 kg/ha (ADB, 2005), as compared with 8 343 kg/ha in pangas.

FIGURE 4
Mixed ingredients for preparation of farm-made aquafeed

[8] Intensive farming required multiple stocking and multiple harvesting with short culture periods. Traditional farming uses single stocking with a longer culture duration.

FIGURE 5
A farmer carrying industrially-manufactured pelleted feeds

Responses concerning the reasons for increased pangas production included an increased supply/availability of feed and quality fry, reduced mortality of fish, and better management. According to the survey of 60 farmers, 33 (55 percent) respondents believed that they could produce more fish mainly by applying more feeds (73 percent), high stocking of fry (18 percent) and better management (9 percent). The reasons given by the 45 percent of respondents who thought that they could not produce more fish were lack of money for inputs as well as high production costs (78 percent), limited knowledge (18 percent) and poor market facility (4 percent).

TABLE 20
Productivity of pangas and FCR by different farming systems/feeding practices

Factors/items	Intensive	Semi-intensive	Traditional	All categories
Stocking rate (No./ha/year)	35 900	23 575	12 065	23 847
Yield (kg/ha/year)	13 945	7 705	3 380	8 343
Amount of feed used (kg/ha/year)	22 370	13 010	5 790	13 723
FCR	1.60	1.69	1.71	1.64

The FCR[9] was computed for pangas farming. FCR is calculated from the kg of feed that are used to produce one kg of fish. A low FCR normally illustrates good management practice, with no overfeeding. Overfeeding or underfeeding will increase the FCR. Regardless of feeding practices, the average FCR was calculated at 1.64 in the study area. The highest average FCR was estimated in traditional farming at 1.71 compared with semi-intensive and intensive farming at 1.69 and 1.60, respectively (Table 20).

FIGURE 6
Application of industrially-manufactured pelleted feed by hand

Most of the harvested pangas (Figure 7) do not reach consumers directly from producers. A large number of rural poor are involved in the domestic fish marketing chain as local agents, traders, intermediaries, day labourers and transporters. The market chain from farmers to consumers encompasses mainly primary, secondary and retail markets, involving sales agents, suppliers, wholesalers and retailers. In general, trucks and pickups are used to transport live pangas to the markets. Plastic containers are commonly used for keeping the pangas during transport. Pangas are traded whole, un-gutted, and fresh without processing apart from sorting and icing. The price of pangas depends on supply and demand (in particular seasonality), quality, size and weight. The average farm-gate price of pangas was found at US$0.615 per kg.

[9] Biological FCR is the net amount of feed used to produce one kg of fish, while the economic FCR takes into account all the feed used, meaning that the effects of feed losses and mortalities, for example, are included (Aquamedia, 2006).

FIGURE 7
Harvesting of fish

3.4 Comparative analysis of production costs

Data on pangas farming production costs were collected to assess their differences between farming categories. The following elements were assessed in the cost analysis:

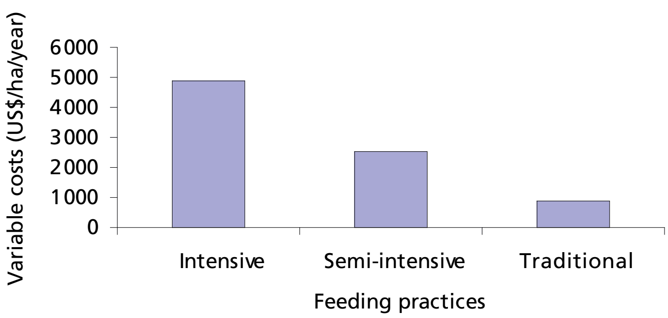
1. costs: including variable costs, such as seed, feed, fertilizers, labour and opportunity costs, harvesting and marketing costs, and miscellaneous, which vary with outputs; and fixed and indirect operating costs, such as staff salary, interest, land use cost and depreciation, which are usually independent of the level of production;
2. assessment of key factors affecting pangas production.

Particular attention was directed to addressing such questions as:

- Which inputs are significant in explaining variation in output from various farming categories?
- Are there economies of scale in pangas production?
- Are farmers making optimal use of inputs?
- Are they technically and economically efficient?
- What constraints inhibit increased production and profitability of existing pangas farming?

It is essential to farm development and management to know the production costs and their performance, identifying the main items where cost efficiencies can be achieved. Production cost data also helps the farmers in decision making and in adjusting to changes, and determines the sales level under which the product cannot be sold without incurring a loss.

FIGURE 8
Variable costs for pangas farming by different feeding practices



3.4.1 Variable costs

The average annual variable costs for pangas farming was estimated at US$2 751 per ha for all feeding practices. There was a significant difference ($P<0.05$) of annual variable costs per ha farm in the different feeding practices, varying from US$4 856 in intensive farming, to US$2 506 in semi-intensive and US$892 in traditional farming (Figure 8). Variable costs in pangas culture are as follows:

3.4.2 Labour costs

Labour was one of the most important inputs in the production process of pangas farming. The sources of supply of human labour were: i) family labour,[10] for which no payment was made; and ii) hired labour, for which farmers had to pay in cash.

[10] Exact quantification of family labour was a challenging task, because the farmers often could not estimate distinctly the use of family labour for different purposes. To overcome these problems, the period of time spent by the family members in different operations was carefully assessed.

Sometimes provision of incentives in the form of food and tobacco were provided to the hired labour and the value of these items was also added to determine the actual cash amount paid for the labour. The hired labour can be further classified into: i) casual hired labour and ii) annually hired labour.

To determine the cost of unpaid family labour the opportunity cost[11] principle was adopted. In this study, a man-day was considered to be 8 hours of work. The labour of women and children has been converted into man equivalent days by representing a ratio of 2 children days = 1.5 women days = 1 man day (Miah, 1987). Labour wage range varies with respect to nature of work, location, number of workers required, and season. The peak labour demand, between February to April, coincides with rice weeding and later harvesting. However, during the early monsoon months of June to August when little work is available, the normal wage rate drops to US$0.92 to 1.30 per day. The average wage rate for pangas farming was estimated at US$1.23/day, ranging from US$0.92 to 1.85/day.

From pond preparation to harvesting and marketing of pangas, human labour was required in different operations and management. The average annual human labour cost was calculated at US$241 per ha farm. Labour utilization and the relevant cost are shown in Table 21 for the different farming systems. The highest average labour cost was noted in intensive farming (US$360/ha/year) followed by semi-intensive (US$240.3/ha/year) and traditional (US$124/ha/year) farming.

TABLE 21
Average annual quantity and cost of human labour by farming systems/feeding practices

Labour	Intensive	Semi-intensive	Traditional	All categories
Man days	293.0	195	101.0	196.0
Wage (US$/day)	1.23	1.23	1.23	1.23
Cost (US$/ha/year)	**360.0**	**240.3**	**124.0**	**241.4**

Note: Includes family labour. Wages represent an average of different payments for different tasks

3.4.3 Cost of fertilizers

Pangas farmers use two types of fertilizer: organic (mainly cow dung); and inorganic (urea and TSP). The price of fertilizers was calculated based on the prevailing market price. The prices of these fertilizers were assumed to be same in all categories of farms. The average prices per kg of these fertilizers were US$0.0077 for cow dung (i.e. US$7.7 per 1000 kg), US$0.092 for urea and US$0.21 for TSP. The average annual costs of inorganic and organic fertilizers were calculated at US$53.5 and US$3.9 per ha, respectively (Table 22). The highest average annual cost of fertilizers was noted among intensive farms at US$112.3 per ha, compared with semi-intensive (US$54.3 per ha) and traditional (US$5.6 per ha) farming.

TABLE 22
Mean average cost of fertilizers (US$/ha/year) by different farming systems/feeding practices

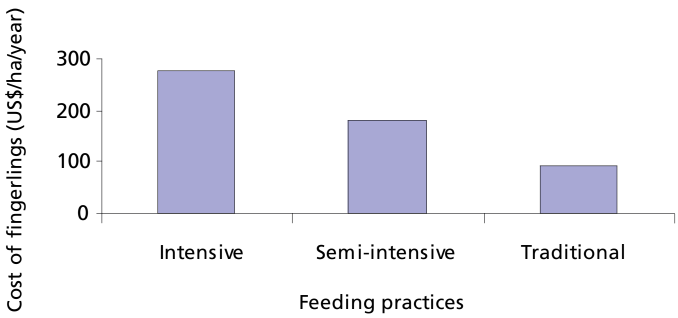
Fertilizers	Intensive	Semi-intensive	Traditional	All categories
Inorganic	103.8	51.5	5.1	53.5
Organic	8.5	2.8	0.5	3.9
Total	**112.3**	**54.3**	**5.6**	**57.4**

[11] Opportunity costs refer to the costs associated with giving up an opportunity. The opportunity cost creates an implicit price relationship between competing alternatives. The opportunity cost of a human labour is its value in its best alternative use. According to Hulse *et al.* (1982), opportunity cost is the return given up by not participating in the next best alternative activity.

3.4.4 Cost of fingerlings

Stocking of fingerlings is one of the major input costs in pangas farming. Farmers normally purchased fingerlings from the fry collectors and/or hatcheries. There was a variation of fingerling prices linked to the source and the time of purchase. The cost was calculated based on the actual prices paid. The average price of pangas seed was US$7.7 per 1000 fingerlings. Regardless of farm categories, the average annual cost of fingerlings was calculated at US$183.4 per ha. The highest average annual cost of fingerlings was found in intensive farming (US$276.2 per ha) followed by semi-intensive (US$181.3 per ha) and traditional (US$92.8 per ha) farming (Figure 9). There was a significant difference (P<0.05) of cost of fingerlings in different farming categories because higher stocking densities were used in intensive and semi-intensive farming.

FIGURE 9
Cost of fingerlings by different farming systems/feeding practices



3.4.5 Cost of feeds

Feed is one of the most essential inputs for increasing fish production. Feed cost constitutes the highest single cost item in intensive, semi-intensive and traditional grow-out farming operations. Farmers used industrially manufactured pelleted feed, farm-made aquafeed and supplementary diet (rice bran, wheat bran and oil cake) in intensive, semi-intensive and traditional feeding practices, respectively. The average cost of these feeds were US$0.18, US$0.14 and US$0.09 per kg for industrially manufactured pelleted feed, farm-made aquafeed and supplementary feed, respectively. The total amount of feeds per ha per year varied by different culture strategies. Regardless of farm categories, the average annual cost of feed was calculated at US$2 128 per ha. There was a significant difference (P<0.05) of feed cost in different feeding practices, an average of US$3 957, US$1 853 and US$574 per ha per year were estimated in intensive, semi-intensive and traditional farming systems, respectively (Figure 10). Results showed that intensive farms incurred the highest feed cost among all farm categories.

3.4.6 Other variable costs

The costs of harvesting, marketing, electricity, vitamin premix, and medicine were calculated under the heading of other variable costs. The average other variable costs were estimated at US$167 per ha per year, varying from US$227 in intensive feeding to US$178 in semi-intensive and US$96 in traditional feeding (Figure 11). There was a significant difference (P<0.05) of other variable costs in the different feeding practices.

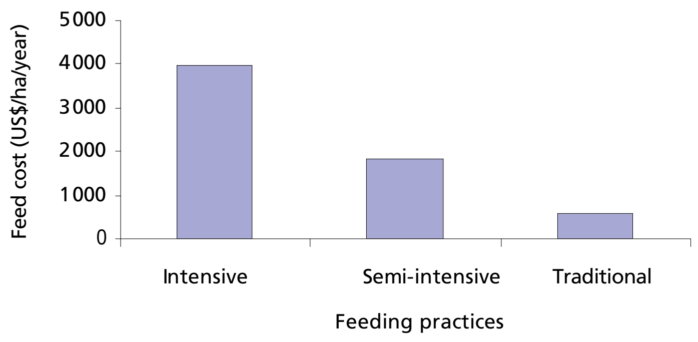
3.4.7 Other costs

Pangas farming required some fixed costs such as depreciation[12] (i.e. water pump, nets and feed machines), permanent staff salary including caretaker and guard,[13] land

[12] [(purchase price – salvage value) / economic life]

[13] Most of the intensive and semi-intensive farmers tend to recruit night guard to protect against poaching which is a common problem in the study area.

FIGURE 10
Cost of feeds by different feeding practices



use cost (or lease money) and interest on operating capital.

Interest on operating capital was calculated by taking into account the amount spent in cash for pangas farming. The amount of money needed to meet the expanse of inputs such as fingerlings, feed, fertilizers, labour are treated as operating capital in this study. Interest on operating capital was charged at the rate of 15 percent per annum and was estimated for the period during the culture period. The standard formula for calculation of interest on operating capital is as follows:

Interest on operating capital (OC) = Alit (Miah, 1987)

Where,

Al = Total investment/2

i = Interest rate which was 15 percent per year during the study period

t = Time (length of the period of pangas cultivation)

The cost of land use may be anticipated by using one of the following three alternative concepts:

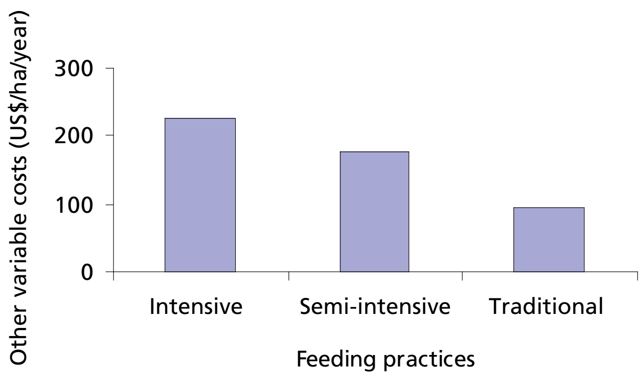
i) interest on the value of land (generally five percent);

ii) valuation of land at its rental price (or if it is leased out); and

iii) foregoing incomes from alternative use.

The average annual fixed costs for pangas farming was estimated at US$187 per ha. There was a significant difference ($P<0.05$) in fixed costs in the different feeding practices, varying from US$285 per ha per year in intensive to US$188 in semi-intensive and US$89 in traditional farming (Table 23). Among the fixed costs, the average annual depreciation cost, salaries, interest and land use cost were calculated at US$27, US$26, US$67 and US$65 per ha respectively. Figure 12 shows the highest average annual fixed costs such as depreciation, staff salary, interest and land use cost reported by intensive, semi-intensive and traditional farms respectively.

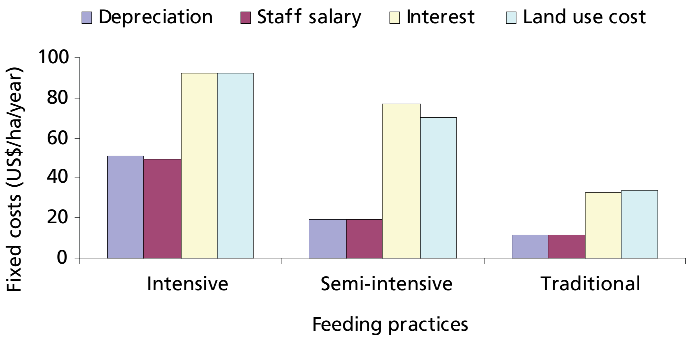
FIGURE 11
Other variable costs for pangas farming by different feeding practices



3.4.8 Total production costs

Table 23 shows that total costs of pangas farming for all sampled farmers averaging US$2 964 per ha per year, varying from US$5 217 in intensive farming to US$2 694 in semi-intensive and US$981 in traditional farming. Regardless of farm category, average variable costs and fixed costs were estimated at US$2 777 and US$187 per ha per year, respectively. Variable costs accounted for 94 percent of total costs, varying from 95 percent in intensive to 93 percent in semi-intensive and

FIGURE 12
Fixed costs for pangas farming by different feeding practices



91 percent in traditional farming. The cost of feeds dominated all other costs representing about 72 percent of total costs (77 percent of variable costs) varying from 76 percent in intensive to 69 percent in semi-intensive and 59 percent in traditional systems (Figure 13). The cost of fertilizers accounted for 2 percent of total costs, varying from 2.2 percent in intensive to 2 percent in semi-intensive and 0.5 percent in traditional farming. The relative proportion of the costs of labour, fingerlings, and other variable costs averaged 8 percent, 6 percent and 5.5 percent of total costs, respectively. Fixed costs represented 6 percent of total costs, varying from 5.4 percent in intensive to 7 percent in semi-intensive and 9 percent in traditional farming.

All interviewed farmers stated that production costs had increased in recent years. In response to the question on how the costs of pangas farming could be reduced, key factors that were cited included:

- the use of farm-made, cheap and locally produced compound feed;
- less inputs (feed, seed and fertilizers); and
- better management.

TABLE 23
Mean average total production costs (US$/ha/year) for pangas farming by different farming systems/feeding practices. Values in parentheses indicate the percent of total costs

Cost items	Intensive	Semi-intensive	Traditional	All categories
i) Variable costs (VC)				
1. Labour (family & hire)	360 .0 (6.9%)	240.3 (8.9%)	124.0 (12.6%)	241.4 (8.1%)
2. Fertilizers	112.3 (2.2%)	54.3 (2.0%)	5.6 (0.5%)	57.4 (1.9%)
3. Fingerlings	276.2 (5.3%)	181.3 (6.7%)	92.8 (9.5%)	183.4 (6.2%)
4. Feeds	3 956.6 (75.8%)	1 852.6 (68.8%)	573.7 (58.5%)	2 127.7 (71.8%)
5. Other variable costs	227.4 (4.3%)	177.7 (6.5%)	96.1 (9.7%)	167.1 (5.6%)
Subtotal	**4 932.5 (94.5%)**	**2 506.2 (93.0%)**	**892.2 (91.0%)**	**2 777.0 (93.7%)**
ii) Fixed costs (FC)				
1. Depreciation	50.8 (1.0%)	19.6 (0.7%)	11.1 (1.1%)	27.2 (0.9%)
2. Salary of permanent staff	49.2 (0.9%)	19.6 (0.7%)	11.1 (1.1%)	26.7 (0.9%)
3. Interest	92.7 (1.8%)	76.9 (2.9%)	32.3 (3.3%)	67.3 (2.3%)
4. Land use cost	91.9 (1.8%)	70.0 (2.6%)	33.8 (3.4%)	65.3 (2.2%)
Subtotal	284.6 (5.4%)	187.7 (6.9%)	88.5 (9.0%)	186.5 (6.3%)
iii) Total costs (TC=VC+FC)	**5 217.1 (100%)**	**2 693.9 (100%)**	**980.7 (100%)**	**2 963.5 (100%)**

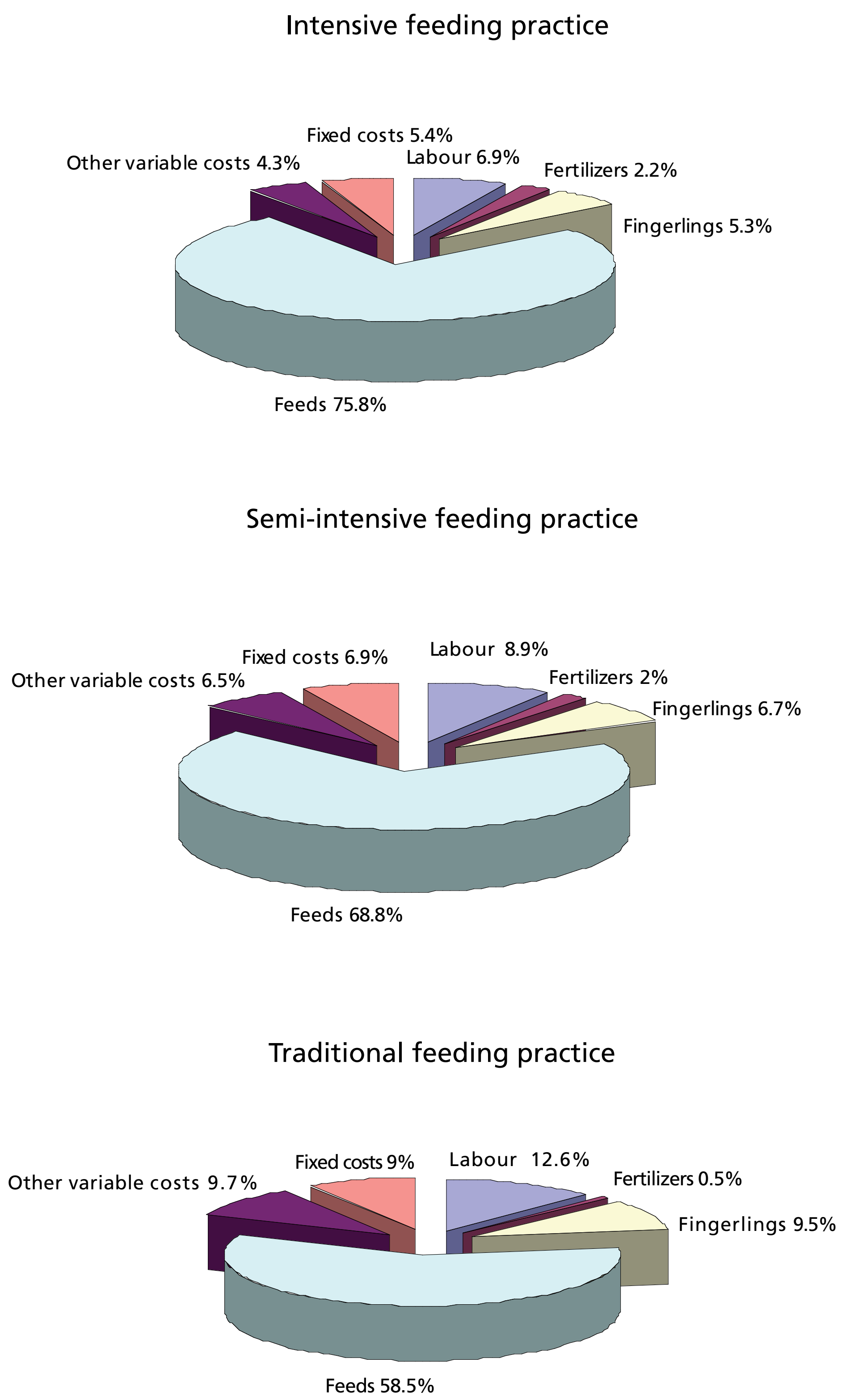
3.5 Comparative analysis of farm income and economic indicators

3.5.1 Gross revenue

Gross revenue is the pecuniary value of total production (gross revenue = sum of value of outputs). Gross revenue was calculated by multiplying the total amount (sold and consumed) of production (kg) by their respective market prices (US$/kg). The average market price[14] of pangas was found at US$0.615 per kg. Gross revenue was calculated

[14] There was no difference in pangas price in different farming systems. In general, traditional farmers produced larger pangus due to single stocking (i.e. longer culture period) while intensive and semi-intensive farmers produced smaller pangas due to multiple stocking and multiple harvesting (i.e. short culture period).

FIGURE 13
Percent of total production costs in different farming systems/feeding practices



at US$5 134 per ha per year, varying from US$8 582 in intensive farming to US$4 742 in semi-intensive and US$2 080 in traditional farming (Table 24). The highest average gross revenue was reported by intensive farmers due to higher production, whilst the lowest average gross revenue was found for traditional farmers due to lower production. The average annual gross revenue per ha is significantly higher among intensive farmers compared with semi-intensive and traditional farmers.

TABLE 24
Mean average gross revenue of pangas production by different farming systems/feeding practices

Pangas farming	Intensive	Semi-intensive	Traditional	All categories
Production (kg/ha/year)	13 945	7 705	3 380	8 343
Market price (US$/kg)	0.615	0.615	0.615	0.615
Gross revenue (US$/ha/year)	8 581.5	4 741.5	2 080	5 134.3

3.5.2 Gross aquaculture margin
Once the fixed investments are made, the aquaculture farmers' decisions should be based on the expected returns or income above variable costs. Fixed investments are considered as sunk costs and may not be recovered for at least one farming season. The highest annual average income above variable cost per ha was revealed by intensive farms (US$3 649) compared with semi-intensive (US$2 235) and traditional (US$1 189) farms (Table 25). It is calculated that all farms were able to generate positive returns to variable costs. These findings indicate that all farming systems, including traditional farms are willing to pursue pangas farming as the returns above variable costs are positive.

3.5.3 Net margin/return
Net return is defined as gross revenue minus total production costs. Regardless of farming categories, the annual net return per ha of pond averaged US$2 170. Despite a higher average production cost per ha, the average annual net return was higher in intensive farming system at US$3 364 compared with US$2 048 in semi-intensive and US$1 099 in traditional farming (Table 25). Despite a lower production cost among traditional farmers, their low production has resulted in lower net returns. On the other hand, intensive farmers' higher production costs are offset by higher yield resulting in a higher net return. Almost all interviewed farmers stated that their returns had decreased as costs of pangas farming had increased significantly while the price of pangas has not increased to a similar degree. However, most of the farmers have improved their social and economic status as a result of pangas farming. In addition pangas farming has generated employment opportunities. Such improved conditions may be described on the basis of qualitative indicators. These comprise: increased food consumption; increased social status; and involvement of women in pangas farming. Study results suggest that farmers have broadly improved their standards of living, purchasing power, choice, and ability as an economic sector.

3.5.4 Returns to land and labour
The average net returns to land of intensive, semi-intensive and traditional farms were US$3 273, US$1 978 and US$1 066, respectively (Table 25). Similarly, the average net retur ns to labour among all feeding practices are positive. These findings indicate that all farming systems, including traditional farms are willing to pursue pangas farming as the returns to land and labour are positive.

3.5.5 Benefit-cost ratio
Benefit-cost ratio (BCR) is defined as gross revenue divided by total production costs, which implies that a ratio of 1.0 means that the operation is at break-even position. The benefit-cost ratios were estimated at 2.12, 1.76 and 1.64 for traditional, semi-intensive

and intensive farms, respectively (Table 25). The findings indicate that the traditional farms are able to recover US$2.12 per US$1.00 of investment while semi-intensive and intensive farms generate a return of US$1.76 and US$1.64, respectively.

TABLE 25
Financial and economic indicators of pangas production by feeding practices

Financial and economic indicators	Intensive	Semi-intensive	Traditional	All categories
A. Total cost[1] (US$/ha/year)	5 217.1	2 693.9	980.7	2 963.5
B. Variable cost[2] (US$/ha/year)	4 932.5	2 506.2	892.2	2 777.0
C. Fixed cost[3] (US$/ha/year)	284.6	187.7	88.5	186.9
D. Gross revenue[4] (US$/ha/year)	8 581.5	4 741.5	2 080	5 134.3
E. Gross margin[5] (US$/ha/year)	3 649	2 235.3	1 187.8	2 357.3
F. Net margin/returns[6] (US$/ha/year)	3 364.4	2 047.6	1 099.3	2 170.4
G. Net returns to land[7] (US$/ha/year)	3 272.5	1 977.6	1 065.5	2 105.1
H. Net returns to labour[8] (US$/ha/year)	3004.4	1 807.3	975.3	1 929
I. Gross total factor productivity/benefit-cost ratio[9]	1.64	1.76	2.12	1.73
J. Break-even price[10] (US$/kg)	0.37	0.35	0.29	0.35
K. Actual price (US$/kg)	0.615	0.615	0.615	0.615
L. Break-even production[11] (kg)	8 478	4 377	1 593	4 816
M. Actual production (kg)	13 945	7 705	3 380	8 343
N. Survival rate[12] (percent)	89.4	84.6	77.8	83.9

[1] Total costs = variable costs + fixed costs (A = B + C)
[2] Sum of costs of fingerlings, fertilizers, feeds, hired and family labour, harvesting and marketing costs, and other variable costs
[3] Sum of land use cost, interest, depreciation and permanent staff salary
[4] The total amount of production (kg) multiplied by their respective market prices
[5] Gross revenue less variable costs (E = D – B)
[6] Gross revenue less total costs (F = D – A)
[7] Net margin/returns less land rent payment
[8] Net margin/returns less cost of labour
[9] Gross revenue divided by total costs (I = D/A)
[10] Total costs divided by total production (J = A/total production)
[11] Total costs divided by average price (L = A/average price of fish: US$0.615 per kg)
[12] (Number of pieces during harvest/number of pieces during stocking) x 100

3.5.6 Break-even price

Break-even price was estimated as total costs (US$/ha/year) divided by production of pangas (kg/ha/year). Regardless of different feeding practices, the average break-even price (cost per kg of fish production) was estimated at US$0.35 per kg (Table 25). This is against the prevailing market price of pangas, US$0.615 per kg. The break even prices for intensive, semi intensive and traditional farms were US$0.37 per kg (-39 percent), US$0.35 per kg (-43 percent), and US$0.29 per kg (-53 percent), respectively. These figures imply that all farming systems can significantly absorb price changes and still achieve profitability.

3.5.7 Break-even production

A major basis in evaluating the soundness of a business operation such as aquaculture production is to determine their levels of productivities in relation to their break-even production levels. The break-even production level considers the farm's total production costs in relation to the prevailing market price of fish per kg (i.e. total production costs/market price of fish per kg).

As shown in Table 25, the break-even production per ha farm for pangas is estimated at 4 816 kg for all categories. Regardless of farm categories, the average annual yield of pangas was found at 8 343 kg/ha. The over-all current performance of pangas production exceeded their break-even production level by 73 percent. This result suggests that regardless of farm categories, current pangas production levels are significantly high enough for a sound aquaculture business in relation to their production costs and prevailing output prices.

By farm category, the respective break-even production per ha farm levels of intensive, semi-intensive and traditional are calculated at 8 478 kg, 4 377 kg and 1 593 kg, respectively. The average annual pangas production per ha pond in intensive, semi-intensive and traditional farming was found at 13 945 kg, 7 705 kg and 3 380 kg, respectively. These results indicate that the current pangas production performances by intensive, semi-intensive and traditional farms exceeded their respective break-even production levels by 64 percent, 76 percent and 112 percent, respectively. The break-even analysis on production levels imply that all farming categories were able to produce productivity levels that have exceeded break-even production levels.

3.5.8 Net return per kilo of fish

The net return per fish kg is the difference between market price (i.e. US$0.615 per kg) and production costs (i.e. US$0.355 per kg) of per fish kg. It can also be calculated as net return (US$/ha/year) divided by the yield of pangas (kg/ha/year). Table 26 shows that the average net return per kg of pangas was estimated at US$0.26. The highest average net return per kg of pangas production was found in traditional farming (US$0.33/kg) followed by semi-intensive (US$0.27/kg) and intensive (US$0.24/kg) farming. Comparing the farming systems, traditional farmers produced at least cost, with a higher net return per kg fish. Conversely, intensive farmers produced at higher cost, therefore having a lower net return per kg fish.

TABLE 26
Average net return per kg of pangas production by different categories of respondents

Pangas farming	Intensive	Semi-intensive	Traditional	All categories
Net return (US$/ha/year)	3 364.4	2 047.6	1 099.3	2 170.4
Production (kg/ha/year)	13 945.0	7 705.0	3 380.0	8 343.0
Net return per kg (US$/kg)	0.24	0.27	0.33	0.26

3.7 Overview of cost structure and profitability

The findings of the study show that the different farming systems have different cost structures, depending on the availability and quality of inputs, mainly feed, seed, fertilizers, labour and other factors (pond size, water quality and management). The average annual production costs varying from US$5 217 per ha for intensive farms to US$2 694 per ha for semi-intensive and US$981 per ha for traditional farms, there being significant difference. The total production costs per ha pond in intensive farming was higher than other two categories, mainly due to both higher variable costs and fixed costs (Table 27). The relatively higher cost of feed for intensive farmers appears to be due to the use of industrially manufactured pelleted feed.

Comparing the three farming systems, production cost was the lowest for traditional farmers, therefore having a lower production. In contrast, intensive farmers produced at highest cost, therefore having a higher production. Regardless of farming systems, yield of pangas averaged 8 343 kg/ha/year, ranging from 13 945 kg in intensive to 7 705 kg in semi-intensive and 3 380 kg in traditional farming. For intensive farming, increased feed supply (22 370 kg/ha/year) resulted in increased per ha pangas production.

However, additional costs reduced profitability per kg of pangas. The highest average net return per kg of pangas was found in traditional systems (US$0.33/kg) followed by semi-intensive (US$0.27/kg) and intensive (US$0.24/kg) farming.

Farmers in all feeding (farming) practices made a profit from pangas farming. On the average, the net return and the benefit-cost ratio is significantly different among the farming categories (Table 27). The highest benefit-cost ratio is found in traditional farming at 2.12, compared with 1.76 in semi-intensive and 1.64 in intensive systems. On the other hand, the highest net return per hectare is found in the intensive farming category, mainly due to the highest production, as producers appear to be able to afford more inputs, such as feed, seed, fertilizers and labour. However, due to the risk levels (i.e. flood, poaching, diseases, and a lower pangas market price) and high production costs, the profitability of intensive farming may not be acceptable over the longer term. It is therefore suggested that semi-intensive systems may be acceptable and it may be necessary to increase profitability by reducing production costs and better management practice.

The further development of the sector depends on its profitability, and increase in yield was the major means of increasing profit in all systems. Factors such as feed, seed, fertilizers and pond management all influence yield and profitability. Reduction in major variable costs, increased production per unit of pond, associated with increased growth rate, good management and increased price per quantity of pangas by aiming at higher valued production may all increase profit.

TABLE 27
Summary of major findings by different farming systems

Pangas farming	Intensive	Semi-intensive	Traditional	All categories
Pond size (ha)	0.36	0.21	0.12	0.23
Stocking rate (No./ha/year)	35 900	23 575	12 065	23 847
Feeding rate (kg/ha/year)	22 370	13 010	5790	13 723
Production (kg/ha/year)	13 945	7 705	3 380	8 343
FCR	1.60	1.69	1.71	1.64
Variable costs (US$/ha/year)	4 932.5	2 506.2	892.2	2 777.01
Fixed costs (US$/ha/year)	284.6	187.7	88.5	185.5
Total costs (US$/ha/year)	5 217.1	2 693.9	980.7	2 963.5
Gross revenue (US$/ha/year)	8 581.5	4 741.5	2 080.0	5 134.3
Net return (US$/ha/year)	3 364.4	2 047.6	1 099.3	2 170.4
Net return per kg fish (US$)	0.24	0.27	0.33	0.26
Benefit-cost ratio	1.64	1.76	2.12	1.73

3.6 Production problems

A number of constraints were reported by pangas farmers, including dike overflow, water pollution, poor water quality, natural disasters (flood, drought), excessive rainfall, theft, poisoning, high production costs, lack of credit facilities, and inadequate marketing facilities. Poaching of pangas is also a common problem in the study area, and is one of the biggest problems for the poor farmers. A few rich farmers tend to recruit guards or night watchmen to protect against theft and poisoning.

Farmers were requested to state problems that they faced with feed. Eighty eight percent of farmers identified the high feed price as the principal problem. Seven percent and five percent of farmers identified procurement problems and lack of feed availability as additional problems. Table 28 shows that all traditional farmers identified the high price of feed as the major problem, hence resorting to the use of supplementary feed. Semi intensive (90 percent) and intensive (75 percent) farmers were also concerned about the high costs of feed, citing feed costs as the major constraint against the greater expansion of pangas farming in the study area.

TABLE 28
Feed related constraints by farmers by different feed types/feeding practices

Constraints of feed	Intensive: pelleted feed		Semi-intensive: farm-made aquafeed		Traditional: supplementary feed		All categories	
	No.	%	No.	%	No.	%	No.	%
High price	15	75	18	90	20	100	53	88.3
Procurement problems	3	15	1	5	0	0	4	6.7
Less availability in market	2	10	1	5	0	0	3	5.0
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**

Farmers were also faced with problem concerning fingerlings. About 73 percent of farmers identified high fingerlings prices as one of their problems, while a further 17 percent and 10 percent mentioned poor quality and poor availability, respectively (Table 29). In case of traditional farming, the high price of fingerlings was identified by 95 percent of the farmer-respondents compared with 75 percent among semi-intensive and 50 percent among the intensive farmer-respondents. On the other hand, a respective 30 percent, 15 percent and 5 percent of intensive, semi-intensive and traditional farmer-respondents also identified poor quality of fingerlings as a problem.

TABLE 29
Fingerlings related constraints faced by farmers by different feeding practices/farming systems

Constraints regarding fingerlings	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
High price	10	50	15	75	19	95	44	73.3
Poor quality	6	30	3	15	1	5	10	16.7
Less availability in market	4	20	2	10	0	0	6	10.0
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**

Partial harvesting was practised by all of the farmers in the study area. In general, traditional farmers undertake their own harvesting. Conversely, semi-intensive and intensive farmers hired local labourers for the task.

Fifty five percent of pangas farmers identified lower market prices (than other species, e.g. carp) as a problem (Table 30). Since production decisions (e.g. investment and profits) are made on the current market price of pangas, any downward fluctuation in the market will affect the profitability as well as viability of the pangas farming.

Other problems included high transport costs (25 percent of respondents), poor road (17 percent) and intermediary influence (3 percent).

TABLE 30
Marketing related constraints faced by farmers by different feeding practices/farming systems

Marketing constraints	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Falling market price	10	50	11	55	12	60	33	55.0
High transport costs	4	20	5	25	6	30	15	25.0
Poor road and transport facilities	5	25	3	15	2	10	10	16.7
Intermediary influence	1	5	1	5	0	0	2	3.3
Total	**20**	**100**	**20**	**100**	**20**	**100**	**60**	**100**

3.8 Statistical analysis

3.8.1 Production function model

Two forms of production function model were initially estimated to determine the effect of variable inputs. These were: 1) Linear and 2) Cobb-Douglas (Table 31). The Cobb-Douglas production function which is linear in its logarithmic form has several advantages (Smith, 1982) such as: 1) the elasticities of production which measure the responsiveness of output to increase units of input are identical to the production coefficients (b_i). Consequently, a percentage change in output that is brought about by a given percentage change in input use can be easily determined. 2) The sum of the production coefficients (Σb_i) can be interpreted as a measure of economies of scale. If $\Sigma b_i > 1$, for example, positive economies of scale exist, this implies that a double of the use of all inputs will result in more than a doubling of output. 3) Input and output data can readily be used, without aggregation to estimate the parameters of the model. 4) The Cobb-Douglas function has only one degree of freedom per explanatory variable.

TABLE 31
Two forms of the production function

1. Linear
$Y = a + b_1X_1 + b_2X_2 + b_3X_3 \ldots\ldots\ldots\ldots + b_nX_n$

2. Cobb-Douglas (log-linear)
$Y = a\ X_1^{b1}\ X_2^{b2}\ X_3^{b3} \ldots\ldots\ldots\ldots X_n^{bn}$
Or
$\text{Log } Y = \text{Log } a + b_1 \log X_{1i} + b_2 \log X_{2i} + b_3 \log X_{3i} \ldots\ldots\ b_n \log X_{ni} + \text{Log } U_i$

Where,
Y = output, X_i = inputs, b_i = factor (input) productivities, a = constants, and
U_i = random error or disturbance term

The Cobb-Douglas production function was chosen on the basis of best fit and significant result on output. Five inputs or explanatory variables were hypothesized to explain pangas farming. It was hypothesized that using all five inputs will have effect on production as well as income of farm. Regression analysis (ordinary least square method) was used to determine the effect of these inputs. The Cobb-Douglas function model of the following form was used for the analysis:

$Y = a\ X_1^{b1}\ X_2^{b2}\ X_3^{b3}\ X_4^{b4}\ X_5^{b5}\ e^U$

Or in its logarithmic form as:

$\text{Log } Y = \log a + b_1 \log X_{1i} + b_2 \log X_{2i} + b_3 \log X_{3i} + b_4 \log X_{4i} + b_5 \log X_{5i} + \text{Log } U_i$

Where,

Y = Gross revenue (US$)

a = Constant parameter in the equation, mathematically interpreted as the intercept

X_1 = Farm size (ha)

X_2 = Stocking cost (US$)

X_3 = Feed cost (US$)

X_4 = Fertilizer cost (US$)

X_5 = Labour cost (US$)

U_i = Random error or disturbance term (residual or error term which may result from measurement and stochastic errors)

$i = 1, 2, 3 \ldots\ldots\ldots\ n$

The explanatory variables (X_i) or inputs are sometimes known as target variables because they are subject to influence by the producer or decision maker (Chong and Lizarondo, 1982). Of the five explanatory variables specified in the model, all are within the control of producers. The production coefficients (b_i) or exponents in the Cobb-Douglas form are the elasticities of production. The bi terms are actually transformation ratios of the various inputs used in pangas production at different amounts.

The management factor was not included in the model because specification and measurement of management factor is almost impossible in the present study, since the farm operator is both a labourer and manager. Other independent variables like water quality and soil condition which might have affected production of farm enterprises were excluded from the model on the basis of some preliminary estimation.

Initially the results of the estimation for different farming categories were not fitting because of the small sample size, the wide range of observed values and multicolinearity among the independent variables. Of first 10 variables were included but to make it more meaningful, 5 of the insignificant variables were omitted to allow the selection of the most relevant explanatory variables.

3.8.2 Interpretation of results

Before interpreting the results obtained from the estimated revenue function, it is necessary to examine the function for its ability to explain output variation. Two interrelated measures of 'goodness of fit' are known as the correlation coefficient (R), and coefficient of multiple determination (R^2). The maximum possible value for R^2 is 1.0, which implies that 100 percent of the output variation is explained by the estimated function. In applied research using cross-sectional data, one would not expect to find such a high value for R^2 (Smith, 1982). The F-test is usually used to test the overall significance of the independent variables chosen for inclusion in the model. The sign test can also be applied to determine if each of the production coefficients (b_i) has the expected positive or negative sign. Finally, t-tests are used to test the significance of the individual production coefficients.

Estimated values of the coefficients and related statistics of Cobb-Douglas revenue function are presented in Table 32. Regression results showed that the coefficient of multiple determination (R^2) for different farming systems varies from 0.926 to 0.995 which indicates that 92 to 99 percent of the total variation in revenue of pangas farms are explained by the five (5) independent variables included in the model. It also indicates that excluded variables for gross revenue accounted for only 1 to 8 percent of the variation for three different farming systems. F-values of all individual equations are highly significant implying that all the included explanatory variables are important for explaining the variation of intensive, semi-intensive and traditional systems. Therefore t-values of the individual coefficients should be expected to be significant. The selected revenue functions have sufficient degrees of freedom for testing statistical significance and are stable with respect to the sign of their regression coefficients. The levels of significance used were one percent, five percent and ten percent.

The relative contribution of specified factors affecting revenue of pangas farming can be seen from the estimates of regression equation for three different farming systems. In total, there are five input coefficients for the production of selected systems and of those all coefficients had proper (positive) sign in semi-intensive and traditional farming. However, three coefficients had improper (negative) sign in intensive farming. Of the five explanatory variables in the model, four regression coefficients in each farming system are statistically significant at different level (0.01 to 0.10), with the exception of labour costs.

Farm size is a key factor in determining the extent of care and management of pangas farming. Size of farm is an important factor influencing the use of inherent inputs of farm income. It contributed 0.681 percent, 0.391 percent, and 0.284 percent in intensive, semi-intensive and traditional farming system, respectively. Farm size was the only factor that had proper sign of coefficient for each farming system. Therefore it is an important factor to increase or decrease the output.

The estimated coefficient of stocking cost was negative in the intensive systems (-0.081) at 5 percent level of significance. It implies that 1 percent increase in the cost of fingerlings, keeping other factors constant, would decrease gross revenue by 0.081 percent. However, the estimated coefficients of stocking cost were positive in semi-intensive (0.382) and traditional (0.557) farming systems and significant at the 1 percent and 5 percent level, respectively. It implies that 1 percent increase in the number of fingerlings stocked, keeping other factors constant, would raise the quantity of fish harvested by 0.382 percent and 0.557 percent in semi-intensive and traditional farming systems, respectively.

TABLE 32
Estimated values of coefficients and related statistics of Cobb-Douglas production function model

Explanatory variables	Intensive	Semi-intensive	Traditional
Y-intercept	2.37*** (0.55)	3.125*** (0.64)	2.580*** (0.578)
Farm size (X_1)	0.681** (0.062)	0.391*** (0.089)	0.284* (0.106)
Stocking cost (X_2)	-0.081** (0.034)	0.382*** (0.085)	0.557** (0.127)
Feed cost (X_3)	-0.191*** (0.045)	0.231*** (0.071)	0.365** (0.094)
Fertilizer cost (X_4)	-0.169* (0.071)	0.115** (0.092)	0.434** (0.125)
Labour cost (X_5)	0.580^{ns} (0.172)	0.092^{ns} (0.012)	0.041^{ns} (0.011)
R	0.997	0.998	0.996
R^2	0.995	0.926	0.993
F value	1 696.06**	1 934.80**	1 433.82***
Return to scale Σb_i	0.820	1.211	1.651

ns = not significant; *significant at the 10 percent level of confidence; **significant at the 5 percent level of confidence; ***significant at the 1 percent level of confidence; figures within parentheses indicate standard error.

In intensive farming, the regression coefficient of feed cost was -0.191 which was significant at the 1 percent level. It implies that 1 percent increase in the cost of feed, keeping other factors constant, would decrease gross revenue by 0.191 percent. However, in semi-intensive and traditional farming estimated coefficients of feed cost were 0.231 and 0.365 respectively, which indicates that there is enough scope to increase the gross revenue by spending additional amount of feed in these farming systems.

The production coefficient of fertilizer cost was also negative in intensive farming (-0.169) which indicates that 1 percent increase in the cost of fertilizer, keeping other factors constant, would decrease gross revenue by 0.169 percent. However, in semi-intensive farming, the regression coefficient (0.115) was significant at the 5 percent level which implies that 1 percent increase in the cost of fertilizer, keeping other factors constant, would increase gross revenue by 0.115 percent. Similarly an increase of 1 percent cost of the fertilizer, remaining other factors constant would result in an increase of gross income by 0.434 percent in traditional farming.

The summation of all the production coefficients (Σb_i) in semi-intensive pangas farming is equal to 1.211 which is greater than 1. This means that the function exhibits increasing returns to scale; that is, if all the inputs specified in the function are increased by a certain percentage, farm income will increase by a larger proportion. In the example above, if all inputs are increased by 1 percent, income will increase by 1.211 percent in semi-intensive farming. Similarly, if all inputs are increased by 1 percent income will increase by 1.651 percent in traditional farming as the summation of all the production coefficients (Σb_i) is equal to 1.651. However, the summation of all the production coefficients (Σb_i) in intensive farming is equal to 0.820 which is lower than 1. This means that production function for intensive framing system exhibits decreasing return to scale.

From the Cobb-Douglas production function model, most of the included variables (except labour cost) were significantly effective on farm production as well as income in different farming systems. There is a positive effect of these factors in semi-intensive and traditional systems. Return to scale indicates that there are enough scopes to increase the production and income from pangas farms in semi-intensive and traditional systems.

4. CONCLUSIONS

The study shows that sutchi catfish (*P. hypophthalmus*) production is fully dependent on quality feed and other factors (i.e. farm size, stocking rate, fertilization and management skill), the importance of feed increases with the intensification of pangas culture. Feed costs generally constitute the highest single operational costs of traditional, semi-intensive and intensive grow-out farming. It is therefore essential that the feed should achieve maximum efficiency in terms of pangas production per unit cost. However, feed cost appears to be one of the major constraints against the greater expansion of pangas farming. The relative importance of production and feed conversion efficiency fully depend upon the quality and cost of feed in relation to the market value of the farmed product. The unit cost of various types of feed and cost of fish production using each of this feed as well as the unit profitability of each system of pangas production must be compared before one type of feed is selected. It is therefore of great importance to the pangas farmers to utilize feed as optimally as possible.

Higher production levels of pangas among intensive, semi-intensive and traditional farms have consequently activated their high acceptable levels of financial and economic indicators. As such, their estimated coefficients such as gross revenues, net returns, and benefit-cost ratios have reached the levels that are considered relatively financially and economically sound. The Cobb-Douglas production function indicates that there is enough scope to increase the production and income from semi-intensive and traditional systems by more inputs of fry, feed, and fertilizer. However, intensive farming system exhibits decreasing return to scale.

For sustainable pangas farming, the development of low-cost fish feed is essential to reduce the current, heavy dependence on industrially manufactured pelleted feed which has been the standard feed since the inception of intensive pangas cultivation. Farmers are at a turning point in their pangas feeding strategies due to the high price of this feed. However, lack of knowledge and information make them uncertain about the application of other feeds. In which case, the best alternative is farm-made aquafeed. Development of a feed based on low-cost locally produced ingredients would help improve farmer's profit margins. In addition, farmers need to extend their basic knowledge and develop better skills in integrated pangas farming with carps and dike cropping. Training and extension services would help to improve profitability and reduce risks. Although traditional farmers are aware of the positive effects of commercial feeds on their farm operation, lack of capital has prevented them from engaging in semi-intensive feeding practice. It is also essential that adequate credits with low interest are provided by the government as well as national banks to the farmers. This is particularly the case for traditional farmers so that they can shift from low density to high density culture, i.e. traditional to semi-intensive farming systems.

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Economics of aquaculture feeding practices: China

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SUMMARY

This case study was conducted to assess the economic implications of adopting various feeding practices in aquaculture production in China. The case study provided a comparative analysis of three different categories of feeding practices; namely: (1) traditional; (2) semi-intensive; and (3) intensive. To minimize variation in terms of fish species being produced, a comparative analysis of the various feeding practices was undertaken for carp polyculture (silver carp, bighead carp, grass carp, crucian carp and Wuchang bream). Each feeding practice had 20 replicate farms. A total of 60 fish farms were sampled. The stratified random sampling (SRS) technique was utilized in selecting the individual farm from 10 counties in Jiangsu province.

The case study assessed the impacts of the various feeding practices in terms of: (i) gross margin; (ii) net margin/return; (iii) gross and net factor productivities; (iv) returns to land and labour; (v) break-even price coefficients; and, (vi) break-even production coefficients.

The average pond area for intensive, semi-intensive and traditional fish farm investigated under the case study was 1.27, 0.74 and 3.96 ha respectively. Profitability was the main factor for engaging in aquaculture production. The stocking strategy for semi-intensive and intensive farms was multiple stocking, while single stocking was generally practised for traditional farms. Semi-intensive farms, used a combination of commercial and farm-made feeds. Likewise, fertilizer and manure were applied in fish ponds. It was also reported that inorganic fertilizer was used in fish ponds in order to improve the water quality and plankton biomass. Intensive fish farms predominantly utilized commercial feed. On some occasions, use of farm-made feed was also reported. Fertilizer and manure were also applied in intensive farms. Commercial feed was applied in fish ponds through feeding machines while the common application of supplementary feed in intensive fish ponds was through broadcast manually.

The average production costs per ha per year ranged from US$3 839 among traditional farms to US$6 494 and US$10 967 among semi-intensive and intensive farms. In general, variable costs accounted for 99 percent of the total costs. Variable costs mainly included labour, cost of fertilizers, fingerlings, feed and others. Average variable costs per ha per year were highest among intensive farms at US$10 840 and lowest among traditional farms at US$3 812.

The average gross factor productivities (benefit cost ratio, BCR) of intensive, semi-intensive and traditional farms were computed at 1.35, 1.30 and 1.37 respectively. Net factor productivities were estimated at 0.35, 0.30 and 0.37 for intensive, semi-intensive and traditional farms, respectively. The average break-even price per kg of intensive, semi-intensive and traditional fish farms was US$0.73, US$0.79 and US$0.61 while the break-even production for intensive, semi-intensive and traditional fish farms were computed at 11 085, 6 891 and 4 132 kg/ha. All the above break even coefficients are well above the actual market prices and current levels of production of all the farms which imply financially sound aquaculture production enterprises.

The following factors are cited as constraints to the expansion in aquaculture production: lack of capital (45 percent), poor market (12 percent), limited seed availability (7 percent), and lack of technical know how (5 percent). On the other hand, the factors that would lead to an expansion in production are: better disease control (25 percent), better management (23 percent), high quality seed supply (23 percent), more feed input (22 percent), improved stocking density (25 percent), and improved water quality in pond (20 percent).

All respondents cited that the major problem was the high cost of commercial feed. There were also problems in procurement of good quality commercial feed for semi-intensive fish farms and traditional fish farms. In the case of farm-made feeds, the major problem was the high cost of making feed in their farm while there was problem of availability of supplementary feed for some semi-intensive fish farm. All the fish farms reported that the low output price was a major problem to be addressed.

By using a regression model, the relationship between production/profit and input factors were analysed, the gross margin was used as the dependent variable while training days attended, fertilizer cost, seed cost, age, labour cost, education and feed costs were used as the independent variables. The regression model identified labour cost, seed cost, feed cost and education as positively related with the dependent variable (gross income).

The general stochastic frontier production (SFP) function was used to express the relationship between inputs and output, calculating the technical efficiency (TE). The highest average technical efficiency (0.816) was reported in intensive fish farms, followed by traditional (0.8), with the lowest (0.77) in semi-intensive fish farms.

1. INTRODUCTION

1.1 Aquaculture in China

Chinese aquaculture production reached 32.09 million tonnes in 2004, 65 percent of China' fishery production and 70 percent of the world's supply of farmed fish (FAO, 2006)

Chinese fish farming evolved from low output based extensive aquaculture systems in the 1970s, with no additional feed input, through to basic feeding systems, i.e. grass for grass carp and Wuchang bream (*Megalobrama amblycephala*), snails for black carp, and rice bran for crucian carp, to intensive systems using supplementary feed. As farmers realized that additional feed increased production and produced larger fish, the scale of diversification from extensive to intensive production increased. By 2004, commercial fish feed production had reached 8.8 million tonnes (production value of US$5 billion), accounting for 12.5 percent of the total feed input production in China. The annual rate of growth in feed supplements was around 17 percent per annum (Liu Qing, 2006). An added benefit for polyculture systems, was that farmers also found that food waste and feces fertilized the ponds and generated natural food organisms that benefited filter feeders.

1.2 Rationale

The combination of induced breeding, feed management and polyculture were the three contributory factors to the fast growth in Chinese aquaculture production. Feed management improved fish farm efficiency and economics by increasing production through reducing the culture period, and improving growth and meat quality. The proposed case study is expected to shed light on the economics of the various feeding practices as applied in China.

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 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 is justified on the grounds of its financial soundness. A technology that provides reasonable financial incentives to the fish farmers will be more easily adopted than technology which does not.

1.3 Objectives

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

Specifically, the country case study is aimed at:

(i) conducting a survey of feeding practices in sixty (60) aquaculture farms, twenty (20) per category;

(ii) processing and analyzing the data to arrive at a comparative analysis of the farms highlighting the following:
- a) general profile,
- b) production (including feeding) practices,
- c) production costs (fixed investment as well as maintenance and operating costs),
- d) income (gross margin and net margin/return),
- e) production problems,
- f) returns on investments (including labour, land and capital),
- g) break-even analyses (break-even price, cost, production, and sales), 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 (3) different categories of feeding practices; namely: (1) traditional/extensive ; (2) semi-intensive; and (3) intensive. To minimize variation in terms of fish species being produced, the comparative analysis of the various feeding practices was undertaken for carp polyculture in China.

Traditional farming refers to a feeding practice where the feed used is sourced or developed locally and is not distributed commercially. Fish farms using traditional feeding practices use farm-made aquafeed and/or supplementary diets consisting of a mixture of locally available feed ingredients. Farms with intensive feeding practices depend solely on commercially manufactured pelleted feeds while semi-intensive farms use a combination of the two.

2.2 Assessment indicators

This case study assessed the impacts of the various feeding practices in terms of: (i) gross margin; (ii) net margin/return; (iii) benefit cost ratio (BCR); (iv) returns on investment

(ROI), (v) returns to land and labour; (vi) break-even price coefficients; (vii) break-even cost coefficients; (viii) break-even production coefficients; and (ix) break-even sales coefficients. The basis of estimating the above indicators were developed based on a prepared questionnaire.

2.3 Sampling technique

The case studies included three representative feeding practices or systems for the aquaculture farms. Twenty farms were assessed as representative of each feeding system. A total of 60 fish farms were sampled. The stratified random sampling (SRS) technique was utilized in selecting the individual sample farms. The complete list was obtained from the fishery technical extension office of the Bureau of Agriculture and Fisheries. The sample farms were interviewed using a pre-agreed using questionnaire as applied in all the country case studies.

2.4 Data processing and analysis

A tabular analysis was used to develop the costs and returns for the various feeding systems observed in the study sites. The analysis identified the variable cost categories of feed, labour and management as well as fixed costs.

2.5 Scope and duration of the study

The work was undertaken between November and December, 2005. The questionnaire was tested and final adjustments were made prior to the field survey. The survey results were entered into MS Excel for analysis.

3. RESULTS AND DISCUSSION

3.1 Description of the study area

Jiangsu province is well known as a centre for pond carp polyculture. Jiangsu province is located at the lower stream of the Yangtse and Huai rivers, flowing east to the Yellow Sea. It is rich in natural water resources with inland waters comprising 1.79 million ha, including lakes (968 000 ha), rivers (608 000 ha), reservoirs (47 000 ha) and ponds (167 000 ha). Jiangsu is also well known as centre for rice and fish production. The region's fish production was 3.5 million tonnes in 2004, representing 11 percent of the total national production (Yearbook of China fishery statistic, 2005).

Fish is an important source of animal protein within the Province. The percentage contribution of aquaculture to agriculture ranges from eight percent to 52 percent in the 65 counties. Carp is the most important species produced in Jiangsu, but other high value species are also cultured. The most common culture model is polyculture. The major cultured species include grass carp *(Ctenopharyngodon idella)* , silver carp (*Hypophthalmichthys molitrix*), bighead carp *(Aristichthys nobilis)*, black carp *(Mylopharyngodon piceus)*, Wuchang bream *(Megalobrama amblycephala)*, common carp *(Cyprinus carpio)* and crucian carp *(Carassius auratus)*. The grass carp, black carp, Wuchang bream, common carp and crucian carp are the major users of fish feed, and silver carp and bighead carp are the major filtering feed fishes. In 2004, the freshwater culture area was 634 000 ha, and carp production in Jiangsu province was 2 million tonnes, which accounted for 28 percent of the national carp production. (Anon., 2006b)

The case study was undertaken in 10 counties where fish culture is significant. Table 1 illustrates the importance of aquaculture production in each county, along with the average income per farmer. The income range in 2005 was from 3 839 Yuan (US$487) to 8 002 Yuan[1] (US$1 016) per farmer per annum.

[1] US1.00 = 7.87 Yuan

60 farms were selected using the stratified random sampling technique. Table 2 shows the sample size from each county. The farms in the survey covered 39 villages. The location of the surveyed farms were scattered from the north, middle and south of Jiangsu, representing a range of feed management in carp farming (Figure 1).

TABLE 1
Fishery production value, its contribution to agriculture and average income by 10 surveyed counties in 2005

County	Total fishery production value		Contribution to agriculture production (%)	Average income of agri-farmer	
	CNY(10^9)	US$($10^9$)		CNY/year	US$/year
1. Dong Tai	1.50	0.191	8.0	5 665	719.82
2. Gao You	1.66	0.211	34.9	4 938	627.45
3. Hai An	2.50	0.318	52.1	5 300	673.44
4. Li Yang	0.76	0.097	36.0	5 331	677.38
5. Su Qian	3.87	0.492	16.3	3 839	487.80
6. Wu Jiang	13.9	1.766	47.6	8 760	1 113.09
7. Xi Shan	0.14	0.018	13.5	8 002	1 016.77
8. Yan Cheng	9.50	1.207	18.5	4 893	621.73
9. Yang Zhou	3.68	0.468	26.4	5 215	662.64
10. Yi Xing	0.88	0.112	26.0	7 010	890.72

TABLE 2
Number and percent of respondents sampled by location

County	Number	%
1. Dong Tai	15	25
2. Gao You	1	2
3. Hai An	8	13
4. Li Yang	8	13
5. Su Qian	5	8
6. Wu Jiang	8	13
7. Xi Shan	2	3
8. Yan Cheng	4	7
9. Yang Zhou	3	5
10. Yi Xing	6	10
Total	**60**	**100**

3.2 Description of the respondents

Of the 60 farmers in the survey, 91.7 percent were male and 8.3 percent female (Table 3).

The average age of all respondents was 49.7 years (Table 4). The average age of the intensive, semi-intensive and traditional farm respondents was 49 years, 49 years and 52 years respectively.

The average household size of all respondents (Table 4) was 4.4. Semi-intensive farmers had the smallest household size of 3.7, traditional and intensive the largest, 4.7and 4.8 respectively.

The average fish farming experience (Table 4) was 12.7 years, with intensive fish farms reporting the longest experiences in fish farming of 13.7 years.

FIGURE 1
Map of China and sample location in Jiangsu province

TABLE 3
Profile of respondents by category

Category	Gender of respondents			
	No. of male	%	No. of female	%
Intensive farms	17	85	3	15.0
Semi-intensive farms	18	90	2	10.0
Traditional farms	20	100	0	0.0
All farms	55	92	5	8.3

TABLE 4
Average age, household size, and years in fish farming by category

Category	Age	Household size	Years in farming
Intensive farms	48.75	4.8	13.70
Semi-intensive farms	48.85	3.7	12.15
Traditional farms	51.6	4.7	12.35
All farms	49.73	4.40	12.73

Of the all respondents, 92 percent were married and 8 percent were single. Whilst most traditional farmers were married (85 percent), a larger number were unmarried relative to the other groups (Table 5).

TABLE 5
Marital status by category

Marital status	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Married	19	95	19	95	17	85	55	92
Single	1	5	1	5	3	15	5	8
Total	20	100	20	100	20	100	60	100

All the respondents have a relatively high education background. Most of the respondents completed primary (38 percent) and secondary school education (42 percent) (Table 6). Twenty percent of the respondents completed high school and 5 percent were able to complete their college education. By the feeding categories, intensive and semi-intensive fish farming respondents were more highly educated with 45 percent and 40 percent having completed secondary education and 20 percent having completed high school respectively.

Farmers with both longer farming experience and higher education, had a greater probability for adopting intensive feeding systems. This may be also explained by better understanding of aquaculture technology and management strategies among the intensive fish farmers.

TABLE 6
Education attainment by category

Education	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Primary	6	30	7	35	10	50	23	38
Secondary	9	45	8	40	8	40	25	42
High school	4	20	4	20	1	5	9	15
College	1	5	1	5	1	5	3	5
Total	20	100	20	100	20	100	60	100

Sixty two percent reported that fish farming was their main occupation (Table 7), with a further 27 percent of farmers describing agriculture as their main occupation. Ten percent of the respondents in the intensive fish farming category claimed that fish trading was their main occupation. Intensive farmers also reported a greater knowledge of economic conditions and market information.

TABLE 7
Main occupation by category

Occupation	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Fish farming	13	65	12	60	12	60	37	62
Fishing	2	10	0	0	1	5	3	5
Fish trading	2	10	0	0	0	0	2	3
Agriculture	2	10	7	35	7	35	16	27
Carpenter	1	5	0	0	0	0	1	2
Others	0	0	1	5	0	0	1	2
Total	20	100	20	100	20	100	60	100

3.3 General profile of the farm

The average total pond area of intensive, semi-intensive and traditional fish farm was 2.7, 2.65 and 6.23 ha respectively. The intensive fish farm had fewer ponds (2.9), while semi-intensive and traditional fish farms had a larger number (4.5 and 4.85). The average pond area for intensive, semi-intensive and extensive fish farms was 1.27, 0.74 and 3.96 ha respectively. The average pond water depth of all categories in the rainy season was 2.42 m, and 1.92 m in the dry season (Table 8).

The traditional fish farms had the largest ponds in all three categories, whilst intensive fish farms had the smallest pond size, while the semi-intensive were somewhere between the two. Ponds with an area of 1 ha were perceived by the respondents as optimal area for culture management, with larger areas difficult to manage.

Twenty seven percent of respondents were single owner occupiers (Table 9). Seven percent were multiple owner occupiers. Sixty five percent of the respondents reported singly leased ponds. These respondents identified fish farming as a promising business opportunity. Forty one percent of the lessees were in the intensive sector where income expectations were greater. However, a not insignificant number were also in the semi-intensive (31 percent) and traditional sectors (28 percent).

TABLE 8
Total number, total area, average area of ponds and average water depth by category of respondents

Item	Intensive	Semi-intensive	Traditional	All categories
Total no. of ponds	2.90	4.50	4.85	4.083
Total area of ponds (ha)	2.70	2.65	6.23	3.86
Average area of ponds (ha)	1.27	0.74	3.96	1.87
Average water depth (m)				
Rainy season	2.27	2.50	2.49	2.42
Dry season	1.88	1.89	2.01	1.92

TABLE 9
Ownership structure by category of respondents

Type of ownership	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Single ownership	4	20	5	25	7	35	16	27
Multiple ownership	0	0	3	15	1	5	4	7
Singly leased	16	80	12	60	11	55	39	65
Jointly leased	0	0	0	0	1	5	1	2
Total	20	100	20	100	20	100	60	100

The average pond lease was 5.78 years. Intensive fish farms had longer lease durations, 6.8 years, while semi-intensive and traditional fish farms had shorter lease durations, 5.2 years. The respondents stated that longer lease periods of 5–7 years were sufficient to invest, plan and maintain (Table 10).

TABLE 10
Ownership, number of lessees and duration for jointly leased farms by category of respondents

Item	Intensive	Semi-intensive	Traditional	All categories
Number of owners (multiple ownership)	-	2	2	2
Number of lessees (jointly leased)	0	0	1	1
Duration of lease (months)	82	62	62	69

Seventy seven percent of the respondents used the ponds exclusively for fish farming (Table 11), while 23 percent used the ponds for other integrated activities including duck and chicken farming as well as other livestock.

TABLE 11
Pond utilization by category of respondents

Pond utilization	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Fish culture	17	85	14	70	15	75	46	77
Multipurpose	3	15	6	30	5	25	14	23
Total	20	100	20	100	20	100	60	100

The average number of full time farm workers was 2.12 (Table 12). Intensive fish farms had less full time labour (1.75), while semi-intensive and traditional fish farms had higher labour levels (2.5 and 2.1 respectively). The respondents said that the higher labour activity in semi-intensive and traditional fish farms was a direct result of using labour for feed collection. This labour comprised family members, including children. Among family members, the wife took care of daily management, feeding and domestic activities, while the husband was responsible for marketing and technical matters.

The average number of part-time workers was 2.14. Traditional fish farms had less part time labour than the other two categories. Part time labour was usually used for stocking, guarding, feeding and routine pond management. The average number of casual workers was 9.16. The main casual responsibilities were for harvesting.

TABLE 12
Average number of labourers employed by category of respondents

Item	Intensive	Semi-intensive	Traditional	All categories
	(Average)	(Average)	(Average)	(Average)
Full-time labour (No.)	1.75	2.50	2.10	2.12
Part-time labour (No.)	2.08	3.00	1.33	2.14
Casual labour (No.)	6.14	12.33	9.00	9.16
Total	3.33	5.94	4.14	4.47

Eighty percent of the respondents reported that fish farming was undertaken for commercial reasons (Table 13). The proximity to water and close access to fish culture was cited as the second main reason for undertaking fish farming. Own consumption was not perceived as a major reason for fish farming.

TABLE 13
Main factors considered in undertaking fish farming by category of respondents

Factor	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Commercial	16	80	14	70	17	85	47	78
Own consumption	1	5	0	0	1	5	2	3
Access to fish culture technology	2	10	3	15	1	5	6	10
Feed availability	1	5	3	15	0	0	4	7
Seed availability	0	0	0	0	1	5	1	2
Others	0	0	0	0	0	0	0	0
Total	20	100	20	100	20	100	60	100

3.4 Farm production practices

3.4.1 Stocking strategies

Polyculture was the only stocking model used by all the farmers. The stocked species included silver carp, bighead carp, grass carp, crucian carp and Wuchang bream. Intensive fish farms adopted multi-harvest and multi-stocking strategies to operate the pond more efficiently.

The culture period for all fish farms was estimated at 301 days. Culture periods for traditional, semi-intensive and intensive farms were 291 days, 324 days and 286 days respectively. It was reported that shorter culture periods, within these cycles enabled farmers to recover financial investments on a continuous basis during the year (Table 14).

TABLE 14
Average culture period (days) for polyculture practice by species and by category of respondents

Type of species	Intensive	Semi-intensive	Traditional	All categories
Silver carp	282	318	280	292
Bighead carp	317	338	289	320
Grass carp	294	325	281	300
Black carp	277	335	299	301
Crucian carp	288	270	269	278
Wuchang bream	286	356	296	318
All species	291	324	286	301

The study revealed that all traditional fish farms applied a single stocking strategy. Eighty percent and 20 percent of intensive fish farms and semi-intensive fish farms applied single stocking, and multiple stocking strategies, correspondingly (Table 15).

TABLE 15
Stocking strategy by category of respondents

Item	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Single stocking	16	80	16	80	20	100	52	87
Multiple stocking	4	20	4	20	0	0	8	13
Total	20	100	20	100	20	100	60	100
Number of stocking (for multiple stocking)								
2x per year	3	75	3	75	0	0	6	75
3x per year	1	25	1	25	0	0	2	25
Total	4	100	4	100	0	0	8	100

Silver carp and bighead carp were the main species stocked in traditional ponds. Black carp would also be stocked if there were snails in the pond. Grass carp, Wuchang bream, crucian carp and black carp were the main species stocked in intensive and semi-intensive farms. However, there were large differences in species mix from one site to the next. The species compositions were usually determined by local market preferences and preferred culture technique.

Fish farmers would usually stock over-winter fingerlings (yearlings) in the pond, and would add fish seed as proceeds from sales generated surplus cash. Some farmers stocked fry in ponds to produce fish yearlings for the next fish production year.

Multi-harvesting was carried out in intensive farms. Fish fingerlings of different sizes were stocked in ponds. The bigger fish were harvested after two to three months growth in the pond, while the others were harvested after 4–6 months. The remainders were retained as over-winter fingerlings for the next production circle.

The biomass in fish ponds was always maintained at high levels in intensive fish farms (Table 16). Moreover, pumps and aerators were applied to keep good water quality and high dissolved oxygen.

TABLE 16
Fingerling stocking density (No./ha/year) and ratio (%) by type of species and by category of respondents

Species	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
1. Silver carp	15 653	31.8	5 652	16.3	7 285	26.6	9 530	25.7
2. Bighead carp	2 393	4.9	2 160	6.2	1 365	5.0	1 973	5.3
3. Grass carp	10 678	21.7	5 323	15.4	4 553	16.6	6 851	18.5
4. Black carp	752	1.5	541	1.6	441	1.6	578	1.6
5. Crucian carp	14 604	29.6	16 966	48.9	11 039	40.3	14203	38.3
6. Wuchang bream	3 145	6.4	2 604	7.5	2 689	9.8	2 813	7.6
7. Other fishes	2 068	4.2	1 414	4.1	53	0.2	1 178	3.2
Total	49 295	100	34 661	100	27 424	100	37 126	25.7

The average stocking rate (by species) for intensive fish farms was 49 295 pieces per ha per year; 34 661 pieces per ha per year for semi-intensive fish farms; and 27 424 pieces per ha per year for traditional fish farms (Table 16). Intensive fish farms had the highest stocking rate, and traditional fish farms had the lowest stocking rate. The higher stocking rate in intensive fish farms was due to multiple stocking, mixed-age and multi-harvest practices. This type of stocking rate normally allows for a harvest frequency of 2–3 times during the stocking season. This balance regulates market supply and improves the economic returns.

Seventy eight percent of respondents reported applying modular stocking[2] in carp farms (Table 17). Fish farmers utilized modular stocking to change the major fish in

[2] Modular stocking is a method to improve the pond production efficiency. This enables the pond operator to stock and harvest the fish continuously. Farmers stock fingerlings in pond for about one month, then shift to another pond for grow-out.

polyculture ponds. Other farmers did not use this practice due to the limited pond area and lack of capital to buy fingerlings.

TABLE 17
Modular stocking by category of respondents

Response	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Yes	14	70	17	85	16	80	47	78
No	6	30	3	15	4	20	13	22
Total	20	100	20	100	20	100	60	100

In terms of cost on fingerling stocking, traditional fish farms cultured more filter feeding species, i.e. silver carp and bighead carp (31 percent of stocking cost). Intensive fish farms spent more feed dependent species i.e. grass carp, Wuchang bream, black carp and crucian carp (75 percent). The semi-intensive fish farms cultured both filter feeders and feed dependent species depending on farmers' economic wealth and seed availability in the area (Table 18).

TABLE 18
Cost of fingerling stocking by species and by category of respondents (US$/ha, percent)

Species	Intensive		Semi-intensive		Traditional		All categories	
	Total cost	**%**	**Total cost**	**%**	**Total cost**	**%**	**Total cost**	**%**
1. Silver carp	442	10.4	615	20.9	415	23.0	491	16.4
2. Bighead carp	364	8.6	237	8.0	141	7.8	247	8.2
3. Grass carp	1705	40.2	968	32.9	574	31.8	1082	36.1
4. Black carp	351	8.3	224	7.6	109	6.0	228	7.6
5. Crucian carp	861	20.3	648	22.0	353	19.6	621	20.7
6.Wuchang bream	264	6.2	175	5.9	134	7.4	191	6.4
7. Other fishes	257	6.1	79	2.7	77	4.3	138	4.6
Total	4243	100	2946	100	1802	100	2997	100

Mixed age stocking provides a sound basis for multi-harvesting. The larger fish grows faster and needs more feed. While the small fish needs less feed and grows slower. The bigger fish are harvested when they reach marketable size (e.g. after 2–3 months). The small fish will reach market size at a much later stage (e.g. 4–8 months). This common multi-harvest practice in intensive fish farming enables the farmers to generate income continuously and address short term cash flow deficiencies during the production process.

3.4.2 Fertilization and feeding practice

Type of fertilizers and feed

Fertilizers
Forty eight percent of the respondents reported applying fertilizer in on-growing fish ponds (Table 20). Sixty five percent of intensive fish farmers used fertilizer to improve water quality. In traditional fish farms, 75 percent fish farmer reported that they did not use fertilizer for on-growing fish ponds. However, they did use fertilizer on grass land to produce more green grass as fish feed. Twenty five percent of fish farmers reported that they applied fertilizer to improve natural food organisms in ponds. Fertilizers/compost comprised cow manure/dung, chicken/poultry manure, pig manure, and inorganic fertilizers such as TSP, and urea.

TABLE 19
Average stocking weight and length by species and category of respondents

Item	Intensive	Semi-intensive	Traditional	All categories
Silver carp				
Weight (g)	213.80	107.50	110.26	143.85
Size (cm)	15.69	12.34	10.79	12.94
Bighead carp				
Weight (g)	159.60	147.00	201.00	169.20
Size (cm)	15.70	13.60	11.80	13.70
Grass carp				
Weight (g)	236.09	122.06	58.58	138.91
Size (cm)	15.39	10.00	9.00	11.46
Black carp				
Weight (g)	433.81	365.00	425.00	407.94
Size (cm)	21.37	20.69	19.83	20.63
Crucian carp				
Weight (g)	60.70	23.20	40.00	41.30
Size (cm)	7.36	7.20	5.71	6.76
Wuchang bream				
Weight (g)	167.50	117.50	52.00	112.33
Size (cm)	14.00	10.63	8.60	11.08

TABLE 20
Use of fertilizer for on-growing by category of respondents

Response	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Yes	13	65	11	55	5	25	29	48
No	7	35	9	45	15	75	31	52
Total	20	100	20	100	20	100	60	100

TABLE 21
Average application quantity (kg/ha/year) of inorganic and organic fertilizers by type of fertilizers and category of respondents

Type of fertilizer	Intensive	Semi-intensive	Traditional	All categories
A. Inorganic				
1. Urea (nitrogen)	147	188	11	136
2. TSP (phosphate)	277	450	173	290
3. MP (potash)	-	-	-	-
4. DAP (potash)	-	-	-	-
5. Others	225	-	-	225
All inorganic	649	638	183	651
B. Organic				
1. Dung	-	-		-
2. Compost	2 503	3 330	2 719	2 808
3. Others, specify	-	-		-
All organic	2 503	3 330	2 719	2 808
All fertilizers	3 152	3 968	2 902	3 459

TSP = triple super phosphate; MP = muriate of potash; DAP = di-ammonium phosphate

TABLE 22
Frequency of fertilizer use by type of fertilizer and category of respondents

Type of fertilizer/frequency	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
A. Cow manure								
Daily	1	50	0	-	0	-	1	50
Irregular	1	50	0	-	0	-	1	50
Total	2	100	-	-	-	-	2	100
B. Poultry/chicken manure								
Daily	0	0	1	25	1	50	2	15
Weekly	1	14	0	0	0	0	1	8
Monthly	1	14	0	0	0	0	1	8
Irregular	5	71	3	75	1	50	9	69
Total	7	100	4	100	2	100	13	100
C. Pig manure								
Daily	0	0	0	0	1	33	1	8
Weekly	0	0	0	0	1	33	1	8
Bi-weekly	0	0	2	29	0	0	2	17
Irregular	2	100	5	71	1	33	8	67
Total	2	100	7	100	3	100	12	100
D. Urea (nitrogen)								
Never	0	0	0	0	0	-	0	0
Daily	0	0	1	33	0	-	1	13
Weekly	2	40	0	0	0	-	2	25
Irregular	3	60	2	67	0	-	5	62
Total	5	100	3	100	0	-	8	100
Type of fertilizer/frequency	**Intensive**		**Semi-intensive**		**Traditional**		**All categories**	
	No.	%	No.	%	No.	%	No.	%
E. TSP (phosphate)								
Bi-weekly	1	33	0	0	0	-	1	25
Irregular	2	67	1	100	0	-	3	75
Total	3	100	1	100	0	-	4	100
F. Others								
Daily	0	0	1	100	0	-	1	33
Irregular	2	100	0	0	0	-	2	67
Total	2	100	1	100	0	-	3	100

Urea and TSP were reportedly used in fish ponds because of their lower costs. Cow, chicken and pig manure were commonly used as compost by all groups of farmers. However, an additional new compound fertilizer (commercially know as FeiShuiBao, the common ingredients include microorganism fertilizer, plant nutritional parts, organic nitrogen and phosphorus, trace elements, amino acids, vitamin complex, and inositol, etc.) was used by intensive fish farmers to improve the water quality in ponds.

Fertilizers were commonly applied weekly, biweekly or irregularly (Table 22). Most of the organic fertilizer was used as base manure (Figures 2 and 3), and inorganic fertilizer was used as additional inputs during the growing period.

Feed

Feed included industrial commercial fish feed, compound feed and farm made fish feed. The crude protein varied from 25.0 percent to 30.6 percent. Intensive fish farms were dependent on pellet fish feed during the grow-out period. The average content of protein was 30.6 percent for intensive fish farms, and 25.0 percent for semi-intensive fish farms. The feed applied by intensive fish farms used to have higher crude protein content. Higher protein feeds were more expensive. Only fewer semi-intensive fish farms reported the use of farm made aquafeed, due to the high cost of operation and fixed investment. This practice is becoming increasingly unpopular among fish farmers (Table 24).

Supplementary feeds were also applied in all farming systems and included rice bran, wheat, oil cake, soybean cake, green grasses, waste water, snail meat and worm meal depending on the local availability. Traditional fish farms applied more supplementary feed for fish i.e. rice bran, oil cake and grasses to improve the fish production. (Figures 4 and 5).

Feeding strategy, frequency and application method
Intensive feeding was common among intensive fish farmers (75 percent), while semi-intensive and traditional feeding were common among semi-intensive and traditional fish farmers (Table 25).

The most common application method for pellet feed was through broadcasting over the pond, especially among semi-intensive and traditional fish farms. This method used more labour in feed management (30 percent in semi-intensive and 25 percent in traditional fish farms). Feeding machines were used in feeding (75 percent reporting using feeding machine) in intensive fish farms (Figure 6). Supplementary feeds were applied through the broadcast method particularly when using rice bran and wheat. Green grasses were normally placed in a feeding frame in the fish pond. In case when the farmer feed the summer-fingerlings, they use feeding tray to prevent the big fish to take the feed. The trays are placed upside down in water, the mesh size allows the fingerlings to swim inside the tray, but the big one can not (Figure 7).

FIGURE 2
Fermented manures are commonly used in fish ponds in China

FIGURE 3
Terrestrial grasses are submerged as fertilizer

3.5 Comparative analysis of farm production costs

3.5.1 Fixed costs

Farm fixed costs include the costs of buildings, truck/pickup, aerator, pumps, feeding machine and others. Pumps and aerators are fixed investment common to all farm categories. Feeding machines were common in intensive fish farms but not used in semi-intensive and traditional systems. The fixed cost per ha of intensive, semi-intensive and traditional fish farm was US$126, US$52 and US$27 respectively (Table 27). Intensive fish farms have the highest average fixed investment relative to semi-intensive and traditional farms. Table 27 shows buildings and aerator as the most significant fixed cost item, with average investments of US$468 and 171 respectively.

TABLE 23
Average proximate composition (% dry matter basis) feeds by type and category of respondents

Type of feed/average proximate composition	Intensive	Semi-intensive	Traditional	All categories
A. Industrially manufactured pelleted fish feed				
1. Moisture	12.4	12.5	-	12.4
2. Crude protein	30.6	25.0	-	27.8
3. Crude lipid	2.8	2.5	-	2.6
4. Ash	15.3	15.5	-	15.4
5. Crude fibre	12.3	14.5	-	13.4
6. NFE[1]	26.6	30.0	-	28.3
Type of feed/average proximate composition	**Intensive**	**Semi-intensive**	**Traditional**	**All categories**
B. Pelleted fish feed produced by cottage feed plant				
1. Moisture	12.0	-	-	12.0
2. Crude protein	24.8	27.3	-	26.1
3. Crude lipid	3.0	-	-	3.0
4. Ash	14.0	-	-	14.0
5. Crude fibre	9.0	-	-	9.0
6. NFE	37.2	-	-	37.2
C. Farm-made aquafeed				
1. Moisture	-	12.0	-	12.0
2. Crude protein	-	30.0	-	30.0
3. Crude lipid	-	-	-	-
4. Ash	-	15.0	-	15.0
5. Crude fibre	-	4.0	-	4.0
6. NFE	-	-	-	-

[1]Nitrogen free extract= 100 - (moisture+ crude protein + crude lipid +ash +crude fibre); "-" refer to data not available

TABLE 24
Average quantity (kg/ha/year) of feed by type and category of respondents

Type of feed	Intensive	Semi-intensive	Traditional	All categories
A. Commercially manufactured pellet	14 202	3 621	-	5 941
B. Farm (home)-made pellet	-	430	75	168
C. Supplementary feed				
1. Rice bran	428	863	450	580
2. Wheat bran/flour	1 118	570	576	754
3. Oil cakes	1 028	1 124	719	957
4. Soybean meal	150	75		75
5. Aquatic plants/green grass	2 700	9 744	3 728	5 390
6. Slaughter house waste	-	281	195	159
7. Snail meat	600	993	420	671
8. Worm meal	-	75	38	38

TABLE 25
Feeding strategy by category of respondents

Item	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Feeding strategy								
Well planned and well practised (regular)	15	75	8	40	10	50	33	55
Well planned but not well practised (occasional)	4	20	6	30	3	15	13	22
Not well planned and practised (irregular)	1	5	6	30	7	35	14	23
Total	20	100	20	100	20	100	60	100

FIGURE 4
Farmer simply mix supplementary feed before feeding

FIGURE 5
Water lamina as feed for grass carp juveniles

FIGURE 6
Auto-feeders are common in intensive fish farms in China

Courtesy of Mohammad R. Hasan

FIGURE 7
Feeding trays are used in modular grow-out pond for fingerlings feeding

3.5.2 Variable costs

Cost of labour
Labour is used for pre-stocking, stocking/release and post stocking. Intensive farms use more labour than the other farming systems (461 man days/ha/year) (Table 28). Semi-intensive and traditional fish farms had fewer labourers (357 and 311 man days/ha respectively). The major differences were accounted for by hired labour, amounting to 304, 209 and 153 man days/ha for intensive, semi-intensive and traditional fish farms. Intensive fish farms had almost double the quantity of hired labour as compared with traditional fish farms.

The average annual labour costs incurred by intensive, semi-intensive and traditional fish farms were US$2 064, US$1 644 and US$1 417 respectively (Table 29).

Cost of fertilizers
The costs of inorganic fertilizer for intensive, semi-intensive and traditional fish farms were estimated at US$1 334/ha/year, US$81/ha/year, and US$20/ha/year, respectively (Table 30). Intensive fish farms have the highest cost in inorganic fertilizer, since they applied specialized fertilizer to improve the water quality.

TABLE 26
Feed application methods by type of feed and category of respondents

Type of feed/application method	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
A. Manufactured pelleted feed								
1. Broadcasting	1	5	6	30	5	25	12	20
2. Feeding tray	0	0	0	0	0	0	0	0
3. Feeding bag	1	5	0	0	0	0	1	2
4. Feeding frame	0	0	1	5	0	0	1	2
5. Automatic feeding	15	75	0	0	0	0	15	25
Total	17	85	7	35	5	25	29	49
B. Pelleted cottage fish feed								
1. Broadcasting	0	0	2	10	2	10	4	7
2. Feeding tray	0	0	0	0	0	0	0	0
3. Feeding bag	0	0	0	0	0	0	0	0
4. Feeding frame	0	0	0	0	0	0	0	0
5. Automatic feeding	1	5	2	10	0	0	3	5
Total	1	5	4	20	2	10	7	12
C. Farm-made aquafeed								
1. Broadcasting	1	5	4	20	2	10	7	12
2. Feeding tray	0	0	0	0	0	0	0	0
3. Feeding bag	0	0	0	0	0	0	0	0
4. Feeding frame	0	0	0	0	0	0	0	0
5. Automatic feeding	0	0	0	0	0	0	0	0
Total	1	5	4	20	2	10	7	12
D. Supplementary feed								
1. Broadcasting	1	5	1	5	1	5	3	5
2. Feeding tray		0	0	0	0	0	0	0
3. Feeding bag	0	0	0	0	0	0	0	0
4. Feeding frame	1	5	3	15	2	10	6	10
5. Automatic feeding	0	0	0	0	0	0	0	0
Total	2	10	4	20	3	15	9	15
E. Pelleted animal feed								
1. Broadcasting	1	5	5	25	3	15	9	15
2. Feeding tray	0	0	0	0	0	0	0	0
3. Feeding bag	0	0	0	0	0	0	0	0
4. Feeding frame	0	0	0	0	0	0	0	0
5. Automatic feeding	0	0	0	0	0	0	0	0
Total	1	5	5	25	3	15	9	15

TABLE 27
Average purchase and depreciation values of fixed investment by type and category of respondents (US$/ha)

Item	Intensive		Semi-intensive		Traditional		All categories	
	Purchase value (US$)	Depreciation (US$)	Purchase value (US$)	Depreciation (US$)	Purchase value (US$)	Depreciation (US$)	Purchase value (US$)	Depreciation (US$)
A. Buildings	695	39	353	23	357	20.0	469	27
B. Truck/pick-up	198	14	26	2.5	10	1.0	78	6
C. Aerator*	296	27	186	15	32	4.0	171	15
D. Feeding machine	242	24	0	0	0	0.0	81	8
E. Pumps	215	18	126	10	29	2.0	123	10
F. Others	54	5	10	1	2	0.1	22	2
Total	1 700	126	701	52	430	27	944	68

*Few traditional farmers use aerators in grass carp pond because of the high stocking density used, and feed only with grasses.

TABLE 28
Average quantity of human labour by type of operation and category of respondents (man day/ha/year)

Type of operation	Intensive			Semi-intensive			Traditional			All categories		
	Hired	Family	Total	Hired	Family	Total	Hired	Family	Total	Hired	Family	Total
A. Pre-stocking	99.0	32.3	131.3	123.0	31.5	154.5	50.3	34.5	84.8	90.8	32.8	123.5
B. Stocking/ release of fingerling	93.8	33.0	126.8	28.5	31.5	60.0	33.0	32.3	65.3	51.8	32.3	84.0
C. Post-stocking	111.0	92.3	203.3	57.0	85.5	142.5	69.8	91.5	161.3	79.3	89.8	169.0
All operations	303.8	157.5	461.3	208.5	148.5	357.0	153.0	158.3	311.3	221.8	154.8	376.5

TABLE 29
Average cost of human labour by type of operation and category of respondents (US$/ha/year)

Type of operation	Intensive			Semi-intensive			Traditional			All categories		
	Hired	Family	Total	Hired	Family	Total	Hired	Family	Total	Hired	Family	Total
A. Pre-stocking	413	132	545	532	139	671	232	169	401	392	147	539
B. Stocking/release of fingerling	390	128	518	133	153	286	163	159	322	229	147	376
C. Post-stocking	551	448	1 000	270	417	687	300	393	693	374	420	794
All operations	1 355	709	2 064	935	709	1 644	696	721	1 417	995	713	1 708

TABLE 30
Average cost (US$/ha/year) of inorganic and organic fertilizers by type of fertilizers and category of respondents

Type of fertilizer	Intensive	Semi-intensive	Traditional	All categories
A. Inorganic				
1. Urea (nitrogen)	3.48	4.69	0.15	2.77
2. TSP (phosphate)	4.15	1.69	0.86	2.23
3. MP (potash)	-	-	-	-
4. DAP (potash)	-	-	-	-
5. Others	3.52	-	-	1.17
All inorganic	11.14	6.38	1.01	6.18
B. Organic				
1. Dung	-	-	-	-
2. Compost	7.03	2.08	0.70	3.27
All organic	7.03	2.08	0.70	3.27
All fertilizers	18.17	8.46	1.71	9.45

Compost was the most common organic fertilizer. The costs of organic fertilizer in intensive, semi-intensive and traditional fish farms were estimated at US$7.03/ha/year, US$2.08/ha/year, and US$0.70/ha/year, respectively (Table 30).

Cost of seeds
Fingerling stocking density and cost differs for each farming system. The average stocking amount was very high because the farms applied multi-harvest and multi-stocking strategies in both intensive and semi-intensive fish farms. Different stocking models also had different costs due to the difference in prices for the different species.

Intensive fish farms had the highest stocking quantity (49 295 pieces/ha/year) and costs (US$4 243/ha/year). This was followed by semi-intensive and traditional fish farms applying 34 661 pieces/ha (US$2 946/ha/year), and 27 424 pieces/ha (US$1 802/ha/year) (Table 31).

TABLE 31
Number and cost of fish seed by type and category of respondents (No. of fish/ha; US$/ha)

Species	Intensive		Semi-intensive		Traditional		All categories	
	Number	Cost	Number	Cost	Number	Cost	Number	Cost
1. Silver carp	15 653	442	5 652	615	7 285	415	9 530	491
2. Bighead carp	2 393	364	2 160	237	1 365	141	1 973	247
3. Grass carp	10 678	1 705	5 323	968	4 553	574	6 851	1 082
4. Black carp	752	351	541	224	441	109	578	228
5. Crucian carp	14 604	861	16 966	648	11 039	353	14 203	621
6.Wuchang bream	3 145	264	2 604	175	2 689	134	2 813	191
7. Other fishes	2 068	257	1 414	79	53	77	1 178	138
Total	49 295	4 243	34 661	2 946	27 424	1 802	37 126	2 997

Cost of feeds

Feed costs varied between fish farm systems. The feeding strategies adopted by intensive fish farms was generally characterized by using pellet feeds, while semi-intensive fish farms and traditional fish farms were partial users of pellet feeds, combined with some low value supplementary feeds. The cost of pelleted feeds in intensive, semi-intensive and traditional fish farms were US$2 872.8/ha, US$800.6/ha and US$11.3/ha per year, respectively. Supplementary feed costs for intensive, semi-intensive and traditional fish farms were US$678.6/ha/year, US$560.8/ha/year and US$400.6/ha/year respectively. Traditional fish farms incurred lowest supplementary feed costs than intensive and semi-intensive fish farms.

The total feed cost picture revealed that it was highest among intensive fish farms at US$3 551/ha, followed by semi-intensive fish farms and traditional fish farms with US$1 361/ha/year and US$412/ha/year respectively (Table 33).

While intensive farms consumed more commercial pellets in their fish farming operations, semi-intensive fish farms applied partial commercial pellets and some farms used farm-made feeds to reduce costs. Supplementary feeds mainly include rice bran, wheat, oil cakes, soybean meal and grasses. These type of feeds are locally available at lower prices.

The study noted that snails were fed to black carps while silkworm meal was also used as supplementary feeds in some farms (Table 33).

Other variable costs

Staff salaries, electricity, office supplies, rent and drugs were reported as other variable costs. The average total other variable cost of intensive fish farms were estimated at US$963/ha. Semi-intensive and traditional fish farms incurred costs of US$483/ha and US$179/ha, respectively (Table 34).

Staff salaries were the highest in intensive fish farms at US$166/ha, relative to semi-intensive fish farms and traditional fish farms which were valued at US$33/ha and US$6/ha, respectively. The cost of drugs in semi-intensive fish farms were reported as the highest US$81/ha compared with intensive fish farms and traditional fish farms of US$47/ha and US$26/ha, respectively.

3.5.3 Total costs

The total costs of traditional, semi-intensive and intensive fish farms were US$3 839/ha/year, US$6 494/ha/year, and US$10 967/ha/year respectively. Variable costs accounted for 99 percent of the total costs in each category. Fixed costs accounted for a very small percentage (1.1 percent, 0.8 percent, 0.7 percent in intensive, semi-intensive and traditional fish farms respectively). Intensive fish farms had the highest total costs in fish production (Table 35).

TABLE 32
Average cost (US$/ha) of fingerlings by type of species and category of respondents

Stocking/species	Intensive	Semi-intensive	Traditional	All categories
A. First stocking				
1. Silver carp	423	610	411	482
2. Bighead carp	320	237	141	233
3. Grass carp	1 616	957	574	1 049
4. Black carp	351	224	109	228
5. Crucian carp	837	646	352	612
6. Wuchang bream	225	175	134	178
7. Other fishes	257	79	77	138
All species	4 029	2 927	1 797	2 918
B. Second stocking				
1. Silver carp	18	6	4	9
2. Bighead carp	44	-	-	15
3. Grass carp	89	11	-	33
4. Black carp	-	-	-	-
5. Crucian carp	23	3	2	9
6. Wuchang bream	39	-	-	13
7. Other fishes	-	-	-	-
All species	213	20	6	79
C. All stocking				
1. Silver carp	442	615	415	491
2. Bighead carp	364	237	141	247
3. Grass carp	1 705	968	574	1 082
4. Black carp	351	224	109	228
5. Crucian carp	861	648	353	621
6. Wuchang bream	264	175	134	191
7. Other fishes	257	79	77	138
All species	4 243	2 946	1 802	2 997

TABLE 33
Average cost of feeds by type of feed and category of respondents (US$/ha/year)

Type of feeds	Intensive	Semi-intensive	Traditional	All categories
A. Commercially manufactured pellets	2 872.8	714.9	-	1 195.9
B. Farm-made pellets	-	85.7	11.3	32.3
Subtotal	2 872.8	800.6	11.3	1 228.2
C. Supplementary feeds				
1. Rice bran	58.5	87.2	11.3	52.3
2. Wheat bran/flour	238.2	91.9	86.2	138.8
3. Pulse bran	-	-	-	-
4. Oil cakes	178.4	189.7	105.4	157.8
5. Fishmeal	-	-	-	-
6. Bone meal	-	-	-	-
7. Soybean meal	64.7	13.1		25.9
8. Aquatic plants/green grass	101.3	47.1	139.8	96.0
9. Slaughter waste		38.7	24.4	21.0
10. Snail meat	37.5	74.4	19.5	43.8
11. Worm meal	0.0	18.8	14.1	10.9
12. Others (specify)	-	-	-	-
Subtotal	678.6	560.8	400.6	546.7
All feed types	3 551.4	1 361.4	411.8	1 774.9

TABLE 34
Other variable costs by type and by category of respondents (US$/ha/year)

Item	Intensive	Semi-intensive	Traditional	All categories
1. Staff salary	166	33	6	69
2. Electricity	252	99	25	125
3. Office supplies	62	7	-	23
4. Rent	435	261	123	273
5. Drugs	47	81	26	51
Total	963	483	179	542

Fry/fingerling/seed costs were the highest cost item among all farm groups (Figure 8). The percentage of seed cost to total cost were 39 percent, 45 percent and 47 percent for intensive, semi-intensive and traditional fish farms respectively.

Feed costs account for 32 percent, 21 percent and 11 percent of total costs in intensive, semi-intensive and traditional fish farms respectively. In three categories, intensive fish farms have the highest percentage of feed costs.

Labour costs were highest in traditional systems (37 percent), followed by semi-intensive (25 percent) and intensive (19 percent) (Table 35).

TABLE 35
Total costs by item and by category of respondents

Item	Intensive		Semi-intensive		Traditional		All categories	
	Amount/ ha/year (US$)	%	Amount/ ha/ year (US$)	%	Amount/ ha/ year (US$)	%	Amount/ ha/ year (US$)	%
A Variable costs								
1. Labour cost	2 064	18.8	1 644	25.3	1 417	36.9	1 708	24.1
2. Fertilizers	18	0.2	8	0.1	2	0.0	9	0.1
3. Fry/fingerlings	4 243	38.7	2 946	45.4	1 802	47.0	2 997	42.2
4. Feeds	3 551	32.4	1 361	21.0	412	10.7	1 775	25.0
5. Other variable costs	963	8.8	483	7.4	179	4.7	542	7.6
Subtotal	10 840	98.8	6 443	99.2	3 812	99.3	7 032	99.0
B Material input*	8 776	80.0	4 799	73.9	2 395	62.4	5 323	75.0
C Depreciated fixed costs	126	1.1	51	0.8	27	0.7	68	1.0
Total	10 967	100	6 494	100	3 839	100	7 100	100

*Material input costs =total variable costs - labour cost

3.6 Comparative analysis of farm income

3.6.1 Gross revenue

Intensive, semi-intensive and traditional fish farms recorded gross revenues of US$14 800/ha/year, US$8 429/ha/year and US$5 261/ha/year, respectively. The average gross revenue of all categories was US$9 498/ha/year (Table 36). As expected, intensive fish farms registered the highest gross revenue while traditional fish farms, the lowest (Figure 9).

Gross margin

Intensive fish farms had the highest gross margin of US$3 960/ha/year, semi-intensive fish farms and traditional fish farms had lower gross margins of US$1 986/ha/year and US$1 449/ha/year respectively. All fish farms were able to realize profits, regardless of category. The average gross margin of fish farms was US$2 466/ha/year (Table 37). This figure was almost double the average gross margin obtained from agricultural crop production (about US$1 000/ha/year) in Jiangsu province (Anon., 2006a).

3.6.2 Net margin/return

The average net margin was recorded at US$2 398/ha/year. The net margins for intensive, semi-intensive and traditional fish farms were estimated at US$3 834/ha/year

US$1 935/ha/year and US$1 422/ha/year respectively (Table 37). Intensive fish farms had the highest net margins in fish farming.

TABLE 36
Annual gross revenues per hectare (US$) by harvest and species and by category of respondents

Type of operation	Intensive	Semi-intensive	Traditional	All categories
A. First harvest				
1. Silver carp	2 333	904	1 271	1 502
2. Bighead carp	1 090	289	818	732
3. Grass carp	3 354	2 518	1 315	2 396
4. Black carp	870	1 025	216	704
5. Crucian carp	3 207	765	988	1 931
6. Wuchang bream	917	1 599	488	724
7. Others	1 230	431	165	609
All species	13 001	7 531	5 261	8 598
B. Second harvest				
1. Silver carp	101	68	0	57
2. Bighead carp	193	174	0	122
3. Grass carp	197	103	0	100
4. Black carp	619	113	0	244
5. Crucian carp	71	68	0	46
All species	1 182	527	0	569
C. Third harvest				0
1. Silver carp	39	0	0	13
2. Bighead carp	0	0	0	0
3. Grass carp	83	0	0	28
4. Black carp	82	0	0	27
5. Crucian carp	0	0	0	0
All species	204	0	0	68
D. Fourth harvest				
1. Silver carp	64	0	0	21
2. Bighead carp	160	0	0	53
3. Grass carp	0	0	0	0
4. Black carp	42	0	0	14
5. Crucian carp	0	0	0	0
All species	266	0	0	89
E All harvest				
1. Silver carp	2 538	972	1 271	1 594
2. Bighead carp	1 443	464	818	908
3. Grass carp	3 633	2 621	1 315	2 523
4. Black carp	1 614	1 138	216	989
5. Crucian carp	3 278	833	988	1 978
6. Wuchang bream	917	1 599	488	724
7. Others	1 230	431	165	609
All species	14 653	8 058	5 261	9 324
F. Biomass carried				
for next year	146	371	0	174
All harvests	14 800	8 429	5 261	9 498

3.7 Comparative analysis of financial impacts of feeding systems

3.7.1 Benefit cost ratio/gross total factor productivity

The average benefit cost ratio (BCR) for intensive, semi-intensive and traditional fish farms were 1.35, 1.30 and 1.37 respectively (Table 37). Intensive fish farms had the lowest benefit cost ratio, while traditional fish farms, the highest.

TABLE 37
Summary of annual financial and economic indicators by category of respondents, per hectare

Item		Intensive	Semi-intensive	Traditional	All categories
A.	Gross revenue (US$)	14 800	8 429	5 261	9 498
B.	Total costs (US$)	10 967	6 494	3 839	7 100
C.	Total variable costs (US$)	10 840	6 443	3 812	7 032
D.	Total fixed costs (US$)	126	51	27	68
E.	Gross margin (US$)	3 960	1 986	1 449	2 466
F.	Net margin/return (US$)	3 833	1 935	1 422	2 398
G.	Net return to land (US$)	3 399	1 674	1 299	2 125
H.	Net return to labour (US$)	1 770	291	5	690
I.	Break-even price (US$)	0.73	0.79	0.61	0.71
J.	Prevailing market price (US$)	1.11	0.98	1.02	1.04
K.	Break-even production (kg/ha)	11 085	6 891	4 132	7 369
L.	Actual production (kg/ha)	38 251	16 111	9 343	21 235
M.	Gross total factor productivity	1.35	1.30	1.37	1.34
N.	Net total factor productivity	0.35	0.30	0.37	0.34

Total costs = variable costs + fixed cost; total variable cost = value of total aquaculture inputs (fertilizer, feeds, fingerlings, hired and family labour, electricity, and other variable costs); total fixed cost = sum of tax (fees, lease, interest and rental), repair costs of equipment, operating costs of equipment plus depreciation; gross revenue = value of total aquaculture outputs (value of home consumed fish + value of marketed fish; gross margin = gross revenue less total variable costs; net margin/return = gross revenue less total cost; net return to land = net return less land rent payment; net returns to labour = net return less cost of labour; net return to capital = net return less 10 percent of fixed investments; gross total factor productivity (benefit cost ratio, BCR) = gross revenue divided by total costs; net total factor productivity = net return divided by total costs; break-even price = total cost divided by total production; break-even production = total cost divided by average price.

3.7.2 Net returns to land

The average net returns to land for intensive, semi-intensive and traditional fish farms were estimated at US$3 399/ha/year, US$1 674/ha/year and US$1 299/ha/year, respectively. Intensive fish farms had the highest return to land compared to semi-intensive and traditional fish farms, although the investment in intensive fish farms was the highest among all categories (Table 37).

3.7.3 Net returns to labour

The average returns to labour for intensive, semi-intensive and traditional fish farms were estimated at US$1 770/ha/year, US$ 291/ha/year and US$ 5/ha/year, respectively. Intensive fish farms had better returns to labour. The efficiency of labour use in intensive fish farms was higher than that of semi-intensive and traditional fish farms. The contributory characteristics for success were high input/proportionally higher output, the focus on fish farming compared to other activities (Table 37).

3.7.4 Break-even analysis of costs, prices and production

The average break-even price for intensive, semi-intensive and traditional fish farms were estimated at US$0.73/kg, US$0.79/kg and US$0.61/kg The average harvest

FIGURE 8
Comparison of total cost composition by category

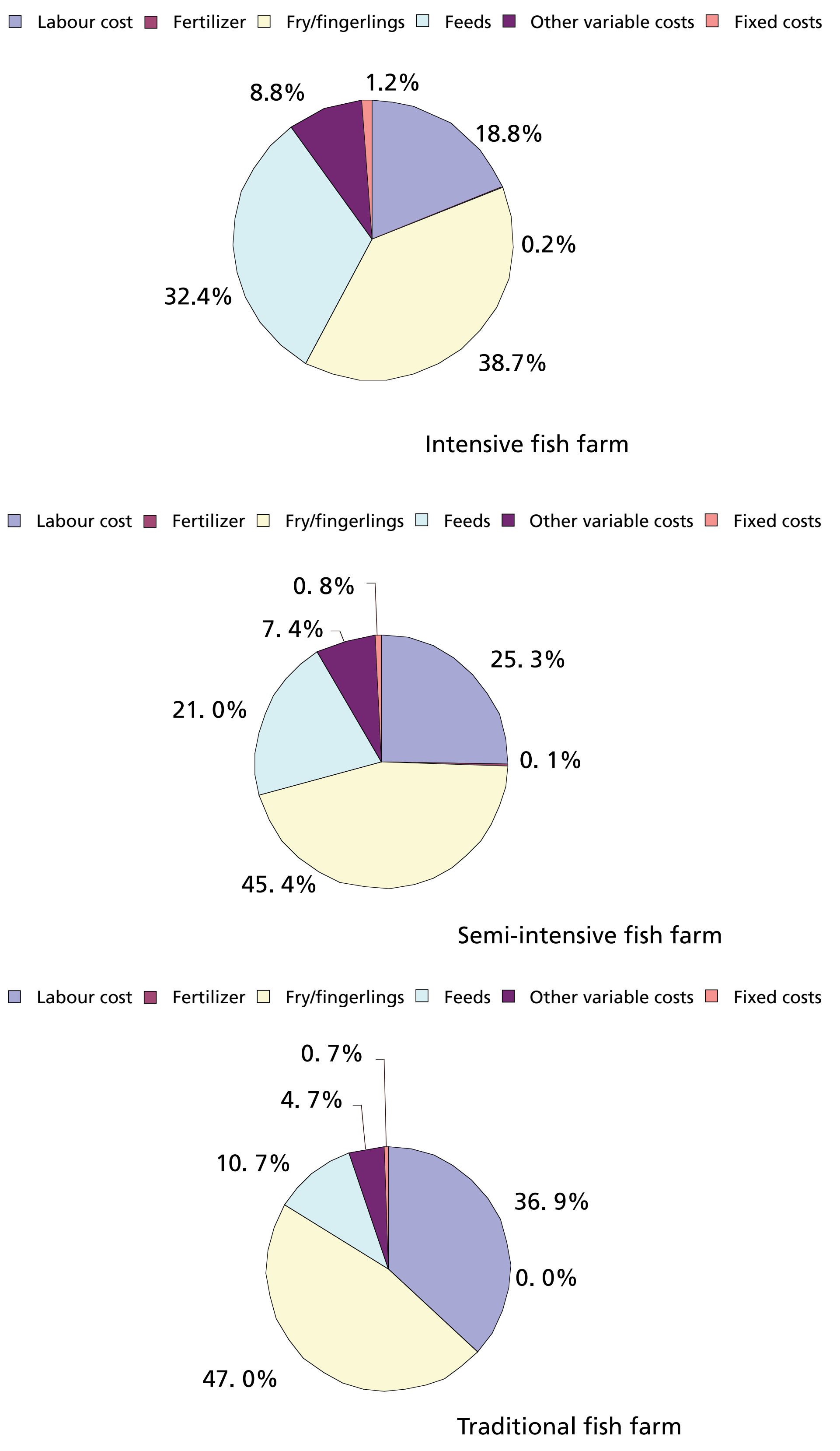
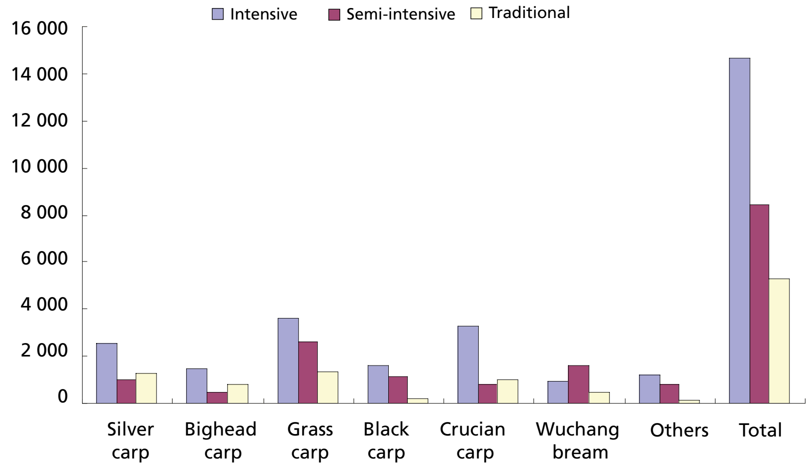


FIGURE 9
Comparison of gross revenue by category



price at pond, i.e. US$1.11/kg (152 percent), US$0.98/kg (124 percent) and US$1.02/kg (167 percent) for intensive, semi-intensive and traditional fish farms respectively (Figure 10). This means that since the actual prices were higher than the estimated break-even prices, fish farmers were financially secure in their fish farming endeavuors. (Table 37)

The break-even production of intensive, semi-intensive and traditional fish farms was 11 085 kg/ha/year, 6 891 kg/ha/year and 4 132 kg/ha/year. This also was lower than that of average harvest production. The actual average production were estimated at 38 251 kg/ha/year (345 percent), 16 111/kg/ha/year (233 percent) and 9 343/kg/ha/year (226 percent) for intensive, semi-intensive and traditional fish farms respectively (Figure 11). The actual production levels were higher than the break-even production levels for all farm categories. This implies that all fish farms are operating well as far as yield performances are concerned (Table 33).

3.8 Production problems

Of all fish farmer respondents, 65 percent of the fish farmers did not wish to expand their fish farming activities. Thirty five percent planned to expand fish farming in the future (Table 38). Respective percentages of 50, 45 and 10 of intensive, semi-intensive and traditional fish farmers indicated their desires to expand. The market for carp is still considered strong within China indicating a fairly prosperous future for farmers.

TABLE 38
Fish farmer's future production expectations by category of respondents

Seeking to expand	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Yes	10	50	9	45	2	10	21	35
No	10	50	11	55	18	90	39	65
Total	20	100	20	100	20	100	60	100

3.8.1 Enabling factors to expand production

The principal enabling factors for expansion in production were improved fish disease control (25 percent), better management (23.33 percent), high quality seed supply (23.33 percent), more feed input (21.67 percent), improved stocking density (25 percent), and improved pond water quality (20 percent) (Table 39). Disease control was perceived to be a very significant issue among intensive and traditional farmers.

FIGURE 10
Comparison of break-even price with actual price by category

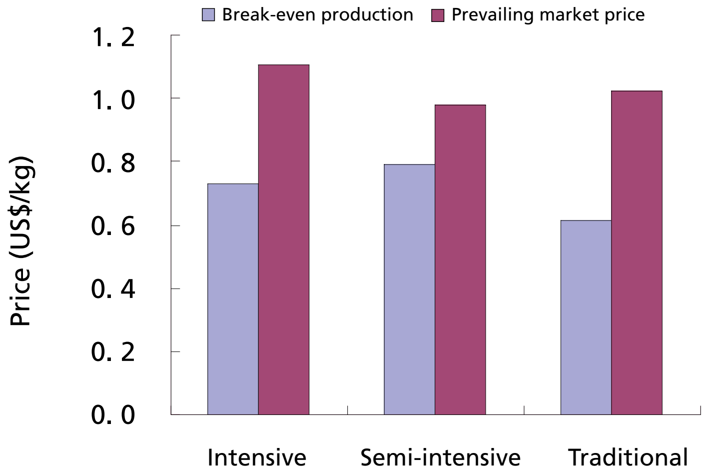
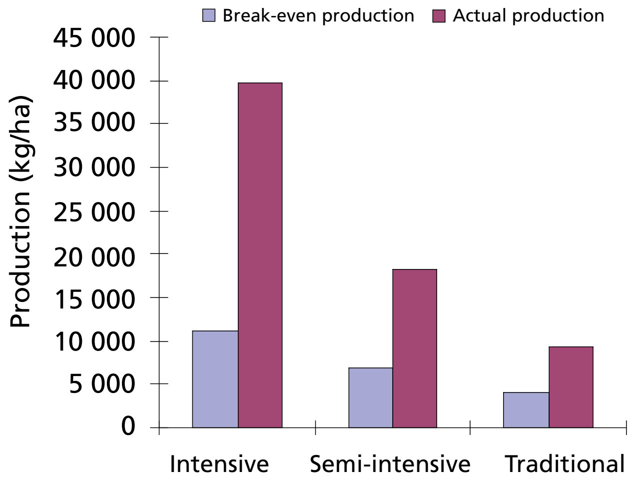


FIGURE 11
Comparison of break-even production and actual production by category



Semi-intensive farmers were looking to increase their usage of commercial feeds, thus changing to intensive.

TABLE 39
Enabling factors to produce more fish by category of respondents

Enabling factor	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
More feed	6	30	6	30	1	5	13	21.7
High stocking of fry	6	30	8	40	1	5	15	25.0
Quality of fry	7	35	6	30	1	5	14	23.3
Better management	7	35	7	35	0	0	14	23.3
Disease control	8	40	5	25	2	10	15	25.0
Improved water quality	6	30	6	30	0	0	12	20.0

3.8.2 Disabling factors to expand production

The study reveals that the factors that prevent expansion in production, included lack of money (45 percent), poor access to market facilities[3] (11.67 percent), limited seed availability (6.67 percent), and a lack of knowledge (5.0 percent).

TABLE 40
Disabling factors to produce more fish by category of respondents

Disabling factor	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Lack of money	7	35	7	35	13	65	27	45
Limited seed availability	1	5	3	15	0	0	4	7
Poor market facility	2	10	3	15	2	10	7	12
Limited knowledge	1	5	2	10	0	0	3	5

High prices of commercial feed were reported as a significant problem for intensive farmers. Commercial feed procurement and availability were not considered as a problem (Table 41)

TABLE 41
Problems concerning industrially manufactured pellet feeds by category of respondents

Problems	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Procurement	0	0	1	5	2	10	3	5
Availability	0	0	2	10	0	0	2	3
High price	20	100	4	20	0	0	24	40
Total	20	100	7	35	2	10	29	48

Farm-made feed was not commonly applied in carp fish farms (Table 42) because of a reluctance to use costly feeding machines.

TABLE 42
Problems concerning farm-made feed by category of respondents

Problems	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Procurement	0	0	0	0	0	0	0	0
Availability	0	0	0	0	0	0	0	0
High price	0	0	2	10	2	10	4	7
Total	0	0	2	10	2	10	4	7

Supplementary feed is popular in carp farming. There was no problem in procurement and the price was affordable for the farmers. A few semi-intensive fish farms (5 percent) reported that the availability of supplementary feed was problem (Table 43).

TABLE 43
Problems concerning supplementary feed ingredients by category of respondents

Problems	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Procurement	0	0	0	0	0	0	0	0
Availability	0	0	1	5	0	0	1	2
Price	0	0	0	0	0	0	0	0
Total	0	0	1	5	0	0	1	2

[3] While there is high demand in carp market, fish farmers are not able to sell their fish in the larger market because of a poor delivery chain (distance from some mountainous areas), as well as lack of real time market information.

There were also problems reported in the supply of fingerlings (Table 44). Semi-intensive fish farms (15 percent) and traditional fish farms (20 percent) reported that procurement of fingerlings in the market is was below the stocking demand[4]. High fingerling prices were reported as a problem for about 5 percent of semi-intensive fish farms. Uncertainty of the health of fingerling was reported as problem for a few intensive fish farms (5 percent) and semi-intensive fish farms (10 percent).

TABLE 44
Fingerling related problems by category of respondents

Problems	Intensive		Semi-intensive		Traditional		All categories	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Procurement	0	0	3	15	4	20	7	12
Availability	0	0	0	0	0	0	0	0
Price	0	0	1	5	0	0	1	2
Health	1	5	2	10	0	0	3	5
Total	1	5	6	30	4	20	11	18

In China, there are a lot of fish varieties sold on the market. Consumers have a lot of choice on what species to buy. Since most carps are considered as low meat quality commodities, their low selling prices were reported as a major problem for 15 percent, 15 percent and 20 percent of intensive, semi-intensive and traditional fish farms, respectively. A farmer suggested that lack of training in fish marketing is also a problem (Table 45)

TABLE 45
Marketing related problems by category of respondents

Problems	Intensive		Semi-intensive		Traditional		All categories	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Transportation	0	0	0	0	0	0	0	0
Storing/icing/packaging	0	0	0	0	0	0	0	0
Price	3	15	3	15	4	20	10	16
Market intermediary								
Influence	0	0	0	0	0	0	0	0
Training	1	5	0	0	0	0	1	2
Total	4	20	3	15	4	20	11	18

4. PROFIT MODEL AND EFFICIENCY ANALYSIS

4.1 Production model

A regression model was used to analyse the relationships between production, profit and inputs, gross profit was used as the dependent variable while training days attended, fertilizer cost, seed cost, age, labour cost, education and feed costs were used as the independent variables in the regression model. The general model is expressed below:

Total income = f (labour, seed, feed, education)

Results of the regression analysis using SPSS 11 are indicated below:

TABLE 46
Regression model summary

Model	R	R Square	Adjusted R Square	Standard error of the estimate
1	0.939	0.882	0.873	1 641.23

Predictors: (Constant), edu, feed, labour, seed

[4] There were some problems in obtaining high quality and appropriate species.

TABLE 47
ANOVA analysis of regression

Model	Sum of Squares	df	Mean Square	F	Level of significance
Regression	1 106 467 060.795	4	276 616 765.199	102.693	0.000
Residual	148 149 166.660	55	2 693 621.212		
Total	1 254 616 227.455	59			

Predictors: (constant), education, feed, labour, seed; b. dependent variable: gross income

TABLE 48
Coefficients of regression of total income and labour, seed, feed cost and education

Model	Unstandardized coefficients		Standardized coefficients	t	Level of significance
	B	Standard Error	Beta		
Constant	426.764	950.594		0.449	0.655
Labour	1.304	0.363	0.182	3.592	0.001
Seed	1.124	0.163	0.37	6.908	0.000
Feed	1.607	0.144	0.607	11.163	0.000
Education	83.966	85.713	0.047	0.980	0.332

Dependent variable: gross income

From the above analysis, the regression model has a good fit with the production function ($R^2 = 0.882$, F = 102.6 significant level at 0.01). The model can be used to explain the factors that affect fish production. Specifically, regression results suggest that 88.2 percent of the behavior of gross profit can be explained by the independent variables. The t-value for education (t = 0.332) is not significant at 5 percent level while the other variables are shown significant.

Of all independents, i.e. labour cost, seed cost, feed cost and education were positively related with the dependent (gross income). This means we may increase the gross income by increasing the inputs of labour, seed, and feed. Feed is identified as the most significant contributory factor to production increases. The more educated the fish farmer, the higher total income expectations. It can be argued that more educated farmers can provide better management in the farms which will consequently increase farm production and income.

4.2 Technical efficiency analysis

The general stochastic frontier production function was used to express the relationship between inputs and output. The general production model was as below:

$Ln(Yi) = \beta_0 + \beta_1 Ln(X_1) + \beta_2 Ln(X_2) + \ldots \beta_k Ln(X_k) + (Vi - Ui)$

Where

Yi is the production of the i-th farm (i = 1 2 3. . . . . .n)

Xi is a vector of input quantities applied by the i-th farm

βi is a vector of unknown parameters to be estimated

Vi is a random variable assumed to be independently and identically distributed with mean zero and variance σ_v^2 [$N(0, \sigma_v^2)$] and independent of Ui; and

Ui is a non-negative random variable associated with technical inefficiency in production. It is assumed to be independently distributed as the truncation (at zero) of the normal distribution with mean μ_i and variance σ_u^2 ($|N(\mu_i, \sigma_u^2)|$);

The technical efficiency of the i-th sample farm, denoted by TEi is derived as follows: TEi = exp (-Ui)

The maximum likelihood estimate (MLE) of the parameters of the model and the generation of farm-specific TE are estimated using the FRONTIER 4.1 package (Coelli, 1994).

The coefficients and technical inefficiency factors are shown in Table 49. All the production costs had a significant effect on the production function. Pond number, average water area, age, sex and experience had positive relationship to the technical efficiency, while pond size, average pond water depth, marital status, family size, education, and training had negative relationship to technical efficiency.

Applying t test, the results show that the technical efficiency of intensive and traditional fish farms has no significant difference (α=0.05), while semi-intensive fish farms has significant difference with intensive and traditional fish farms (Table 50).

The highest average technical efficiency was reported in intensive fish farms (0.816), followed by traditional (0.8) and semi-intensive (0.77). This can be explained by the low feed management efficiency of semi-intensive fish farms. This low feed management efficiency among semi-intensive farms may be due to their eagerness to increase production by simply increasing the feeds supplied without looking at the feed conversion ratios. Intensive fish farms had more efficiency in feed management under the high input of feed costs. Traditional fish farms with their lower investment on feeds, also had a high efficiency in feeding based on a lower input scenario.

TABLE 49
Maximum-likelihood estimates of the stochastic c–d production frontier function and technical inefficiency model

		Coefficient	Standard error	t-ratio
Stochastic frontier function				
beta0		3.494	0.513	6.813
beta1	Labour cost	0.201	0.066	3.045
beta2	Fertilizers	0.017	0.017	0.979
beta3	Fingerlings	0.460	0.056	8.198
beta4	Feeds	0.067	0.016	4.167
beta5	Variable costs	0.010	0.016	0.647
beta6	Fixed costs	0.021	0.021	1.030
Technical inefficiency factors				
delta1	Pond number	0.005	0.004	1.345
delta2	Pond size	-0.002	0.001	-1.509
delta3	Average water area	0.075	0.031	2.383
delta4	Average water depth	-0.024	0.051	-0.466
delta5	Age	0.004	0.003	1.700
delta6	Sex	0.050	0.097	0.512
delta7	Marital status	-0.018	0.083	-0.215
delta8	Family size	-0.009	0.017	-0.524
delta9	Education (year)	-0.038	0.028	-1.362
delta10	Experience (year)	0.000	0.004	-0.104
delta11	Training	-0.017	0.067	-0.258
	δ^2	0.029	0.029	0.006
	Γ	0.123	0.123	0.254
		λ=-2(L(H_0)-L(H_1))= 174		

TABLE 50
Feeding technical efficiency by category of respondents

	Intensive	Semi-intensive	Traditional
Average	0.816[a]	0.769[b]	0.803[a]
Maximum	0.926	0.925	0.993
Minimum	0.611	0.605	0.679

Average values with different superscripts are significantly different ($p<0.05$)

Analysing the distribution of feeding technical efficiency in intensive, semi-intensive and traditional fish farms, the highest frequencies of intensive fish farms occurred at TE of 0.8–0.9, while semi-intensive fish farms and traditional fish farms occurred at TE of 0.7–0.8 both (Figures 12, 13 and 14).

FIGURE 12
Distribution of technical efficiency in intensive fish farms

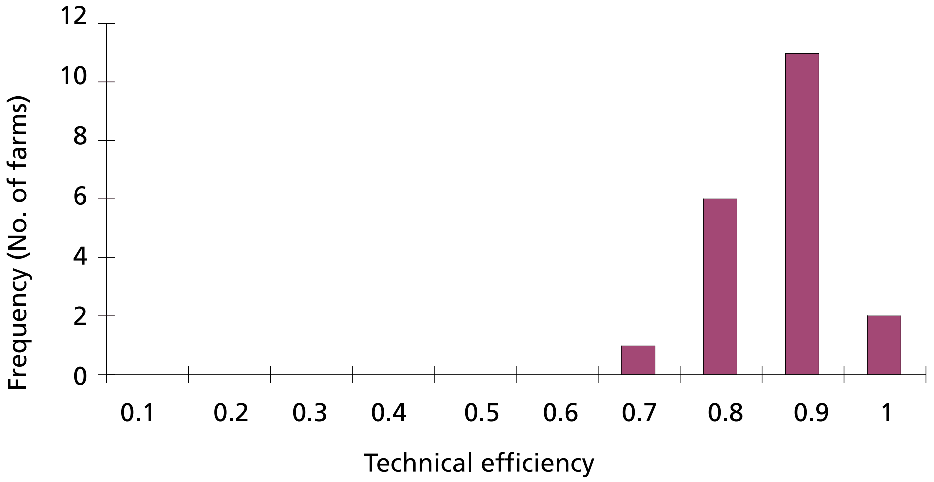


FIGURE 13
Distribution of technical efficiency in semi-intensive fish farms

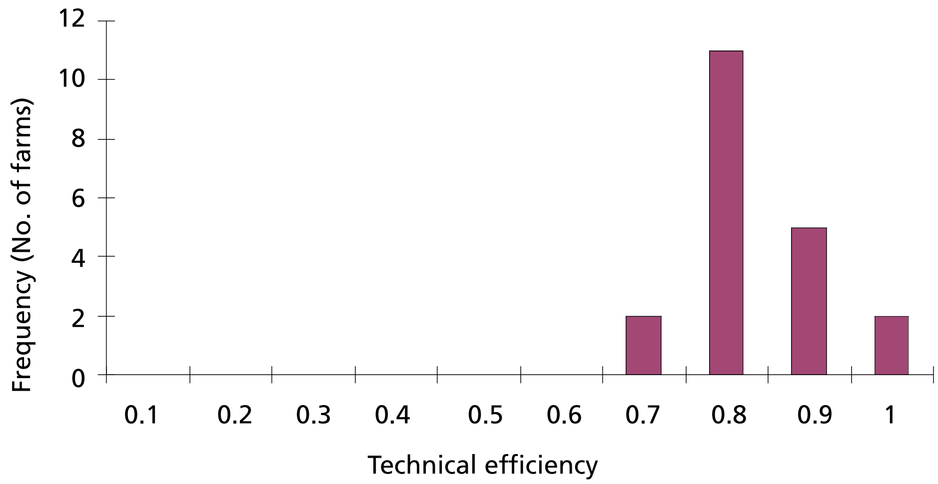
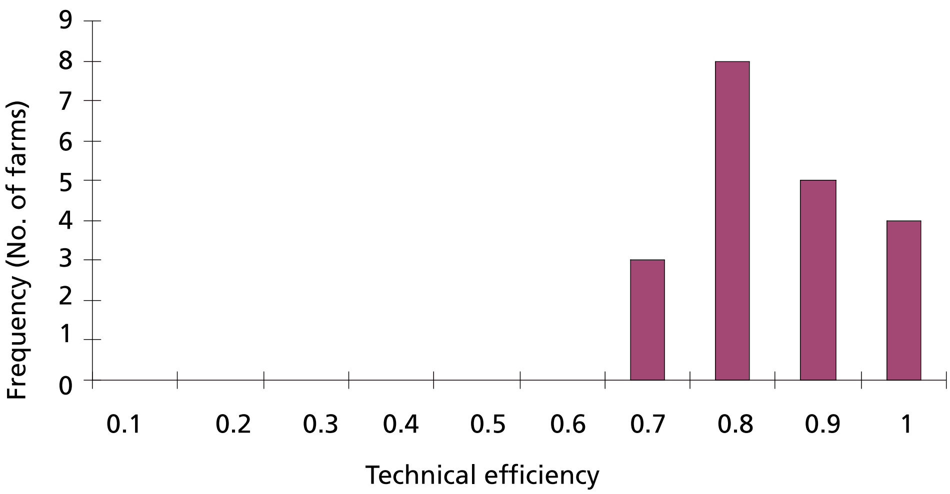


FIGURE 14
Distribution of technical efficiency in traditional fish farms



5. CONCLUSIONS AND RECOMMENDATIONS

Results of the study imply that intensive and semi-intensive fish farms have higher input level and higher production, the economic return is also higher. The major factor is the adoption of commercial feed and intensive feed management. Improved fish production and gross income will result from a combination of increases in adoption of commercial feed inputs and intensive feed management. Feeding fish with commercial pellets and supplementary feeds were the common approach used to improve the production of traditional fish farms.

The intensive fish farms have the highest technical efficiency among the three categories. The technical efficiency analysis indicates that semi-intensive farms have the lowest technical efficiency in feed management and hence this category of fish farms need to improve the technical efficiency through improved farm management. Traditional fish farms should adopt pellet feed feeding strategies to increase the production. Feeding fish with partial commercial feeds and supplementary feeds will be a good strategy in improving production.

The fixed costs in intensive fish farms were the highest in all categories. Buildings, pickup/trucks and feeding machine were used to improve the feed efficiency. Semi-intensive and traditional fish farms has comparatively lower fixed inputs, as feed stuffs are broadcasted into pond by hand.

Lack of money, inadequate access to market facilities, limited seed availability, and a lack of knowledge were reported as the major constraints to expanding production. Expansion in production could be facilitated by improved disease control, better farming practices, high quality/certified seed supply, increased feed input, better stocking, access to credit and improved pond water quality.

The high price of commercial feeds, the poor health fingerlings and lack of marketing training were reported as the problems for intensive fish farms. Lower market price of commercial feed and local resources for supplementary feed development for fish farming are suggested. Training and education can be provided by the commercial feed companies.

The results of the regression analyses as reflected in the values of R^2 and F and *t* statistic suggest that seed, feed application and labour are statistically significant predictors of the behavior of net profit in carp production. Increasing the use of these inputs shall increase profitability.

Recommendations:

i) To promote the application of commercial feed and supplementary feed in aquaculture practice.
ii) To carry out research on how to improve the feeding efficiency in semi-intensive fish farms.
iii) To improve the market accessibility for aquaculture products in terms of access to real time information and improved delivery systems.
iv) To improve the quality of seed supply system to farmers.
v) To establish a training and education programme for rural fish farmers.

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Economics of aquaculture feeding practices: Punjab, India

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SUMMARY

The State of Punjab is emerging as the major carp farming state of India with several farmers diversifying from wheat and paddy cultivation into aquaculture. A survey was undertaken to assess the economics of carp (Indian major carps, Chinese carps and common carp) farming in the state by selecting farmers at random who were largely using industrially produced pellet feed (semi-intensive farmers) and others using on-farm feed mixtures largely consisting of rice bran mixed with oiled/de-oiled mustard cake (traditional farmers). Ponds were usually large in size with an average area of 1.7 ha for traditional systems and 2.3 ha for semi-intensive. These ponds were stocked with Indian major carps along with exotic carps with an average stocking density of 24 984 seed/ha/year and 20 936 seed/ha/year in both semi-intensive and traditional systems, respectively.

Most farmers adopted multiple stocking and harvesting with the majority of farmers harvesting fish sized between 300–500 g, which had a high market demand. Pond fertilization was done usually using organic manures (cow/buffalo dung) along with inorganic fertilizers like urea, di-ammonium phosphate (DAP), triple super phosphate (TSP) and muriate of potash (MP). The amount of fertilizers applied into the ponds was regulated based on the colour of water. The average dose of organic manure applied was about 17 tonnes/ha and of the inorganic fertilizers was 247 kg/ha/year.

Fish were fed with pellet feed by semi-intensive farmers and rice bran and mustard oil cake mixture by traditional farmers. Feed constituted the largest input cost in both the semi-intensive system (US$1 109/ha/year) and traditional system (US$1 121/ha/year) with an overall average of US$1 114/ha/year. Among the other variable costs, labour (US$343/ha/year), seed (US$267/ha/year) and fertilizer (US$124/ha/year) contributed significantly to the input cost. With inputs, semi-intensive farmers were able to obtain a production of 5 699 kg/ha/

year while those of traditional farmers obtained a production of 5 853 kg/ha/year. Several of the ponds were community ponds in traditional farming.

In terms of total variable costs, semi-intensive farmers spent less (US$2 036/ha/year) than traditional farmers (US$2 134/ha/year) on labour, feed, fertilizer and seed. Although in terms of net return, there was no major difference between the two systems (US$1 878/ha/year in semi-intensive system as compared to US$1 821/ha/year among traditional farmers), benefit cost ratio was better in semi-intensive system (BCR 1.81) than the traditional system (BCR 1.75). Most importantly, a better food conversion ratio (1.55) was obtained by farmers when feeding pellets as compared to traditional farmers (2.11), which is important from the view points of feed cost as well as impact on environment. The break-even price was US$0.41/kg in semi-intensive farming as compared to US$0.42/kg in traditional farming. Similarly, the net return per kg fish was slightly better in semi-intensive farming (US$0.33/kg) as compared to traditional farming (US$0.31/kg).

The application of Cobb-Douglas production function analysis showed that the revenue of farmers could be significantly increased by increasing feed and fertilizers inputs. However, the results also indicated that, any increase in labour and other variable costs would reduce the income of farmers.

Farmers faced the problem of bird predation in fish ponds as one of the major problems along with the depleting level of ground water, availability of feed resources in adequate quantity at the right time and the strong market demand for the live fish as compared to dead fish. Fish produced in the State was largely consumed by the immigrant population and some was exported to the adjoining states like Delhi.

1. INTRODUCTION

1.1 Aquaculture in Punjab

Aquaculture in the State of Punjab is a fast developing income generating activity, providing a quality and low cost protein diet to the people (Agarwal, 1999). Being traditionally an agricultural state, Punjab was reluctant at first to evolve into fish farming. However, aquaculture production expanded as from 1980, facilitated by access to the States abundant water resources. Four major rivers, several rivulets, reservoirs and lakes support a vast irrigation system, and water is also extracted from a rich ground water resource (Dhawan, 2006). Punjab aquaculture has now established itself as a profit making venture and as a means of diversification from agriculture (wheat-paddy rotation). The commercial success of carp culture in some of the other states like Andhra Pradesh has also encouraged some of the farmers to venture in to carp farming in Punjab. This has generated considerable interest in fish farming and persons from all income groups have taken up fish farming either in newly excavated ponds in their own agricultural/non-agricultural land and/or in renovated village ponds through leasing. Some progressive farmers have even started diversification by converting part of their productive agricultural land to fish farms and have adopted integrated fish farming with agriculture and animal husbandry. At present, nearly 9 890 ha is under fish farming as compared to 343 ha in 1980–81 and fish production increased in subsequent years from 2 800 to 86 000 tonnes, including both capture fisheries and aquaculture, For the last ten years, the States aquaculture production has contributed an annual average growth of 6 000 tonnes per annum.

Aquaculture production per ha in Punjab is more than double the national average production of 2 600kg/ha/year. Average farmer income (by adopting scientific technologies) varies from Rs 75 000–100 000 (US$1 666–US$2 426)[1]/ha, which is

[1] US$1.00 = Rs41.00 (Indian Rupee, INR)

much higher than the earnings experienced in agriculture and livestock rearing. The establishment of the Fish Farmer Development Agency has also helped in the development of aquaculture in the State. Along with self excavated ponds, village ponds (including community ponds established in the village and owned as community resource) were converted to aquaculture. Most of the commercial aquaculture is undertaken in constructed ponds that derives water from bore wells, using underground water. Farmers culture Indian and exotic carps using the seed procured by the Government and private hatcheries established within the State. The contribution of fisheries (GSDP) in Punjab was US$7.13 m in 2005–06 as compared to US$1.7 m in 1995–96. The income from the annual renting of village community ponds during the year 2005–06 was US$0.23 million. The Government of Punjab increased the allocation of support funding for fish farming for 2006–07 to US$1.8 million as compared to US$0.61 million in the last fiscal year and urged farmers to take up aquaculture as an option to enhance their earnings.

1.2 Rationale

The State of Punjab has witnessed a rapid growth in the aquaculture sector in the last two decades. Farmers are gradually moving from the traditional practice of culturing fish without feed to improved methods of fish cultivation with a focus on fish feeds as a means of increasing output. In order to increase profitability from each of the present systems, it is necessary to evaluate culture practices and identify critical areas where management interventions can assist farmers in reducing risk and increasing value added.

1.3 Objectives of the study

This study was undertaken with the following objectives:

(a) to study the economics of carp culture prevalent in the State of Punjab;
(b) to study the economics of carp feeding regimes as applied to the different systems and the resulting profitability; and
(c) to recommend management measures that would help farmers to optimize their income.

2. GENERAL APPROACH AND METHODOLOGY

2.1 Sampling technique

A survey was undertaken for both semi-intensive and traditional farmers. The definitions were based on those who use mainly pellet feed (semi-intensive) and those who used the traditional feed mixture of rice bran and oil cakes as supplementary feed to the fish (traditional). Twenty farmers were selected from each system through the stratified random sampling method and the survey was undertaken using the survey questionnaire developed by the FAO Aquaculture Management and Conservation Service (FIMA).

2.2 Data processing

Survey data was extracted from either farmer records, or their best estimates. The gathered information was analysed using the programme developed in the Microsoft Excel by FAO FIMA to generate the required information. The data was also analysed using Cobb-Douglas production function analysis to identify the parameters that influence production and to identify suitable strategies that could improve carp farm profitability.

3. RESULTS AND DISCUSSION

3.1 Description of the study area

Carp culture is practised in all the 19 districts of Punjab (Figure 1). Twenty of the farmers practised pellet feeding and another twenty farmers followed traditional feeding practices (Table 1).

TABLE 1
Number and percent of respondents reporting by location

District/subdistrict	Number	Percent
Ludhiana	9	22.5
Gurudaspur	10	25.0
Jalandhar	5	12.5
Patiala	7	17.5
Muktsar	1	2.5
Sangur	4	10.0
Fatehgar Sahib	4	10.0
Total	**40**	**100.0**

FIGURE 1
Map of Punjab showing the study area

3.2 Description of the respondents

3.2.1 Age, household size, and years in fish farming

The average age of farmers was found to be from 43 to 44 years in both semi-intensive and traditional systems. Traditional farmers had a larger household size (6.1) as compared to semi-intensive farmers (5.3). The semi-intensive farmers had longer years of experience in farming (8.4) as compared to traditional farmers (7.5). This implies that aquaculture is a relatively new occupation (Table 2) with the expectation that uptake will increase exponentially. The scale of uptake in aquaculture in Andhra Pradesh in the last 20 years supported a high prospect for growth in Punjab. Availability of a ready market for the fish produced in the country and the development of cost-effective packing and transportation technology developed should provide further stimulus for the growth of carp culture in the country (Veerina, Nandeesha and Gopal Rao, 1993).

TABLE 2
Average age, household size, and years in fish farming of the farmers by category of respondents

Category	Age	Household size	Years in farming
Semi-intensive farms	43.3	5.3	8.4
Traditional farms	43.9	6.1	7.5
All farms	43.6	5.7	7.9

3.2.2 Marital status

All but one semi-intensive farmer was married. The marriage age is around 25 years and elders in the agriculture families tend to marry off their children early and allow them to settle (Table 3).

TABLE 3
Marital status of the farmers by category of respondents

Marital status	Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%
Married	19	95	16	80	35	87.5
Single	1	5	4	20	5	12.5
Widowed	0	0	0	0	0	0.0
Separated	0	0	0	0		0.0
Total	**20**	**100**	**2**	**100**	**40**	**100**

3.2.3 Education

All the farmers were literate with varying educational qualifications. Among the semi-intensive farmers, a good percentage (40 percent) attended college level of education. The majority of traditional farmers attended high school (50 percent) with a sizable percentage of farmers having completed primary level of education (Table 4). This finding supports the view that better education influenced the farmers in adopting improved technologies such as pellet feeding.

TABLE 4
Education attainment of the farmers by category of respondents

Education	Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%
No Education	0	0	0	0	0	0.0
Primary	1	5	6	30	7	17.5
Secondary	2	10	0	0	2	5.0
High School	8	40	10	50	18	45.0
College	8	40	2	10	10	25.0
Others	1	5	2	10	3	7.5
Total	**20**	**100**	**20**	**100**	**40**	**100**

3.2.4 Occupation

A large percentage of farmers among the traditional group indicated fish farming as their primary occupation (55 percent). Although a good percentage of semi-intensive farmers also listed aquaculture as their primary occupation (40 percent). However, a large number of farmers had agriculture as their primary occupation (45–50 percent). Farmers in Punjab are known for their excellence in agriculture, particularly in scaling up the activity to a commercial level. Among both groups of farmers, agriculture and aquaculture were used the main source of family income. However, women's activities in farm operations were found to be quite minimal (Table 5).

TABLE 5
Primary occupation of the farmers by category of respondents

Occupation	Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%
Fish farming	8	40	11	55	19	47.5
Fish trading	1	5	0	0	1	2.5
Agriculture	10	50	9	45	19	47.5
Business	1	5	0	0	1	2.5
Total	**20**	**100**	**20**	**100**	**40**	**100**

3.2.5 Training

All but one farmer had received training in fish culture. This reflects the high attention paid by the Department of Fisheries in training farmers and the interest of farmers in acquiring knowledge for commercial scale operations (Table 6). However, only male family members received the benefits. Thus women are denied the opportunity of contributing to household income. Focusing on gender within the training component has to be a strategy for consideration (Dhawan and Kaur, 2005).

TABLE 6
Attendance of aquaculture training by category of respondents

Training undergone	Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%
Yes	20	100	19	95	39	97.0
No	0	0	1	5	1	2.5
Total	**20**	**100**	**20**	**100**	**40**	**100**

3.3 General profile of the farm

The total land area owned by the farmers under each category varied widely. Semi-intensive farmers had a total 64 ponds covering an area of 145 ha with an average size of ponds being 2.3 ha. Traditional farmers owned 40 ponds with an area of 67.5 ha and an average size of ponds being 1.7 ha. The average overall size of pond was 2 ha (Table 7).

This indicates that for carp farming, farmers prefer large size ponds for grow out as the growth is faster in such larger ponds (Veerina, Nandeesha and Gopal Rao, 1993). Farmers also maintained good depth of water, which was 1.9 metres in pellet fed farms and 1.5 metres in traditional farms, including in the dry season.

A large number of ponds were owned singly under the traditional farming system (65 percent) as compared to the semi-intensive system (30 percent). Multiple ownership was not found in the traditional system. A good number of farms were leased for both semi-intensive as well as traditional systems, but most of them were leased with single ownership. This indicates that under the prevailing system of social structure, the single ownership operation is mostly preferred (Table 8). In most cases of joint ownership (15 percent), there were only two to three partners (Table 9).

A typical fish pond in Punjab, India. Fish ponds used for growing market size fish are larger in size varying from 1.5–2.5 ha and generally undrainable in nature. Pond dykes are used for growing different types of timber trees and other useful plants.

TABLE 7
Total number, total area, average area of ponds and average water depth in different farming systems

Item	Semi-intensive	Traditional	All categories
Total number of ponds	64.0	40.0	52.0
Total area of ponds (ha)	144.7	67.5	104.0
Average area of ponds (ha)	2.3	1.7	2.0
Average water depth (m)			
Rainy season	2.2	1.7	1.9
Dry season	1.9	1.5	1.7

TABLE 8
Type of pond ownership by category of respondents

Ownership	Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%
Single ownership	6	30	13	65	19	47.5
Multiple ownership	3	15	0	0	3	7.5
Singly leased	7	35	5	25	12	30.0
Jointly leased	4	20	2	10	6	15.0
Total	20	100	20	100	40	100

TABLE 9
Average number of ownership for multiple ownership and average number of lessee and duration for jointly leased farms by category of respondents

Item	Semi-intensive	Traditional	All categories
Number of owners (multiple ownership)	2.0	0.0	2.0
Number of lessees (jointly leased)	2.0	3.0	2.4
Duration of lease (months)	98.8	56.0	90.3

Nylon netting over the pond water surface. In areas of Punjab where bird predation is common, in nursery ponds as well as in grow out ponds, in the early stages when the fish size is smaller, nylon threads are tied over the pond surface to prevent bird predation.

Most ponds under the semi-intensive system were used exclusively for fish culture, except in one case where the pond was used for storing water for irrigation of agricultural crops. Under the traditional system, a good number of ponds were also used for multipurpose activities including catering to the necessities for villagers as well as farm animals (Table 10).

All the farmers indicated profitability as the main reason for starting fish culture. Reasons cited as significant issues in adopting aquaculture were:

- the low labour requirements for fish culture relative to paddy or wheat cultivation;
- Punjab was a major grain production centre, large scale quantities of agricultural by-products were available at reasonable prices;
- buffalo and cattle manure was readily available in the region; and
- the large number of hatcheries (Government and private sector) allowed for easy access to seed.

Sector growth in Punjab, has been stimulated by a high immigrant work force from other states, as well as access to the strong market in the nearby New Delhi. Carp itself is not popular to the indigenous population because of the intramuscular spines.

All the farmers surveyed indicated profitability as the prime incentive for taking up fish culture.

TABLE 10
Pond utilization by farmers in different farming systems

Pond utilization	Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%
Fish culture	19	95	16	80	35	87.5
Multipurpose	1	5	4	20	5	12.5
Total	**20**	**100**	**20**	**100**	**40**	**100**

3.4 Farm production practices

The respondent carp polyculture species consists of Indian major carps: catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus cirrhosus*) and exotic carps silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*), common carp (*Cyprinus carpio*) and bighead carp (*Aristichthys nobilis*). The culture takes place throughout the year, though fish growth is slow during December and January because of the lowering of the temperature. Farmers resort to drying up of ponds when there is too much accumulation of sludge at the bottom. De-silting is undertaken once in 3–4 years.

3.4.1 Stocking strategies and rates

Most of the farmers adopt multiple stocking and harvest 2–3 times per every year (Table 11). Only a small percentage of farmers adopt single time stocking, but even such farmers resort to multiple harvesting by stocking a larger number of seeds at the initial stage and harvesting the adult fish as the season progresses.

TABLE 11
Stocking strategy and frequency of stocking in different farming systems

Item	Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%
Stocking strategy						
Single stocking	6	5.0	9	45.0	15	37.5
Multiple stocking	14	70.0	11	55.0	25	62.5
Total	20	75.0	20	100	40	100
Number of stocking						
3 times per year	9	64.3	6	54.6	15	60.0
4 times per year	5	35.7	1	9.1	6	24.0
Continuous stocking	0	0	4	36.4	4	16.0
Total	**14**	**100**	**11**	**100**	**25**	**100**

The stocking density adopted by farmers was more than double the recommended level of 10 000/ha/year in both semi-intensive and traditional farming systems. Although no specific species mix was adopted, rohu was stocked at high density with a large number of bottom dwelling species like mrigal and common carp. Catla was stocked at a lower percentage, while silver and grass carp were also stocked in small numbers. Some farmers with large water areas resort to nursing fish seed in a nursery and use the nursed seed for repeated stocking, while others stocked small size fish seed in large numbers directly into the stock pond and culture them whilst they harvest the bigger size fish. This results in a lowering of fish numbers in the pond and thereby provides good opportunity for the remaining fish to grow (Table 12). The size of the seed stocked was reasonably large in most farms, particularly when the farms had their own nursery. The size of seed stocked would invariably be based on the availability of nursing space on the farm, which helps farmers keep stunted fish seed and then restock as they harvest marketable sized fish.

TABLE 12
Average stocking rate (No./ha/year) and average stocking size (g) in different farming systems

Item	Semi-intensive	Traditional	All categories
Rohu			
Stocking rate	6 820	6 518	6 669
Stocking size (g)	7.88	9.33	8.60
Catla			
Stocking rate	2 713	4 179	3 446
Stocking size (g)	7.31	6.70	7.01
Mrigal			
Stocking rate	6 190	4 607	5 398
Stocking size (g)	7.52	6.84	7.18
Common carp			
Stocking rate	5 368	3 121	4 203
Stocking size (g)	6.33	5.85	6.09
Silver carp, grass carp and bighead carp			
Stocking rate	3 894	2 511	3 202
Stocking size (g)	7.00	5.13	6.06
Total for all species (No./ha/year)	24 984	20 936	22 918

3.4.2 Fertilization

Farmers use organic fertilizers consisting largely of buffalo and cow manures, while small numbers of farmers use poultry manure and biogas slurry. This is based on availability. The dosage of organic manure application is largely determined by the water colour and quality in order to keep the water green to ensure adequate food availability for fish. The inorganic fertilizers like urea and DAP (di-ammonium phosphate) were used

Fertilization of fish pond with inorganic fertilizers is common in India. Inorganic fertilizers like urea, super phosphate, di-ammonium phosphate (DAP), are dissolved in water and spread all over the pond to have speedy and uniform effect all over the pond.

A farmer has stacked potatoes at the edge of the pond meant for feeding fish. They are pushed into the ponds in small quantities daily. This is not a normal practice but farmers incline to use any feedstuff that is obtained cheap and easily available.

most commonly by most farmers with the latter being the commonly used fertilizers by large majority of the farmers. Other inorganic fertilizers like TSP (triple super phosphate) and MP (muriate of potash) were also used by some farmers. Inorganic fertilizer application was regulated by the water colour to ensure good fish growth (Table 13).

3.4.3 Feeds and feeding

Fish were fed with supplementary feed either with pellet feed or with farm derived feed mixtures. The pellet feed used by farmers had a protein level of less than 25 percent with 3–4 percent fat. Those using derived mixtures used both de-oiled rice with a protein content of 10–15 percent with less than 2 percent fat, or mustard oil cake with a protein level 35–40 percent and fat of 3–4 percent. Both were mixed in a ratio of 1:1. Therefore, these had similar protein and fat levels to the pellet feed. Farmers using the pellet feed also used the supplementary feed such as rice bran and oilcake for some parts of the year. Rice bran along with mustard oil cake was commonly used by the traditional farmers. Pellet feed use benefits has been mainly as a convenience feed and because the form has reduced wastage. The large majority of farmers apply feed by broadcasting as well as through bag feeding. Only one farmer was found to be using an automatic feeder. In general, farmers practised the bag feeding method. The technique keeps the rice bran and oil cake inside the feed bag. Small holes in the bottom allow for an efficient dispersion of the feed. Fish tend to browse the feed through holes in the bag and when the holes become big, the bags are replaced (Table 14).

Industrially manufactured feed was used by some farmers. The cost of such pellet feeds being Rs 6–8 (US$0.15–0.20/kg), which was competitive. Farmers were gradually adopting pellet feeds. The supplementary feed mixture was also reported as costing around the same price when rice bran and oil cake mixture was used. The feed mills sold feed with minimal profits in order to attract more buyers. They were able to do this since they could procure ingredients in bulk. Fish are generally fed once a day, though in one case, more than once a day feeding was reported along with another farmer reporting irregular feeding under the traditional practice (Table 15).

TABLE 13
Type of fertilizer and frequency of fertilization in different farming systems

Type of fertilizer/frequency	Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%
A. Cow-dung						
Daily	1	5	2	10	3	7.5
Weekly	10	50	9	45	19	47.5
Bi-weekly	0	0	6	30	6	15.0
Monthly	3	15	1	5	4	10.0
Irregular	6	30	2	10	8	20.0
Total	**20**	**100**	**20**	**100**	**40**	**100**
B. Poultry/chicken manure						
Never	18	90	17	85	35	87.5
Bi-weekly	1	5	2	10	3	7.5
Irregular	1	5	1	5	2	5.0
Total	**20**	**100**	**20**	**100**	**40**	**100**
D. Urea (nitrogen)						
Never	1	5	0	0	1	2.5
Weekly	1	5	0	0	1	2.5
Bi-weekly	8	40	9	45	17	42.5
Monthly	10	50	7	35	17	42.5
Irregular	0	0	4	20	4	10.0
Total	**20**	**100**	**20**	**100**	**40**	**100**
E. DAP (phosphate)*						
Bi-weekly	3	15	4	20	7	17.5
Monthly	13	65	12	60	25	62.5
Irregular	4	20	4	20	8	20.0
Total	20	100	20	100	40	100
F. Others (TSP, NPK etc)						
Never	19	95	20	100	39	97.5
Irregular	1	5	0	0	1	2.5
Total	**20**	**100**	**20**	**100**	**40**	**100**

*DAP = di-ammonium phosphate; TSP= triple super phosphate; NPK= nitrogen, phosphorus and potassium

TABLE 14
Feed application methods by type of feed in different farming systems

Type of feed/application method	Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%
A. Industrial pellet feed						
Broadcasting	8	40	0	0	8	20.0
Feeding tray	2	10	0	0	2	5.0
Feeding bag	8	40	0	0	8	20.0
Feeding frame	1	5	0	0	1	2.5
Automatic feeding	1	5	0	0	1	2.5
Total	**20**	**100**	**0**	**0**	**20**	**50.0**
B. Supplementary feed						
Broadcasting	6	30	11	55	17	42.5
Feeding bag	1	5	9	45	10	25.0
Feeding frame	2	10	0	0	2	5.0
Total	**9**	**45**	**20**	**100**	**29**	**72.5**

TABLE 15
Feeding frequency by type of feed in different farming systems

Item	Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%
A. Type of feed						
Industrial pellet feed	12	60	0	0	12	30.0
Supplementary diet & industrial pellet feed	8	40	0	0	8	20.0
Supplementary diet	0	0	20	100	20	50.0
Total	**20**	**100**	**20**	**100**	**40**	**100**
B. Feeding frequency						
More than twice daily	1	5	1	5	2	5.0
Once daily	18	90	18	90	36	90.0
Weekly	0	0	1	5	1	2.5
Irregular	1	5	0	0	1	2.5
Total	**20**	**100**	**20**	**100**	**40**	**100**

A farm labour dumping the brewery waste in the pond. Some farmers resort to use of brewery waste when available easily and this acts as both feed and manure. Farmers in India use rice bran combined with various oilcakes as common supplemental feeds.

3.4.4 Labour utility in the farm operation

Most of the farmers use 1 to 4 workers on a regular basis depending on the farm size. Additional workers were hired when there was high labour demand, such as for the application of manure and the cleaning of ponds. On a per hectare basis, the number of full time workers used was higher under semi-intensive farming (0.33 person/ha/day) as compared to traditional farmers (0.27 person/ha/day). The use of hired labour was higher in the traditional system with 82 man days/ha as compared to 55 man days/ha in semi-intensive system (Table 16).

The amount of money spent on hiring causal workers (US$179/ha/year) and full time workers (US$181/ha/year) was almost equal among traditional farmers, while in the case of semi-intensive farmers, the amount spent on full time workers was higher (US$206/ha/year). The per hectare overall cost on labour was lower in the case of pellet feed (US$325/ha/year) systems as compared to traditional farming systems (US$360/ha/year) (Table 17). The overall cost of labour was much lower as compared to other agricultural practices prevalent in the area, because of the lower labour requirement in the case of aquaculture.

TABLE 16
Average quantity (ha/year) of human labour by type of operation in different farming systems

Type of labour	Semi-intensive		Traditional		All categories	
	Hired	Family	Hired	Family	Hired	Family
Casual (man-days)	55	-	82	-	69	-
Full time (No.)	0.33	-	0.27	-	0.30	-

TABLE 17
Average cost of human labour (US$/ha/year) by type of operation in different farming systems

Type of labour	Semi-intensive		Traditional		All categories	
	Hired	Family	Hired	Family	Hired	Family
Casual	119	-	179	-	149	-
Full time	206	-	181	-	194	-
Total	**325**	**-**	**360**	**-**	**343**	**-**

3.5 Comparative analysis of farm production costs

3.51 Application of inorganic and organic fertilizers: quantity and cost

DAP was the most commonly used inorganic fertilizer and on an average 122 kg/ha was used by the farmers. Some farmers also used urea and triple super phosphate. Overall, the amount of inorganic fertilizers used by the farmers amounted to 243 kg/ha in the case of the semi-intensive culture system, although usage in the traditional system was broadly similar (251 kg/ha).

The level of organic manure used was lower in the case of semi-intensive farming farmers (15 747 kg/ha) as compared to traditional farmers (18 757 kg/ha). Traditional farmers also use biogas slurry, while semi-intensive farmers, used potato wastes and other scraps (Table 18).

An arrangement in the pond for placing feed on a perforated plastic gunny bag. When the feed, generally consisting of rice bran and various oil cakes, is in place, usually the bag is in a sunken stage and when the feed is consumed/ leached out of the bag completely, it is light and floats on the water surface.

3.5.2 Stocking: quantity and cost

Semi-intensive farmers and traditional farmers applied an average seed stocking of 24 984/ha/year and 20 936 seed/ha/year respectively. As indicated earlier, farmers resort to multiple stocking and multiple harvesting and hence the standing crop may be higher at the beginning of the season. This reduces with the harvest of larger size fish. In cases where lower stocking density was used, fish from the nursery was used to restock the pond to make up the harvested level of fish. However, it should be noted that in general, the stocking density was higher than the recommended level of stocking density of 10 000 fingerlings /ha for the composite fish culture (Jhingran, 1988) (Table 19).

TABLE 18
Average quantity (kg/ha/year) and cost (US$) of inorganic and organic fertilizers in different farming systems

Type of fertilizer	Semi-intensive			Traditional			All categories		
	Quantity (kg)	Cost/kg	Total cost	Quantity (kg)	Cost/kg	Total cost	Quantity (kg)	Cost/kg	Total cost
Inorganic									
Urea (nitrogen)	108	0.109	11.8	124	0.109	13.5	116	0.109	12.6
TSP (phosphate)	4.0	0.150	0.6	0.0	0.200	0.0	2.0	0.150	0.3
DAP	118	0.193	22.8	127	0.193	24.5	122	0.194	23.7
Others	14	0.164	2.3	0.0	0.000	0.0	7.0	0.157	1.1
All inorganic	243	0.154	37.4	251	0.151	38.0	247	0.153	37.7
Organic									
Dung	15 068	0.005	67.4	15 204	0.005	71.9	15 136	0.005	69.7
Compost	0	0.000	0.0	213	0.007	1.4	107	0.007	0.7
Others*	679	0.013	8.6	3 340	0.001	3.7	2 010	0.003	6.2
All organic	15 747	0.005	76.0	18 757	0.004	77	17 252	0.004	76.5
All fertilizers	15 990	0.007	113.4	19 008	0.006	115	17 499	0.007	114.2

*Poultry manure, biogas slurry, potato chip waste etc

TABLE 19
Average quantity (No./ha/year) and cost (US$) of fingerlings by type of species in different farming systems

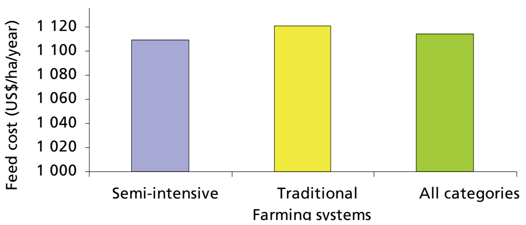
Species	Semi-intensive			Traditional			All categories		
	No.	Price/ piece	Total cost	No.	Price/ piece	Total cost	No.	Price/ piece	Total cost
Rohu	6 820	0.014	96.37	6 518	0.011	72.67	6 669	0.013	84.29
Catla	2 713	0.013	36.23	4 179	0.009	36.2	3 446	0.011	38.23
Mrigal	6 190	0.013	82.66	4 607	0.011	51.37	5 398	0.012	66.14
Common carp	5 368	0.011	60.29	3 121	0.008	24.62	4 203	0.009	39.64
Chinese carps*	3 894	0.013	50.79	2 511	0.01	24.69	3 202	0.011	36.63
All Species	**24 984**	**0.013**	**326.33**	**20 936**	**0.01**	**209.54**	**22 918**	**0.012**	**264.9**

*Silver carp, grass carp and bighead carp

3.5.3 Feeding

Semi-intensive farmers applied an average 8 806 kg/ha/year, comprising 6 494 kg/ha/year pellet feed and 2 313 kg/ha/year for other feeds. Other feeds included rice bran, oil cake and green grasses. Rice bran and oil cake was used by most traditional farmers. Along with these two ingredients, farmers also used small amounts of fish meal, green grasses and soybean meal. However, the total quantity of feed used by traditional farmers was 12 322 kg/ha. In terms of total cost, there was not much variation in the amounts spent on feed between semi-intensive (US$1 110/ha) and traditional farming systems (US$1 121/ha). Regardless of farm category, the estimated average expenditure on feed was US$1 114/ha (Table 20 and Figure 2).

FIGURE 2
Feed costs in different farming systems



3.5.4 Power cost and utility in the fish farm

The major cost of power was for pumping underground water since most farmers used ground water to supply their fish ponds. Interestingly, traditional farmers spend more on electricity/diesel in pumping the water (US$146) as compared to semi-intensive farmers (US$86/ha). In addition to electricity/diesel cost, there were other costs involved and these costs were also higher in case of traditional farmers. An average of US$253/ha was spent on electricity and other costs (Table 21). To enrich the water with oxygen farmers also used simple aerators in ponds for pumping the bottom water and spraying in the air by using pumps on floating platforms. It should be noted that some of the progressive farmers used, solar pumps for pumping the water. Whilst the initial establishment cost was reported to be high, there was no recurring cost for electricity.

TABLE 20
Average quantity (kg/ha/year) and cost (US$) of feeds by type in different farming systems

Type of feeds	Semi-intensive			Traditional			All categories		
	Quantity (kg)	Price/kg	Total cost	Quantity (kg)	Price/kg	Total cost	Quantity (kg)	Price/kg	Total cost
A Commercial pellet	6 494.0	0.14	893.6	0	0	0	3 247.0	0.14	446.80
B Supplementary feed									
Rice bran	1 245.0	0.10	129.2	6 590.0	0.08	536.15	3 918.0	0.08	332.67
Oil cakes	617.0	0.11	61.8	4 019.0	0.12	471.01	2318.0	0.07	266.41
Fishmeal	0	0	0	223.9	0.23	52.58	112.0	0.23	52.58
Soybean meal	0	0	0	156.1	0.11	16.96	78.0	0.11	16.96
Aquatic plants/ green grass	192.5	0.04	8.4	287.5	0.05	13.89	240.0	0.05	13.89
Others	257.8	0.07	16.8	1 045.0	0.03	30.88	651.2	0.05	30.88
Subtotal	**2 313.0**	**0.09**	**216.2**	**12 322.0**	**0.09**	**1 121.48**	**7317.0**	**0.09**	**713.40**
All feed types	**8 806.0**	**0.13**	**1 109.8**	**12 322.0**	**0.09**	**1 121.48**	**10 564.0**	**0.11**	**1 114.00**

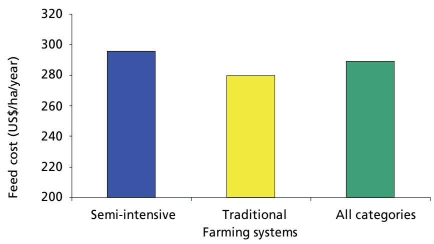
TABLE 21
Average annual power cost (US$/ha) by type in different farming systems

Item	Semi-intensive	Traditional	All categories
Electricity and diesel cost for pump	85.81	145.53	114.10
Others	129.68	151.62	139.20
Total	**215.49**	**297.15**	**253.30**

3.5.5 Fixed costs

Most fish farmers maintained a building attached to the fish farm. This was used for storing materials as well as for office purposes. Farmers also kept a truck/pick up van for transporting various materials to and from the fish ponds. The semi-intensive farmers invested more on buildings and providing vehicle support as compared to traditional farmers. Almost all farmers own either electrical or diesel pumps and each farm makes an investment of US$150/ha/year on such items. The land use cost was higher in the case of semi-intensive systems as many ponds were leased at higher costs from local panchayats. The land use cost reflects the actual lease value paid by the farmer. In cases where the farmers owned the land, the lease amount prevailing in that area was used to compute the land use cost. Over all, in case of semi-intensive farms, their average fixed cost was higher than for traditional farmers as they spent more on buildings, and transport (Table 22 and Figure 3).

FIGURE 3
Fixed costs in different farming systems



3.5.6 Variable costs

Labour, feed, fertilizer and seed constituted major variable costs in the farm operation. Feed constituted the biggest input cost in both the semi-intensive as well as the traditional fish farms with almost equal cost in both the systems with an average of US$1 115/ha/year. Seed costs were not very high due to the ease of availability. Seed costs averaged US$67/ha. The labour cost was higher in both systems with more amounts spent on labour in traditional farms (US$360/ha/year) as compared to US$325/ha/year in the pellet farm. On an average in both the types of farms, US$2 085/ha/year was spent (Table 23 and Figure 4).

FIGURE 4
Variable cost in different farming systems

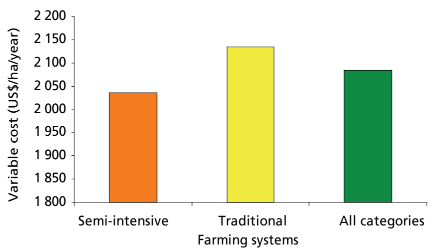


TABLE 22
Average annual fixed cost (US$/ha) by type and category of respondents

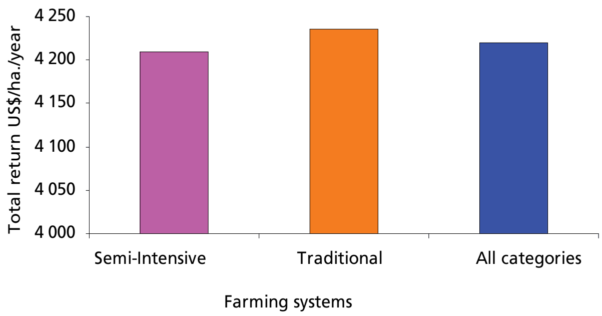
Item	Semi-intensive	Traditional	All categories
A. Depreciation of buildings	8.0	6.6	7.3
B. Depreciation of truck/pick-up van	3.1	0.7	1.9
C. Depreciation of pump	5.6	6.2	5.9
D. Land use cost	278.3	266.4	273.5
E. Other depreciations	1.2	-	0.6
Total	**296.2**	**279.9**	**289.2**

TABLE 23
Total cost (US$/ha/year) by item in different farming systems

Item	Semi-intensive		Traditional		All categories	
	US$	% of total	US$	% of total	US$	% of total
A. Variable costs						
Labour cost	325	13.9	360	14.9	343	14.4
Fertilizer	113	4.8	115	4.8	114	4.8
Fry/fingerling	283	12.1	251	10.4	267	11.2
Feed	1 110	47.6	1 120	46.4	1 115	47.0
Miscellaneous	0	0	15	0.6	7	0.3
Other variable costs	219	9.4	240	9.9	229	9.6
Subtotal	**2 036**	**87.3**	**2 134**	**88.4**	**2 085**	**87.8**
B. Fixed costs	296	12.7	280	11.6	289	12.2
Total	**2 332**	**100**	**2 414**	**100**	**2 374**	**100**

Harvest of Indian major carps from polyculture pond in Punjab, India. Harvest of carps from the ponds is done using cast and drag nets. Fish weighing around 500 g are harvested and sold. Generally fish are harvested twice a year.

FIGURE 5
Annual gross revenue from different farming systems



3.6 Comparative analysis of farm income and economic indicators

3.6.1 Gross revenues

The average yield of fish was 5 699 kg/ha/year in semi-intensive farms as compared with 5 853 kg/ha/year in traditional farms. This was considered a good yield relative to the amount of input provided into the pond. However, farmers were adopting a method of not growing the fish to one kg sizes, but harvesting them at an early age when they would be about 300–500 g. This size fish was easily marketable and the strategy adopted by farmers had helped to increase fish yields. The gross revenue obtained by farmers was almost the same for both the groups of farmers with an overall average of US$4 421/ha/year. The fish price being almost constant with an average price of about US$0.73/kg, farmers in both systems appeared to benefit from this strategy (Table 24 and Figure 5).

3.6.2 Net margin/returns

The net returns were slightly higher in the case of semi-intensive farming systems with an average of US$1 878/ha as compared to the traditional fish farmers at US$1 821/ha (Table 26). The lower net returns in traditional farming were due to the relatively higher cost of labour and electricity costs. The overall net return/ha was US$1 846/ha. This was however, considered to be a better income as compared to other agriculture crops. Fish prices were almost constant with an average prize of about US$0.73/kg (Table 25).

TABLE 24
Annual gross revenues (US$/ha/year) in different farming systems

Type of operation	Semi-intensive			Traditional			All categories		
	Volume (kg)	Price/kg	Total return (US$)	Volume (kg)	Price/ kg	Total return (US$)	Volume (kg)	Price/ kg	Total return (US$)
Total harvest (all species)	5 650	0.74	4 176	5 780	0.72	4 187	5 715	0.73	4 182
Biomass carried in from Previous year	49	0.69	34	73	0.66	48	57	0.68	39
All harvests	5 699	0.74	4 210	5 853	0.72	4 235	5 772	0.73	4 221

Note: Returns per species is not possible since the returns relate to a composite culture system

TABLE 25
Key financial and economic indicators by farming systems

Financial and economic indicators	Semi-intensive	Traditional	All categories
A. Total cost[1] (US$/ha/year)	2 332	2 414	2 374
B. Variable cost[2] (US$/ha/year)	2 036	2 134	2 085
C. Fixed cost[3] (US$/ha/year)	296	280	289
D. Gross revenue[4] (US$/ha/year)	4 210	4 235	4 220
E. Gross margin[5] (US$/ha/year)	2 174	2 101	2 135
F. Net margin/returns[6] (US$/ha/year)	1 878	1 821	1 846
G. Net returns to land[7] (US$/ha/year)	1 600	1 554	1 573
H. Net returns to labour[8] (US$/ha/year)	1 553	1 461	1 503
I. Gross total factor productivity/benefit-cost ratio[9]	1.81	1.75	1.78
J. Break-even price[10] (US$/kg)	0.41	0.42	0.42
K. Actual price (US$/kg)	0.74	0.72	0.73
L. Break-even production[11] (kg)	3 151	3 353	3 252
M. Actual production (kg)	5 699	5 853	5 772
N. Survival rate[12] (%)	48.78	53.93	51.35

[1] Total costs = variable costs + fixed costs (A = B + C)
[2] Sum of costs of fingerlings, fertilizers, feeds, hired and family labour, harvesting and marketing costs, and other variable costs
[3] Sum of land use cost, interest, depreciation and permanent staff salary
[4] The total amount of production (kg) multiplied by their respective market prices
[5] Gross revenue less total variable costs (E = D – B)
[6] Gross revenue less total cost (F = D – A)
[7] Net margin/returns less land rent payment
[8] Net margin/returns less cost of labour
[9] Gross revenue divided by total costs (I = D/A)
[10] Total costs divided by total production (J = A/total production)
[11] Total costs divided by average price (L = A/average price of fish)
[12] (Number of pieces during harvest/number of pieces during stocking) x 100

3.6.3 Returns to land and labour

The average net returns to land (US$1 600) and labour (US$1 553) in semi intensive farms was slightly higher than those observed with traditional farmers (Table 25). This implies that after paying the rent of land and wage of labour, the semi intensive farmers were still getting slightly higher profit than the traditional farmers.

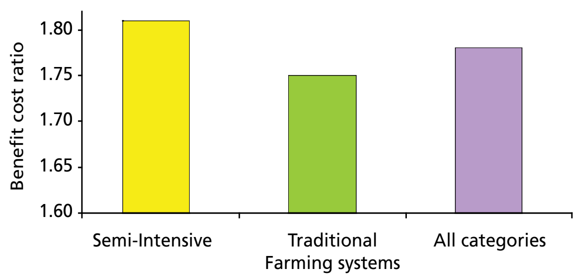
3.6.4 Benefit cost ratio

The benefit cost ratio (BCR) in the case of semi-intensive farmers was slightly better (1.81) as compared to traditional farmers (1.75). Regardless of farm category, an overall BCR average of 1.78 was recorded (Table 25 and Figure 6). The BCR clearly indicates that the aquaculture systems practised in Punjab are profitable.

3.6.5 Break-even price

The break-even price was found to be slightly lower in the case of semi-intensive farmed fish (US$0.41/kg) as compared to traditional fish (US$0.42/kg). This reflects that using the quality feed, it is possible to produce the fish at lower cost as compared to traditional feeding practices (Table 25 and Figure 7).

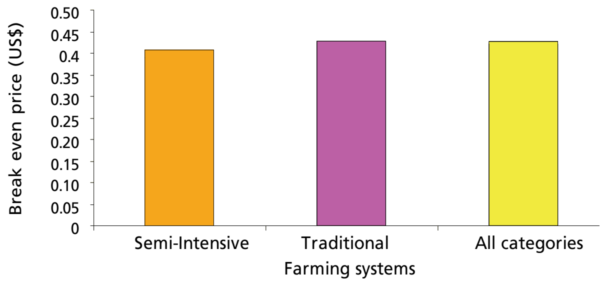
FIGURE 6
Benefit–cost ratio obtained form different farming systems



3.6.6 Break-even production

The break-even production for the level of input given to the pond was at 3 252 kg/ha for all farms (Figure 8). As the average production level obtained by farmers was much higher than the break-even production, it could be concluded that

FIGURE 7
Break-even price for fish production in different farming systems



the system was economically viable. It was also observed that there were many possibilities to increase production further by introducing and adopting better management practices (Table 25 and Figure 8).

3.6.7 Net return per kg of fish

The net returns to per kg of fish (Table 26) was slightly higher in semi-intensive farming (US$0.33/kg) as compared to traditional farming (US$0.31/kg). This was considered by farmers as a good profit as compared to other farming activities like rice and wheat farming.

TABLE 26
Average net return per kg of fish by different farming categories

Item	Farming categories		
	Semi-intensive	Traditional	All categories
Production (kg/ha/year)	5 699	5 853	5 772
Net return (US$/ha/year)	1 878	1 821	1 846
Net return per kg fish (US$)	0.33	0.31	0.32

3.7 Overview of cost structure and profitability

The overall comparison between the semi-intensive and traditional systems, clearly demonstrates the better economic returns in the former system (Table 27). Though the average production was found to be lower in the case of the semi-intensive system with higher stocking density, efficient management of feed has contributed for the better economic returns. In addition, better quality of the pellet feed resulted in an improved food conversion ratio (Figure 9).

FIGURE 8
Break-even production levels for different farming systems

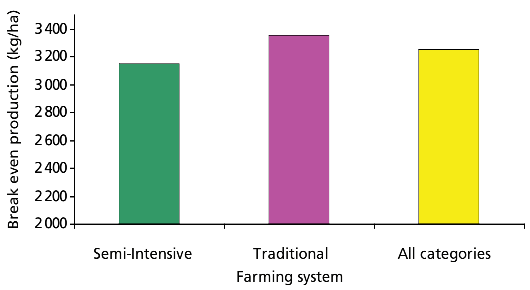
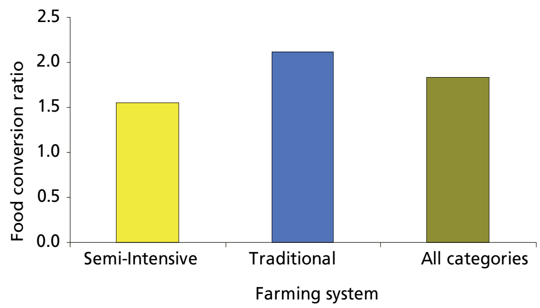


FIGURE 9
Food conversion ratio obtained in different farming systems



3.8 Production problems

The farmers were unaware of the benefits of quality feed in terms of improving their returns on investment. Some farmers who had initiated feeding fish with pellets had begun to realize these benefits. However, there is a need to educate farmers on the benefits of feeding fish with quality feed to reduce production expenses as well as to safe guard the environment. Water being a scarce resource, the declining water table was found to be a major concern for farmers. Predation by birds was experienced as another major constraint by the farmers and provision of nets on the ponds to prevent bird predation was found to add a large cost to production when adopted. Transportation of fish in a live condition to market was found to be a major problem. In addition, farmers had not been able to explore the market opportunities available in the North East because of the insurgency problems.

TABLE 27
Summary of major findings by different farming systems

Item	Semi-intensive	Traditional	All categories
Pond size (ha)	2.3	1.7	2.0
Stocking rate (No./ha/year)	24 984	20 936	22 918
Feeding rate (kg/ha/year)	8 806	12 322	10564
Production (kg/ha/year)	5 699	5 853	5 772
Food conversion ratio (FCR)	1.55	2.11	1.83
Variable costs (US$/ha/year)	2 036	2 134	2 085
Fixed costs (US$/ha/year)	296	280	289
Total costs (US$/ha/year)	2 332	2 414	2 374
Gross revenue (US$/ha/year)	4 210	4 235	4 220
Net return (US$/ha/year)	1 878	1 821	1 846
Net return per kg fish (US$)	0.33	0.31	0.32
Benefit-cost ratio	1.81	1.75	1.78

TABLE 28
Cobb-Douglass profit function outputs

R	R^2	Adjusted R^2	Standard error of the estimate	R^2 Change	F Change	df1	df2	Significance of F Change
0.788	0.621	0.538	0.286	0.621	7.484	7	32	1% level of confidence

Independent variable	Unstandardized coefficients	Standard error	Standardized coefficients	t-value
Constant	6.254	1.563		4.002*
Cost of labour	-0.129	0.140	-0.107	-0.917
Cost of inorganic fertilizer	0.115	0.100	0.138	1.148
Cost of organic fertilizer	0.262	0.098	0.319	2.661*
Cost of fingerlings	0.061	0.110	0.082	0.560
Cost of feed	0.334	0.080	0.580	4.157*
Cost of electricity and fuel	0.007	0.014	0.059	0.494
Other variable cost except electricity and fuel	-0.002	0.015	-0.014	-0.115

*T values are significant at 1% level of confidence.

3.9 Statistical analysis

3.9.1 Cobb-Douglas profit function

A log-linear production function model was used to determine the relationship between inputs and outputs of fish production as identified from the samples.

The model obtained used to define total revenue was

$$LnY = 6.25 - 0.107LnX_1 + 0.138LnX_2 + 0.319LnX_3 + 0.082LnX_4 + 0.580LnX_5 + 0.059LnX_6 - 0.014X_7$$

Where

Y = Total revenue

X_1 = Cost of labour

X_2 = Cost of inorganic fertilizer

X_3 = Cost of organic fertilizer

X_4 = Cost of fingerlings

X_5 = Cost of feed

X_6 = Cost of electricity/fuel

X_7 = Other variable costs excluding electricity/fuel costs

The above model produced a 62 percent variation in the total output. The overall regression equation was significant at 1 percent ($F_{7,32} = 7.48$). The sum of the production elasticities was 1.06 indicating that the production function exhibited increasing returns to scale. This indicates that if all the inputs specified in the production function are increased by 1 percent, revenue will be increased by 1.06 percent. Each of the independent variables used in the study indicates the production elasticities as:

i. a 10 percent increase in cost of labour will contribute to 1.07 percent decrease in total revenue;
ii. a 10 percent increase in cost of inorganic fertilizer will result in 1.38 percent increase in total revenue;
iii. a 10 percent increase in cost of organic fertilizer will influence to a level of 3.19 percent increase in total revenue;
iv. a 10 percent increase in cost of fingerlings will add to 0.82 percent increase in total revenue;
v. a 10 percent increase in cost of feed will bring a substantial gain of 5.8 percent increase in total revenue;
vi. a 10 percent increase in cost of electricity/fuel will contribute to 0.59 percent increase in total revenue; and
vii. a 10 percent increase in other variable cost excluding electricity/fuel will only add 0.14 percent decrease in total revenue.

Hence, it was clear from the results of economic analysis that correlate well with the observations and experience of some the farmers that feed is the most powerful explanatory variable with highest output elasticity followed by fertilizers and when these two variables are effectively managed, they will contribute to increased net revenue (Table 28).

It should be noted that in Andhra Pradesh, by adopting good management practices particularly in regard to feed and fertilizers, they are able to obtain an average production of about 8 tonnes/ha commonly (Nandeesha and Ramakrishna, 2006). In Punjab too, some of the farmers have been able to get a production of even up to 11 tonnes/ha by following good management practices. Hence, it was observed that by providing good scientific support to farmers, production can be increased further substantially.

4. CONCLUSIONS

The present study clearly show that carp farming practices in Punjab were profitable. Though the production level was slightly higher in traditional systems (5 853 kg/ha/year) as compared to semi-intensive (5 699 kg/ha/year), but in terms of food conversion ratio, the latter system proved to be better, which is important from the environmental point of view. Even the benefit-cost ratio showed the benefits of semi-intensive farming (1.81) as compared to traditional system (1.75). The results of the study thus indicate that there is an opportunity to improve the food conversion ratio and profitability by employing the quality feed and better management practices. The study also demonstrated that large ponds appear to be better suited for carp culture than small ponds. Farmers developed several indigenous methods to improve production and reduce production costs. These included improved method of pond fertilization by using slurry combined with inorganic fertilizers, use of various agricultural wastes as feed for carp and use of solar pumps for pumping water. Though the farmers resorted to stocking more than double the recommended number of fingerlings (22 918 seeds/ha), the survival rate was 51 percent. This was largely due to the small size of the fish stocked. The size of fish at harvest was small (300–500 g) as there was a strong demand for this size of fish. The overall profitability of the farmers was better in semi-intensive system with the use of pellet feed as compared to the traditional system. The overall net returns to per ha was found to be US$1 828 and this level of profit with low labour requirement was found to be better than all other agricultural activities prevalent in the area. The Cobb-Douglas profit function analysis clearly showed that the production and profitability of the system can be increased further by judicious application of fertilizer and feed. Other variables like labour showed negative returns and hence farmers have to carefully manage labour inputs. With the availability of the large amount of feed ingredients in the State, significant improvements in fish production was achieved. It is likely that the current level of profitability would encourage more land to be converted to aquaculture, particularly by using the vast amount of waste land available in the State. However, it is important to note that local people do not prefer carp because of the intramuscular spines. It was suggested that technology could be developed for the culture of alternative species, such as catfish, which could have a higher demand in the local market. In addition, promoting fish as a health food would bring more revenue to farmers, assuming that demand will increase within and outside the state. Fish culture systems are recognized as users of a valuable water resource, even though they are more efficient than the prevailing crops like rice and wheat cultivation (Sondhi and Joir, 1993). However, in view of the declining water tables in the region as a whole, it is suggested that ground water exploitation should be reduced and efficient use of water should be planned. Aquaculture is recognized by the farmers in Punjab as a profitable alternate cropping system that can generate an assured level of income. In view of the positive impact, there is opportunity to expand fish farming and help farmers to derive the benefits from this new activity.

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Economics of aquaculture feeding practices: the Philippines

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SUMMARY

The objective of the study was to assess the economic implications of adopting various feeding practices in aquaculture production in the Philippines. The case study provided a comparative analysis of three different categories of feeding systems/practices in freshwater prawn (*Macrobrachium rosenbergii*) and milkfish (*Chanos chanos*) polyculture, or in some cases milkfish monoculture. The systems explored are: (1) traditional/extensive, (2) semi-intensive, and (3) intensive. To make a comparative analysis of the various feeding practices only two species were studied.

Likewise bioeconomic 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.

Intensive farms fed an average of 58.3 and 4.9 kg (53.3 and 1.39 kg on dry weight basis) per 100 pieces of milkfish and prawn, respectively while semi-intensive farms fed lower averages of 31.9 and 4.5 kg (21.03 and 0.73 kg on dry weight basis) per 100 pieces of milkfish and prawn respectively. Traditional farms had the least feed consumption with 28.6 and 2.7 kg (16.08 and 0.28 kg on dry weight basis) per 100 pieces of milkfish and prawns respectively.

Consumption of industrial feeds was higher among intensive farms at 33.8 and 1.1 kg (30.4 and 1.0 kg on dry weight basis) per 100 pieces of milkfish and prawns, respectively. Semi-intensive farms reported a low industrial feed consumption of only 8.1 and 0.3 kg (7.3 and 0.29 kg on dry weight basis) per 100 pieces of milkfish and prawn, correspondingly while traditional farms did not use any industrial feeding.

The annual average aquaculture production cost was highest among intensive farms at US$1 975/ha. This was followed by traditional farms which incurred an average production cost of US$1 249/ha. Semi-intensive farms recorded the lowest production cost of US$993/ha. As expected, the major cost item for intensive farms was the cost of feeds which was estimated at US$1 110. This represented 56.2 percent of the total production cost. Among traditional and semi-intensive farms, labour costs accounted for the largest proportions of their total production costs at 56.5 percent and 42.3 percent, respectively.

The average annual gross aquaculture margin per hectare was highest for intensive fish farm operators (US$3 422) compared with those of semi-intensive farms (US$1 072). A very low margin of US$238 was computed among traditional farms. Nevertheless, the actual returns above cash costs (gross margin) among traditional farms were much better when the imputed cost of family labour at US$309 was excluded.

Gross total factor productivities of 2.66 and 2.01 were estimated for intensive and semi-intensive farms, respectively. In terms of net total factor productivity, intensive farms (1.66) and semi-intensive farms (1.01) were able to register favourable figures while traditional farms yielded a slightly negative net factor productivity coefficient of –0.002.

The estimated break-even prices among intensive farms were 82 percent and 143 percent lower than the prevailing market prices of milkfish and prawn. In the case of semi-intensive farms, the estimated break-even prices for milkfish (US$0.72/kg) and prawn (US$2.38/kg) were also lower than the prevailing respective market prices of US$0.94/kg and US$7.57/kg. Traditional farms performed below in terms of break-even price for milkfish but has performed well as far as prawn production is concerned.

Intensive farms have exceeded their break-even productivity levels by 80 percent and 450 percent for milkfish and prawn, correspondingly. The actual level of milkfish production per hectare among traditional farms was 22 percent below the break-even production level while their average prawn production level at 87 kg was 27 percent above its estimated break-even production.

The break-even analysis on productivity levels implies that as commercial feeding intensifies, the higher yields support their adoption. Both intensive and semi-intensive farms were able to register productivity levels that exceeded the break-even point while traditional farms, due to their non-adoption of commercial feeding practices, were slightly below their break-even level of productivity for milkfish production.

Lack of capital has been a major constraint among traditional farmers (80 percent) which is perhaps the principal reason why they do not engage in commercial feeding practices.

The high cost of industrial feeds has been a major concern among traditional farms (90 percent) and semi-intensive farms (45 percent). While traditional farm respondents have readily recognized the importance of commercial feeding, its high cost per given unit has resulted in a reduced dependence on these feeds.

Higher fish weights at harvest show that the adoption of commercial feeding benefited intensive and semi-intensive farms in terms of higher yields as measured in kilograms of milkfish and prawn production. Traditional farms suffered from poor production levels relative to other farms solely because of they stuck to a less effective feeding practice. Except for the adoption and non-adoption of commercial feeds, the feeding technologies during the grow-out periods for all farm categories were similar. Likewise, since the farm conditions of the study areas were geographically similar, it emphasized the definitive edge of commercial feed users in terms of increasing their production per given area.

The higher levels of milkfish and prawn production among intensive and semi-intensive generated high gross revenues, gross and net margins, net returns on land, labour and capital. Gross and net factor productivities were financially sound. In addition, the break even price and production figures of both the intensive and semi-intensive farms were exceeded by the prevailing market prices. Traditional farms on the other hand, did not perform as sound business entities and could be interpreted as subsistence aquaculture farm operations.

Results of the regression analyses reveal that variations in the disaggregated net profit for either milkfish or prawn production as well as the aggregated net profit for both milkfish and prawn production were statistically explained either by stocking rate, recovery rate, total cost of all feeds, total cost of industrially-manufactured feeds. Total area of operation and cost of stocks also explain the variation of net profits in some of the best fit models identified in the study.

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 practice/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 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. A technology that provides reasonable financial incentives to the fish farmers will easily be adopted than technology which does not. This case study is expected to shed light on the economics of the various feeding practices in the Philippines.

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 the Philippines.

Specifically, this country case study is aimed at:

(i) conducting a survey of twenty (20) aquaculture farms for each of three (3) different categories or systems of feeding practices, using a pre-tested questionnaire;

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

- a) general profile,
- b) production (including feeding) practices,
- c) production costs (fixed investment as well as maintenance and operating costs),
- d) income (gross margin and net margin/return),
- e) production problems,
- f) returns on investments (including labour, land and capital),
- g) break-even analyses (break-even price, cost, production, and sales), 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 provides a comparative analysis of three different categories of feeding systems/practices: namely (1) traditional/extensive, (2) semi-intensive, and (3) intensive. To minimize variation in terms of fish species being produced, the comparative analysis of the various feeding practices was undertaken for same species in the country.

In the context of the study, extensive/traditional systems refer to a feeding practice where the feeds utilized in the fish farms were sourced or developed locally and were not being sold or distributed commercially. Fish farms based on traditional feeding practices generally use farm-made aquafeed and/or supplementary diets consisting of mixture of locally available feed ingredients. Farms with intensive feeding practices depend largely on commercially manufactured pelleted feeds while a semi-intensive category refers to a feeding practice that combines the two with at least 25 percent of either one being utilized.

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 and land, (v) break-even price coefficients, (vi) break-even production coefficients, (vii) gross total factor productivity (benefit cost ratio, BCR), and (viii) net total factor productivity.

2.3 Sampling technique

The case study includes three representative feeding practices for the aquaculture farms. Each feeding practice was analysed based on a survey of 20 farms. A total of 60 fish farms represented the sample size for the country case study. The stratified random sampling (SRS) technique was utilized in selecting the individual sample farm. The SRS was directly applied on a general listing of fish farms obtained from the municipality. The complete listing was obtained from the field office of the Bureau of Fisheries and Aquatic Resources (BFAR) in Hagonoy, Bulacan. From this listing of aquaculture farms, they were categorized by type of feeding practices namely (i) intensive, (ii) semi-intensive, and (iii) traditional. After which, the respondents for each feeding practice were randomly selected.

2.4 Data processing and analysis

In general, a tabular analysis was employed to develop the cost and returns tables for the various feeding practices observed in the study sites. The cost and returns analysis indicated the variable cost categories including feeds, fingerlings, fertilizers, labour, gasoline and electricity. The fixed 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 milkfish and prawn 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, training attendance and farming experience, were undertaken. Likewise bioeconomic models relating to net profit with economic variables (e.g. input and output prices) and non-economic variables (e.g. recovery rate, stocking rates, quantity of feeds, size of ponds, etc) were also undertaken to determine the existence of statistical relationships between them.

2.5 Scope and duration of the study

The study was conducted from 15 October 2005 to14 February 2006. The municipality of Hagonoy in the province of Bulacan, Philippines was selected as the site of the study (see Figure 1). The study site has been selected based on the availability or presence of aquaculture farms that represent the three feeding categories for similar species of fish. A total of 60 milkfish *(Chanos chanos)* and prawn (giant freshwater prawn *Macrobrachium rosenbergii*) farms were analysed in the study. A total of 20 respondents for each of the three feeding categories observed in the fish farms were interviewed.

2.6 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 practices. Amongst the important non-economic parameters that were not included in the study were water quality, stocking rates, feed quality and types of training. An analysis of their effects could have enriched the analysis and interpretation section of the report. For example, the volume of feeds consumed by the various farm categories could have improved the study findings 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 collection system (e.g. personal interviews by recall) which may question the reliability of the data generated in the study. Finally, the number of samples per category of feeding practice (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 encountered when increasing the number of samples. Nevertheless, the analysis at the regional level has the advantage of a larger number of samples.

3. RESULTS AND DISCUSSION

3.1 Description of the study area

The study site is located in the municipality of Hagonoy, Province of Bulacan. It has a total land area of 103 square kilometers or an equivalent of 10 310 hectares (ha). Of the total land area, 24 percent is devoted to agriculture, 60 percent to the aquaculture industry while 16 percent represent dwellings for more than 100 000 residents.

The town is a marshland and its elevation is only a couple of feet above sea level. Hagonoy has the lowest elevation level among the 24 municipalities of Bulacan. At the southern part of the town, the elevation is even lower and it is under water throughout the year. This condition however, makes the place suited for the aquaculture activity/ industry.

The province is located in Region III among the eleven Regions of the Government of the Philippines (see Figure 1). The Philippines recorded a total fish production of 4 163 150 tonnes in 2005, of which 1 895 790 tonnes (46 percent) was produced from aquaculture. The proportion of aquaculture production to total fish production has been steadily increasing from 40 percent in year 2003 (Table 1).

TABLE 1
Proportion of fish production (in thousand tonnes) by source and year, the Philippines

Source	2003	%	2004	%	2005	%
Commercial	1 110	31	1 128	29	1 135	27
Municipal	1 055	29	1 081	28	1 132	27
Aquaculture	1 455	40	1 717	44	1 896	46
Total	3 620	100	3 926	100	4 163	100

Source: BAS (2005)

3.2 Description of the respondents

The respondents of the study comprised 85 percent male and 15 percent female. The average age of the respondents was 51 years. Respondents representing semi-intensive and traditional farms had an average age of 52 years while intensive farm respondents were younger with an average age of 49 years. All respondents from the three farm categories reported similar average household sizes of five. In terms of aquaculture farming experience, semi-intensive and intensive farm respondents reported being in the profession for 14 years and 15 years, respectively. Respondents using traditional feeding practices had only 8 years of experience (Table 2).

FIGURE 1
The Study Area of Hagonoy, Bulacan, Philippines

Source: Wikipedia (2007)

TABLE 2
Average age, household size, and years in fish farming by category of respondents

Category	Age	Household size	Years in farming
Intensive farms	49	5	15
Semi-intensive farms	52	5	14
Traditional farms	52	5	8
All farms	51	5	12

Of the total respondents in the case study, 57 (95 percent) were married, two (3 percent) were single and one (2 percent) was widowed (Table 3). Most of the respondents (40 percent) had completed tertiary education while 28 and 25 percentages of respondents had respectively completed their primary and secondary education. Only a few respondents (7 percent) were unable to attend any formal education.

Fifty percent and 45 percent of respondents engaged in intensive and semi-intensive feeding practices were formally educated. Only 25 percent of the respondents belonging to the traditional fish farming category had reportedly completed tertiary level of education (Table 4).

TABLE 3
Marital status by category of respondents

Marital status	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Married	19	95	19	95	19	95	57	95
Single	0	0	1	5	1	5	2	3
Widowed	1	5	0	0	0	0	1	2
Total	20	100	20	100	20	100	60	100

TABLE 4
Educational attainment by category of respondents

Education	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
No education	2	10	0	0	2	10	4	7
Primary	4	20	5	25	6	30	15	25
Secondary	4	20	6	30	7	35	17	28
Tertiary	10	50	9	45	5	25	24	40
Total	20	100	20	100	20	100	60	100

The above statistics on farming experience and educational attainment appear to have influenced the feeding practices adopted by the respondents. As indicated in

Table 4, the more experienced and formally educated respondents tended to practice the intensive and semi-intensive feeding practices in favour of the traditional method of aquaculture farming. These demographic characteristics may have influenced the respondents to adopt the use of commercial feeds based on their better awareness of the benefits of adopting the technology.

On the average, 77 percent of the respondents claimed that aquaculture farming was their major occupation while 22 percent of the respondents were engaged in other business ventures. Only 65 percent of the respondents from the intensive farming category reported that it was their major occupation while 85 percent and 80 percent of the respondents from semi-intensive and traditional farming categories stated that fish farming was their major sources of income, correspondingly (Table 5).

TABLE 5
Major occupation of the farmers by category of respondents

Occupation	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Fish farming	13	65	17	85	16	80	46	77
Business	7	35	3	15	3	15	13	22
Carpenter	0	0	0	0	1	5	1	2
Total	20	100	20	100	20	100	60	100

3.3 General profile of the farms

The average size of aquaculture farm was estimated at 8.77 hectares (ha). Intensive farms were generally big farms with an average of 16.88 ha while semi-intensive farms recorded an average of 7.28 ha while traditional farms have the lowest average of 2.16 ha. Intensive, semi-intensive, and traditional farms operated an average number of 4, 3 and 2 ponds respectively with an average area of 4.18, 2.38, and 1.02 hectare per pond. As practised, the over-all average water depth of the aquaculture farms was 1.43 and 0.95 metres during the dry and wet season cropping, correspondingly (Table 6).

TABLE 6
Number and area of the ponds, and water depth by category of respondents

Item	Intensive	Semi-intensive	Traditional	All categories
Total number of ponds	4.0	2.8	2.1	2.9
Total area of ponds (ha)	16.88	7.28	2.16	8.77
Average area of ponds (ha)	4.18	2.38	1.02	2.53
Depth during rainy season (m)	1.47	1.41	1.43	1.43
Depth during dry season (m)	0.98	0.99	0.88	0.95

Fifty seven percent of the respondents were single owners of the fish farms and 13 percent were multiple owners. These types of ownerships have prevailed based on the land tenure and the financial capabilities of the respondents. A farmer owning the fishpond and who has sufficient capital to run the operation will tend to decide as a single owner. On the other hand, a farmer who owns his pond but has insufficient capital to run the business will tend to invite others to jointly operate the aquaculture business. Twenty-seven percent of the respondents were single lessees while 3 percent of the fish farms were jointly leased. Statistics on pond ownership indicated that 85 and 70 percent of the respective respondents from the semi-intensive and intensive farm categories were either single and/or multiple fish farm owners. Fourty five percent of traditional farmers owned their own ponds, with 45 percent leasing the ponds (Table 7). This information may imply that traditional fish farmer-respondents were less well-off compared with the intensive and semi intensive farmer-respondents.

TABLE 7
Type of pond ownership by category of respondents

Type of ownership	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Single ownership	10	50	15	75	9	45	34	57
Multiple ownership	4	20	2	10	2	10	8	13
Singly leased	4	20	3	15	9	45	16	27
Jointly leased	2	10	0	0	0	0	2	3
Total	20	100	20	100	20	100	60	100

TABLE 8
Average number of ownership for multiple ownership and average number of lessee and duration of lease for jointly leased farms by category of respondents

Item	Intensive	Semi-intensive	Traditional	All categories
Number of owners (multiple ownership)	3	2	5	3
Number of lessees (jointly leased)	4	-	-	4
Duration of lease (months)	12	12	8	10

Table 8 indicates that the average number of multiple owners was three while the number of lessees for jointly leased fish farms was four. The average duration of leasehold contracts were reported at 12 months for semi-intensive and intensive fish farmer-respondents and 8 months for traditional fish farmer-respondents. This short contract period has been a traditional practice in the area. This has been practised to allow both the leasers and lessees to have more flexibility particularly in terms of crop failures (for lessees) and general price increases (for leasers). It should be noted however, that the contract is renewable annually. The fish ponds were only being utilized for aquaculture purposes. The decision of the respondents to engage in aquaculture production was largely influenced by their perceived profitability (83 percent). It was common knowledge among the fish farm operators that a sound knowledge of the aquaculture technology coupled with favourable weather conditions and output prices would provide huge returns on investment. The next most important factor that influenced the respondents into aquaculture production was their easy access to fish culture technology as reported by 48 percent of the respondents (Table 9). In the study site, aquaculture production technology was disseminated through relatives, neighbours and extension workers from the Bureau of Fisheries and Aquatic Resources.

TABLE 9
Main factors considered in undertaking fish farming by category of respondents

Factor*	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Profitability	20	100	16	80	14	70	50	83
Own consumption	4	20	2	10	0	0	6	10
Access to fish culture technology	14	70	8	40	7	35	29	48
Feed availability	6	30	2	10	1	5	9	15
Fingerling availability	4	20	6	30	3	15	13	22

*Multiple responses

3.4 Farm production practices

3.4.1 Stocking strategies

The survey revealed that the majority (73 percent) of the respondents were engaged in the production of both milkfish and prawn production in a single pond while only 27 percent opted to raise a single species (e.g. milkfish only) (Table 10). The practice of polyculture was more dominant among intensive (85 percent) and semi-intensive (80 percent) farms compared with traditional farms where only 55 percent of the farmers resorted to polyculture (Table 10). The rearing of prawns with milkfish in the same pond provides the fish farmers with additional income due to the high market price of the former. For the milkfish-prawn pond system, prawns are normally stocked ahead of the milkfish while the ponds are still growing aqua green plants (PCARRD, 1983). The main reason cited by traditional farmer-respondents for monoculture fish production was lack of access to finance to support the input costs required for polyculture production.

TABLE 10
Reported aquaculture practices by category of respondents

Aquaculture practices	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Monoculture	3	15	4	20	9	45	16	27
Polyculture	17	85	16	80	11	55	44	73
Total	20	100	20	100	20	100	60	100

The average culture period (days) observed by all the respondents was four months or 120 days for both milkfish and prawn production with two cycles per year. This has been a tradition among the fish farms in the municipality of Hagonoy, Bulacan (Table 11). The culture period was the same for all farming systems. The cycle periods were perceived to be particularly prohibitive for smaller farmers were low feed input in this period resulted in very low average sizes of prawn harvested. Further discussion on this aspect is found on the gross revenue section of this study.

TABLE 11
Average culture period (days) by type of species and category of respondents

Type of species	Intensive	Semi-intensive	Traditional	All categories
Milkfish *(Chanos chanos)*	122	118	118	119
Prawn *(Macrobrachium rosenbergii)*	121	119	121	120
All species	122	118	120	120

The average stocking rate per hectare per year for milkfish varied from 2 923 pieces among traditional farms to 4 348 and 7 826 pieces for semi-intensive and intensive aquaculture farms respectively. The overall average for all farms was 5 033 pieces. The stocking rates per hectare per year (considering a two-season crop) was way below the recommended stocking rate of about 10 000 fish per hectare as prescribed by the Philippine Council for Marine and Aquaculture Research and Development (PCMARD) and Bureau of Fisheries and Aquaculture Research (BFAR). It may be interesting to determine the impact of varying stocking rates on the production potential of this species in future studies. Until the 1980's high density stocking rates were not economically attractive to farmers. In 1987, research conducted at the University of the Philippines' research centre in Iloilo successfully demonstrated the technological and economic feasibility of raising milkfish at densities of 7 000–12 000 fingerlings per hectare. By the late 80's private companies have made initial gains in raising the stocking density to 10 000–20 000 fingerlings per hectare (Aqua Farm News, 1995).

TABLE 12
Average stocking rate and size by species and size category of respondents

Item	Intensive	Semi-intensive	Traditional	All categories
Milkfish				
Stocking rate (No./ha/year)	7 826	4 348	2 923	5 033
Stocking size (cm)	10	11	11	10
Prawn				
Stocking rate (No./ha/year)	27 798	26 329	26 500	26 876
Stocking size (cm)	3	3	3	3

In the case of prawn production, the average stocking rate was estimated at 26 876 pieces per hectare per year (Table 12). The variation in stocking rates by farm category was minimal. This stocking rate was lower than the ideally prescribed stocking rate (e.g. 50 000 pieces per hectare per year or 25 000 pieces per cropping per season) recommended by Philippine fishery agencies. The effect of the level of stocking rates on production levels is also very interesting to determine for this particular species especially when mixed with milkfish.

FIGURE 2
Aquaculture practices by farm category

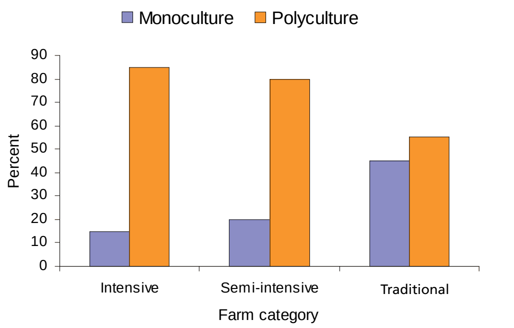
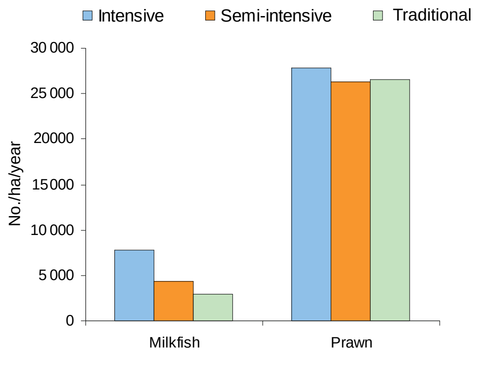


FIGURE 3
Stocking rate by species and by farm category



Stocking sizes for both species were determined based only on the length since the respondents failed to account for their weights as payments were made based on the length and not on the weight of the fry/fingerlings. For milkfish, the stocking size of the fingerlings was reported at 11 cm for semi-intensive and traditional farms and 10 cm for intensive farms. In the case of prawn, the stocking size of 3 cm has been a general practice for all farm categories.

The majority of the respondents adopted the multiple stocking strategy as reported by 78 percent of the respondents. Fifty seven percent of the traditional farms reported that they stocked their ponds twice a year which implied that one stocking was made per cropping season. About 29 percent of the traditional farms recorded a stocking frequency of three times a year which indicates that there was more than one stocking made per cropping season.

In the case of semi-intensive and intensive farms, 65 percent and 63 percent (Table 13) were observed practising three stockings per year which implies that more than one stocking was done made per cropping season of 120 days[1].

[1] It must be noted that aquaculture production in the study site reported a maximum of two croppings per year per given pond.

TABLE 13
Stocking strategy and number of stocking by category of respondents

Item	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Stocking strategy								
Single stocking	3	15	4	20	6	30	13	22
Multiple stocking	17	85	16	80	14	70	47	78
Total	20	100	20	100	20	100	60	100
Number of stocking (for multiple stocking)								
2x per year	4	24	5	31	8	57	17	36
3x per year	11	65	10	63	4	29	25	53
4x per year	1	6	1	6	1	7	3	6
Continuous stocking	1	6	0	0	1	7	2	4
Total	17	100	16	100	14	100	47	100

3.4.2 Feeding practice

Type of feeds

Aquaculture producers used five different types or categories of feeds, namely; (i) industrial or commercial feeds, (ii) aqua green plant or generally called hydrophytes or macrophytes (also termed "lumot" in the local dialect), (iii) bread, (iv) noodles, and (v) snail meat (termed "sulib" in the local dialect) (Table 14). Industrial feeds were generally used for both milkfish and prawn consumption during the rearing period and was the most expensive type of feed, costing about P10–15 per kg (US$0.196–0.294)[2]. Aqua green plant was likewise used during the rearing stage and was considerably cheaper at P1.0–2.0 (US$0.0196–0.0392) per kg. Bread and noodles were considered as supplementary feeds for milkfish production and were moderately priced at about P6.0 (US$0.118) per kg and was generally used during the "on-growing" or "grow-out" period prior to harvesting. As reported, these supplementary feeds were used to fatten milkfish immediately before they were sold. Snail meats were also fed during the "grow-out" stage to harden the covering of the prawn in order to increase its marketability.

All semi-intensive and intensive farms were found to use commercial/industrial feeds in their milkfish and prawn productions while traditional farms did not use these feeds. As expected aqua green plants was used as the main feed item for all traditional farms. Most of the semi-intensive (85 percent) and intensive (70 percent) farms also fed their fish with aqua green plants as supplementary feed. The strategy of using aqua green plants as part of their feeding practice was reportedly to reduce overall feed costs because of the high price of commercial feeds.

Old bread was a popular feed item used by 92 percent of all respondents during the milkfish "grow-out" period. Its intended impact was to add more fats to the belly (portion) of milkfish in order to enhance its marketability. Filipino consumers have developed their preference for fat-bellied milkfish products. The use of bread for grow-out feeding was being practised by at least 90 percent of the respondents regardless of farm categories. In some instances, intensive farms would resort to using "noodles" during the grow-out period to enhance the quality of milkfish. This was reported by 20 percent of intensive farmer-respondents (Table 14). Unfortunately, this study did not quantify the productivity impacts of these practices but it has reportedly contributed to increased buyers' preference.

[2] US$1.00 = P51.00

TABLE 14
Type of feeds used by category of respondents

Item	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
A. Type of feeds								
1. Industrial feeds[1]	20	100	20	100	0	0	40	67
2. Aqua green plants[1]	14	70	17	85	20	100	51	85
3. Bread[2]	18	90	19	95	18	90	55	92
4. Noodles[2]	4	20	0	0	0	0	4	7
5. Snail meat[3]	16	80	11	55	11	55	38	63
B. Feed type based on mode of sinking								
1. Industrial feeds[1]								
a. Floating	1	5	5	25	0	0	6	16
b. Slow sinking	18	90	15	75	0	0	33	87
c. Fast Sinking	1	5	0	0	0	0	1	3
2. Aqua green plants[1]								
a. Floating	14	100	17	100	20	100	51	100
3. Bread[2]								
a. Floating	16	89	17	89	17	94	50	91
b. Slow sinking	2	11	2	10	1	6	5	9
4. Noodles[2]								
a. Floating	1	25	0	0	0	0	1	25
b. Slow sinking	3	75	0	0	0	0	3	75
5. Snail meat[3]								
a. Fast sinking	16	100	11	100	11	100	38	100

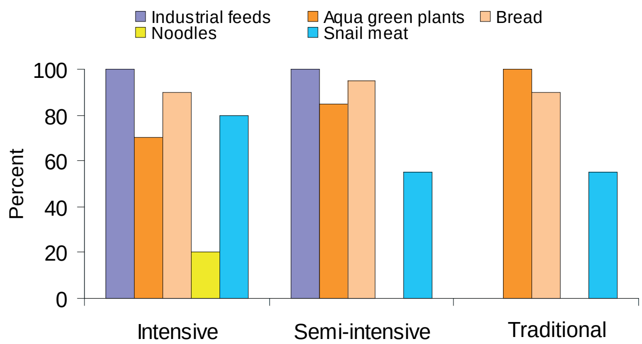
[1]Feeds used for milkfish and prawn; [2]Feeds used for milkfish; [3]Feeds used for prawn

Semi-intensive and intensive farms have generally favoured to use "slow-sinking" types of pelleted industrial feeds as cited by 75 and 90 percent of the respondents. Though there was no technical explanation provided, respondents claimed that this mode of sinking was the most efficient during the rearing stage of milkfish and prawn (Table 14).

Aqua green plants (e.g. macrophytes or hydrophytes) by its physical characteristics, is a floating type of feed. In the same manner bread and noodles are also floating when being fed to the fish. Snail meat is the only fast-sinking type of feed.

Table 15 indicates that most intensive farms (80 percent) utilized industrial commercial feeds strictly for the rearing of fingerling while 15 percent of the respondents claimed that commercial feeds were used for both the rearing and "grow-out" periods of milkfish and prawn production. Among semi-intensive farms, the majority of the respondents (65 percent) reported that commercial feeds were intended for both the rearing and "grow-out" periods of their operation. Only 25 percent reported that commercial feeds were strictly used during the rearing stage.

FIGURE 4
Type of feeds used by farm category



Aqua green plants were considered as a general purpose type of feed by all the respondents although semi-intensive farms (88 percent) and traditional farms (90 percent) reported that this type of feeds was addressing the feed demand of the fish crops during the rearing and "grow-out" stages. Most intensive farms (79 percent), however, used aqua green plants during the rearing stage. Bread, noodles, and snail meat were considered by all the respondents as feed supplements which were essential during the "grow-out" period to enhance the quality of the milkfish and prawn products prior to their harvests.

3.4.3 Frequency and intensity of feeding

The most widely practised feeding frequency of commercial feeds was "once a day" as cited by 80 and 75 percent of semi-intensive and intensive fish farmers respectively. Aqua green plants were likewise available to the fish on a daily basis as they were left floating in the ponds. The feeding frequencies for bread products varied for each farm category. Among intensive farms, bread was fed twice a week by 61 percent of the respondents as a supplement feed during the "grow-out" period. A smaller proportion of intensive farms (17 percent) would feed bread once a day. Among semi-intensive farms, 42 percent of the respondents each reported feeding frequency of once a day and twice a week. In the case of traditional farms, feeding frequencies for bread products were weekly (39 percent), once a day (33 percent), and twice a week (28 percent) were noted.

The snail meat feeding frequency was weekly. This was reported 56, 73 and 45 percent of intensive, semi-intensive and traditional fish farms, correspondingly. Other feeding frequencies observed for snail meat products were "once a day" and twice a week (Table 16).

Industrial feeds (pelleted) were generally broadcasted when fed to the fish. Ninety and 80 percent of the respective respondents from semi-intensive and intensive farms reported using the broadcast method (Table 17). Only a few respondents among intensive farms used either the feeding tray (15 percent) and/or automatic feeding (5 percent). Among semi-intensive farms, only 5 percent each of respondents used either feeding bags or automatic feeding.

Aqua green plants were either planted or broadcasted among semi-intensive and intensive farms. Since these two types of farms generally used the commercial feeds, only about half of the respondents in those farm categories grew their own aquatic green plants in their ponds. However, the area covered was less when compared with traditional farms.

Bread, noodles and snail meat were all fed to the fish using the broadcast method. The broadcast method was being extensively followed by the fish pond operators since it was part of the work performed by the "watchers" employed by the fishpond owners. The watchers were given incentives by the owners which were based on the volume and quality of harvests.

Table 18 shows the amount of feed per hectare by type of feed and fish farm category. Semi-intensive farms consume an average of 435 kg of industrial feed per hectare per year or an average of 217.5 kg per hectare per cropping season. Intensive farms on the other hand, consume 3 278 kg per hectare per year which is 7.5 times more than the rate or intensity of feeding by semi-intensive farms. The rate of aqua green plant feeding ranged from 223 (intensive farms) to 388 (traditional farms) 416 (semi-intensive farms) per kg per hectare per year. The dry matter equivalents for the various types of feeds are also indicated in the Table 18. Overall, a dry weight equivalent of 4 565 kg of feed per hectare per year has been estimated among intensive farms relative to only 1 407 and 844 kg per hectare per year for semi-intensive and traditional farms, correspondingly.

TABLE 15
Type of feeds used at different stages of rearing by category of respondents

Type of feeds/stages of rearing	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
1. Industrial feeds[1]								
a. Rearing of fingerling	16	80	5	25	0	0	21	53
b. On-growing/grow-out	1	5	2	10	0	0	3	8
c. Rearing of fingerling and on-growing/grow-out	3	15	13	65	0	0	16	40
2. Aqua green plants[1]								
a. Rearing of fingerling	11	79	2	12	2	10	15	29
b. Rearing of fingerling and on-growing/grow-out	3	21	15	88	18	90	36	71
3. Bread[2/]								
a. Rearing of fingerling	0	0	0	0	1	6	1	2
b. On-growing/grow-out	18	100	18	95	17	94	53	96
c. Rearing of fingerling and on-growing/grow-out	0	0	1	5	0	0	1	2
4. Noodles[2]								
a. Rearing of fingerling	0	0	0	0	0	0	0	0
b. On-growing/grow-out	2	50	0	0	0	0	2	50
c. Rearing of fingerling and on-growing/grow-out	2	50	0	0	0	0	2	50
5. Snail meat[3]								
a. Rearing of fingerling	1	6	0	0	0	0	1	3
b. On-growing/grow-out	15	94	11	100	11	100	37	97

[1]Feeds used for milkfish and prawn. Field observations also indicate that intensive farmers do not use industrial feed during on-growing while semi-intensive farmers use industrial feed for both fingerling production and on-growing; [2]Feeds used for milkfish; [3]Feeds used for prawn

TABLE 16
Type of feeds and feeding frequency by category of respondents

Type of feeds/feeding frequency	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
1. Industrial feeds[1]								
a. More than twice daily	1	5	2	10	0	0	3	8
b. Once daily	15	75	16	80	0	0	31	78
c. Twice in a week	3	15	1	5	0	0	4	10
d. Weekly	1	5	0	0	0	0	1	3
e. Irregular	0	0	1	5	0	0	1	3
2. Aqua green plants[1]								
Once daily*	14	100	17	100	20	100	51	100
3. Bread[2]								
a. Once daily	3	17	8	42	6	33	17	31
b. Twice in a week	11	61	8	42	5	28	24	44
c. Weekly	2	11	2	11	7	39	11	20
d. Monthly	1	6	0	0	0	0	1	2
e. Irregular	1	6	1	5	0	0	2	4
4. Noodles[2]								
a. Once daily	3	75	0	0	0	0	3	75
b. Weekly	1	25	0	0	0	0	1	25
5. Snail meat[3]								
a. Once daily	5	31	2	18	2	18	9	24
b. Twice in a week	2	13	1	9	3	27	6	16
c. Weekly	9	56	8	73	5	45	22	58
d. Irregular	0	0	0	0	1	9	1	3

[1]Feeds used for milkfish and prawn; [2]Feeds used for milkfish; [3]Feeds used for prawn. *Once daily left on the surface of the pond.

TABLE 17
Feed application methods for industrially-manufactured pelleted feed by category of respondents

Feed application methods	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
1. Broadcasting	16	80	18	90	0	0	34	57
2. Feeding tray	3	15	0	0	0	0	3	5
3. Feeding bag	0	0	1	5	0	0	1	2
4. Automatic feeding	1	5	1	5	0	0	2	3
Total	20	100	20	100	0	0	40	67

It is interesting to note that the intensive farms used less aqua green plants compared to other farm types. Intensive farms considered aqua green plants as supplementary feeds since they relied more on commercial feeds to satisfy the feeding requirements. The traditional farmers grew all their own aqua green plants to ensure the adequate of supply on a daily basis. On the other hand, about half of the respondents of the intensive and semi-intensive farms did not plant their own aqua green plants but would buy their supply from co- fish farmers as and when the need arose. Despite the fact that aqua green plants can grow even when organic matter content of the soil is low, fish farmers limits its production. It was reported that much growth of aqua green plants could restrict the water circulation, fish movement and may even contribute to oxygen depletion (Aqua Farm News, 1990).

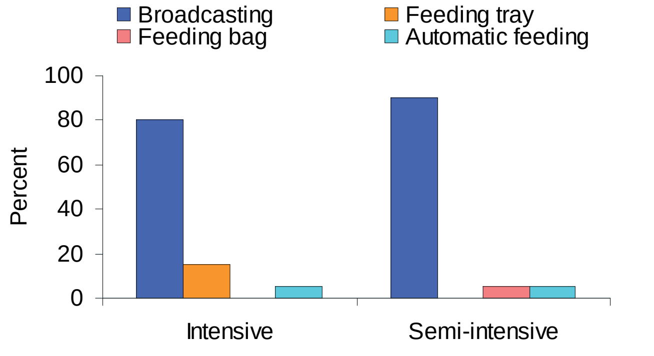
TABLE 18
Amount of feed (kg/ha/year) used by type of feeds and by category of respondents

Type of feeds used	Intensive		Semi-isntensive		Traditional		All categories	
	Fresh weight	Dry weight[4]	Fresh weight	Dry weight[4]	Fresh weight	Dry weight[4]	Fresh weight	Dry weight[4]
1. Industrial feeds[1]	3 278	2 950	435	391	-	-	1 238	1 114
2. Rice bran	543	470	188	163	421	364	384	332
3. Aqua green plants[1]	223	33	416	62	388	58	342	51
4. Bread[2]	869	759	802	701	401	350	691	604
5. Noodles[2]	301	271	21	19	12	11	111	100
6. Snail meat[3]	816	82	714	71	609	61	713	71
Total	6 030	4 565	2 576	1 407	1 831	844	3 479	2 272

[1]Feeds used for milkfish and prawn; [2]Feeds used for milkfish; [3]Feeds used for prawn.
[4]Conversion from fresh weight to dry weight were based on the following: industrial feeds = 90%, aqua green plants = 15%, rice bran = 86.6, wheat bran/flour/bread = 87.4%, noodles = 90% and snail meat = 10%

The average feeding rates for bread products of 401, 802 and 869 kg per hectare per year were respectively estimated for traditional, semi-intensive, and intensive farms (Table 18). These feeding rates of the various farm classifications were correlated with the stocking rates for milkfish. A high stocking rate requires higher feed requirements during the "grow-out" period assuming a constant mortality rate among all farm categories. In the case of snail meat feeding, semi-intensive and intensive farms recorded high rates of 714 and 816 kg/ha/year

FIGURE 5
Industrially-manufactured pelleted feed: application method by farm category



which was higher than the snail meat feeding rate of 609 kg/ha/year among traditional farms. Traditional farmers reported their incapacity to finance the perceived optimum feeding requirements particularly during the later stages of the farming operation. This resulted in lower snail meat feeding rates

Fertilizer application has not been a normal practice in the survey site. Only two respondents reported using fertilizer in their fish ponds.

A more meaningful assessment can be made by looking at feed consumption per 100 pieces of fish stocked as shown in Table 19. It shows that regardless of feed type, intensive farms fed an average of 58.31 and 4.89 kg (53.3 and 1.39 kg on dry weight basis) per 100 pieces of milkfish and prawn respectively while semi-intensive farms fed lower averages of 31.85 and 4.49 kg (21.03 and 0.73 kg on dry weight basis) per 100 pieces of milkfish and prawn respectively. Traditional farms had the least feed consumption of 28.64 and 2.65 kg (16.08 and 0.28 kg on dry weight basis) per 100 pieces of milkfish and prawn, respectively.

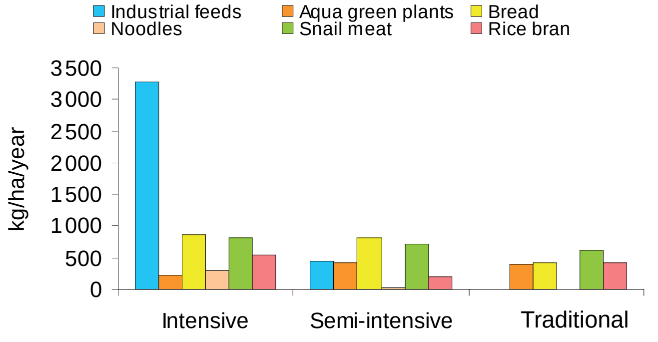
TABLE 19
Amount of feed (kg/100 fish) (as fed and dry weight basis), by species and by type of feeds used, by category of respondents

Type of feeds used	Intensive		Semi-intensive		Traditional		All categories	
	Fresh weight	Dry weight	Fresh weight	Dry weight	Fresh weight	Dry weight	Fresh weight	Dry weight
1. Industrial feeds[1]								
Milkfish	33.79	30.41	8.14	7.33	-	-	28.63	25.77
Prawn	1.11	1.00	0.32	0.29	-	-	1.07	0.96
2. Aqua green plants[1]								
Milkfish	3.34	0.50	9.57	1.45	12.18	1.83	7.12	1.07
Prawn	0.11	0.02	0.38	0.06	0.33	0.05	0.27	0.04
3. Bread[2]	15.35	13.29	14.14	12.25	16.46	14.25	15.22	13.18
4. Noodles[2]	5.83	5.10	-	-	-	-	5.83	5.10
5. Snail meat[3]	3.67	0.37	3.79	0.38	2.32	0.23	3.74	0.37
Total								
Milkfish	58.31	53.30	31.85	21.03	28.64	16.08	56.80	45.12
Prawn	4.89	1.39	4.49	0.73	2.65	0.28	5.08	1.37
All species	63.19	54.69	36.33	21.76	31.29	16.36	61.87	46.49

[1]Feed used for milkfish and prawn; [2]feed used for milkfish; [3]feed used for prawn.
Note: Estimates of rice bran has not been included due to lack of information.

Consumption of industrial feeds was highest among intensive farms at 33.79 and 1.11 kg (30.4 and 1.0 kg on dry weight basis) per 100 pieces of milkfish and prawn, respectively. Semi-intensive farms reported a low industrial feed consumption of only 8.14 and 0.32 kg (7.3 and 0.29 kg on dry weight basis) per 100 pieces of milkfish and prawn, correspondingly. It is interesting to note that aqua green plants consumption per 100 pieces of milkfish was highest among traditional farms (12.18 kg) compared with semi-intensive (9.57 kg) and intensive farms (3.34 kg). Bread consumption among all three farm categories was almost similar at about 14–16 kg per 100 pieces of milkfish. Snail meat

FIGURE 6
Amount of feed (as fed basis) by feed type and by farm category



consumption per 100 pieces of prawn is almost similar for semi-intensive and intensive farms at about 3.6–3.8 kg. Traditional farms provided the least quantity of snail meat at 2.32 kg per 100 pieces of prawn.

3.4.4 Labour utilization and cost

Part time and occasional labour were normally hired to do activities during pre-stocking operations such as excavation, cleaning and dikes repairs and post-stocking activities particularly harvesting.

On a per farm basis, fish farmers were able to employ full time employees with an average of one, two and three in traditional, semi-intensive and intensive farms, respectively. On part time basis, these farms were respectively able to employ averages of 2, 4, and 6 people. The average number of occasional employment generated by these farms was about 6 people, ranging from only two (traditional farms) to 11 for semi-intensive farms (Table 20).

TABLE 20
Average number of labour employed by category of respondents

Type of labour	Intensive	Semi-intensive	Traditional	All categories
Full-time labour	3	2	1	2
Part-time labour	6	4	2	4
Occasional labour	6	11	2	6
Total	15	17	5	12

In general, full time employment was required for fishpond "watchers" or "caretakers". Theft was common place if a farmer was unable to employ a trusted person on full-time basis. These full-time employees normally stay on the fish-farms for the duration of the production period particularly when the fish species reached marketable size.

On a per hectare basis, the total labour utilization (Table 21) for all farm operations was estimated at 165 man-days, for all farm categories, of which, 56 man-days (33.94 percent) came from family labour. Post stocking operations accounted for 87 percent of the total labour utilized. The largest proportion of labour utilization per hectare was spent on "caretakers" at 129 man-days representing 78.18 percent of the total.

The respondents claimed that this trend in labour utilization was primarily to minimize incidences of poaching activities among the various farms. In addition, caretakers provided assistance in other fish farming activities. Among traditional farms, a total of 257 man-

FIGURE 7
Average rate of feeding (as fed basis) per 100 pieces of milkfish by feed type and by farm category

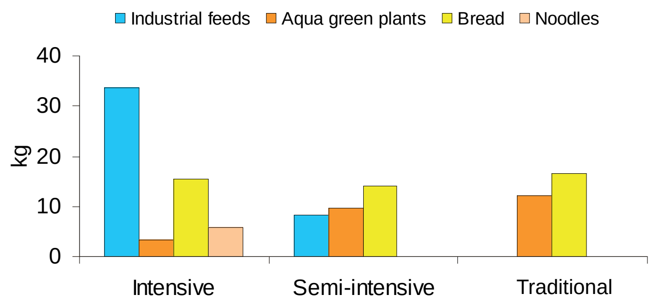


FIGURE 8
Average rate of feeding (as fed basis) per 100 pieces of prawn by feed type and by farm category

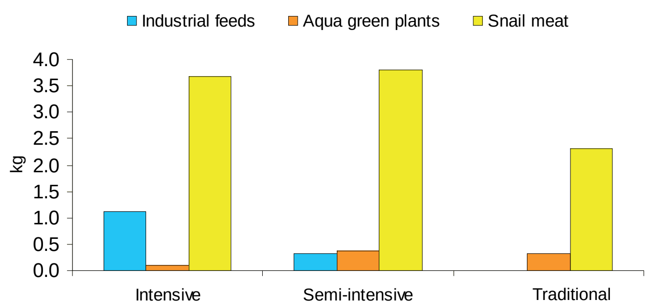
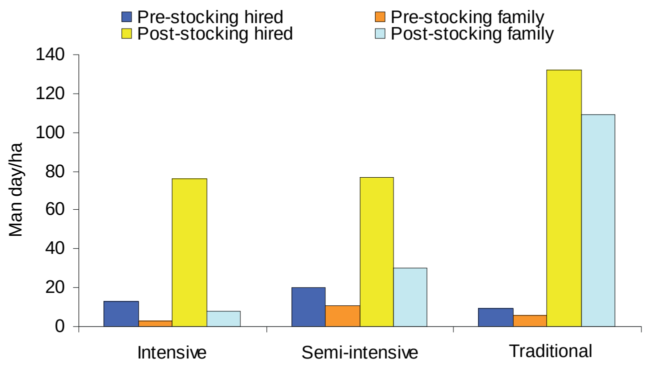


FIGURE 9
Average labour utilization (man day/ha) by farm category



days per hectare was utilized wherein family labour accounted for 44.75 percent of the total. For semi-intensive and intensive farms, labour utilization per hectare was pegged at 138 and 100 man-days, correspondingly. Respective family labour utilization per hectare accounted for 29.71 and 11 percent, among semi-intensive and intensive farms. The largest proportion of family labour inputs (44.74 percent) was observed among traditional farms.

3.5 Fish production costs

3.5.1 Capital investment

The major investment items identified during the survey included the construction of hut(s), acquisitions of banca(s)[3], a vehicle truck/pick-up, fish nets, coolers, and pumps (Table 22). Regardless of farm categories, the average fixed investment per hectare was estimated at US$369. Construction of huts (which were used for storage as well as field offices for caretaker), and acquisition of bancas required an average investment of US$111 per hectare. Equivalent per hectare fixed investments of US$32, US$29, US$25 were incurred for a truck/pick-up, coolers and fish nets.

It is interesting to note that by farm categories, fixed investment per hectare was largest among traditional farms at US$506 compared with semi-intensive and intensive farms with fixed investments of US$369 and US$230 per hectare, respectively. This trend is explained by the presence of economies of scale. Since traditional farms had smaller pond areas relative to semi-intensive and intensive farms, their equivalent fixed investment per hectare were higher than the other farm categories. This is manifested in higher equivalent fixed investment per hectare for bancas (US$175), huts (US$145) and fish nets (US$44) among traditional farms.

Table 22 also indicates that only the intensive and semi-intensive farms incurred fixed investments on pick-up trucks in their fish farming operations. The respondents of the study reported that such fixed investments were necessary to support the larger scale operations.

3.5.2 Variable costs

Variable cost items identified in the case study included the costs of labour, cost of fry/fingerlings, cost of feeds, cost of gasoline and electricity, and other rental costs. Variable costs were more directly related to the scale of operations of the fish farms at any given time.

[3] A "banca" is the local term for a motorboat used for fishing

TABLE 21
Average annual labour utilization (man-days/ha) by type of operation and category of respondents

Type of operation	Intensive			Semi-intensive			Traditional			All categories		
	Hired	Family	Total	Hired	Family	Total	Hired	Family	Total	Hired	Family	Total
A. Pre-stocking												
1. Excavation	4	0	4	10	8	18	1	0	2	5	3	8
2. Cleaning	5	1	6	5	2	7	7	2	9	6	1	7
3. Dikes repair/ construction	2	1	3	2	0	2	1	2	3	2	1	3
4. Fertilizer application	0	0	0	2	0	2	0	0	0	1	0	1
5. Procurement of feed ingredients	0	1	1	1	0	1	0	0	0	0	1	1
6. Transport of feed ingredients	1	0	1	0	1	1	0	1	1	0	1	1
7. Storage of feed ingredients	1	0	1	0	0	0	0	0	0	0	0	0
Subtotal	13	3	16	20	11	31	9	5	15	14	7	21
B. Post-stocking												
1. Feed application	4	7	11	0	3	3	2	0	2	2	3	5
2. Sampling/netting for growth observation	5	0	5	10	0	10	0	0	0	5	0	5
3. Watchmen/caretaker[1/]	64	0	64	64	26	90	127	106	233	85	44	129
4. Harvesting	3	0	3	3	1	4	2	1	3	3	1	4
5. Marketing	0	0	1	0	0	1	1	1	2	1	0	1
Subtotal	76	8	84	77	30	107	132	109	241	95	49	144
All operations	89	11	100	97	41	138	141	115	257	109	56	165

[1] The watchmen/caretaker undertakes a multiple of activities aside from being a watcher of ponds and these included application of fertilizers, collection of feeds/ingredients, and feed preparation, procurement of fry/ fingerlings.

3.5.3 Labour costs

As expected, the annual labour costs per hectare incurred by traditional farms was highest among the three farm categories at US$706 compared with semi-intensive and intensive farms which reported labour costs of US$420 and US$317, respectively (Table 23). The proportion of costs allocated for family labour among intensive and semi-intensive farms was low at 15 percent and 29 percent, correspondingly. Traditional farms on the other hand, provided about 44 percent of family labour as a proportion of the total cost of labour. The labour cost figures also showed that in absolute figures, the hired labour cost per hectare was highest among traditional farms at US$397 when compared with the respective hired labour costs of semi-intensive and intensive farms at US$299 and US$275. For all farm categories,

FIGURE 10
Average labour cost by farm category

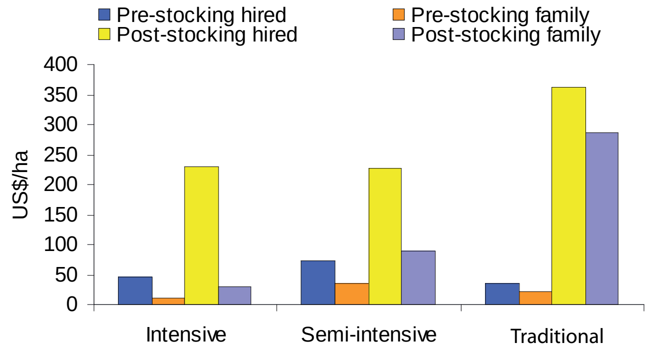
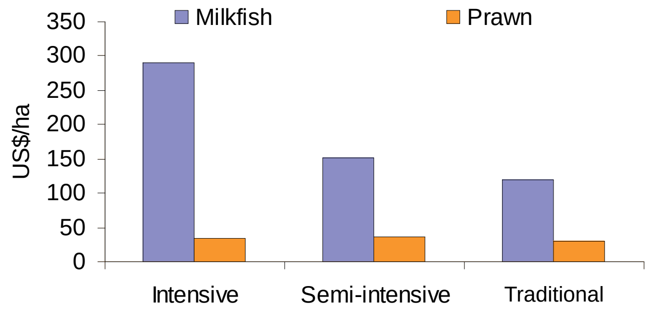


FIGURE 11
Cost of stocking by species and farm category



the proportion of labour cost per hectare was highest for payments made to "caretakers" (74 percent) which had been the general trend for traditional (88 percent), semi-intensive (62 percent) and intensive (58 percent) farms. The annual cost of labour per hectare during post-stocking operations represented about 85 percent of the total labour cost regardless of farm category. The major cost items during the pre-stocking operations included the cost of cleaning and excavation.

TABLE 22
Average purchase and scraps values (US$/ha) of fixed investment by category of respondents

Items	Intensive		Semi-intensive		Traditional		All categories	
	Purchase value	Scrap value	Purchase value	Scrap value	Purchase value	Scrap value	Purchase value	Scrap value
A. Huts	58	3	130	5	145	14	111	7
B. Transport	56	5	40	2	-	-	32	2
C. Fish nets	12	0	19	0	44	2	25	1
D. Coolers	27	1	33	1	28	1	29	1
E. Banca	51	5	106	11	175	8	111	8
F. Autofeeder	6	-	-	-	-	-	2	-
G. Pumps	21	6	41	11	113	3	58	7
Total	230	-	369	-	506		369	-

Note: US$1.00 = P51.00

Cost of stocking

On a per hectare basis, the annual average purchase cost for stock regardless of farm category was estimated at US$221. Intensive farms incurred the highest stocking costs at US$325 per hectare. For semi-intensive and traditional farms, the annual average stocking per hectare cost was lower at only US$187 and US$149 respectively (Table 24). The cost of stocking was significantly higher for milkfish at US$187 relative to prawn at US$33. This was attributed to the average price per piece of milkfish fingerlings which was about 17 times higher at US$0.034 compared with only US$0.002 for prawn. This pricing scheme partly resulted in the respondent's decision to purchase larger volumes of stocks for prawn production (13 695 pieces) than milkfish stocks (5 284 pieces). The cost of purchase per piece of milkfish fingerlings was slightly lower for intensive farms at US$0.033 per piece relative to semi-intensive at US$0.037 per piece and traditional farms at US$0.039 per piece. The respondents stated that the cost per unit decreased as the volume of purchase increased. In the case of prawn, semi-intensive farms reported higher prices than those prices paid by intensive and traditional farms.

Cost of feeds

Regardless of farm category, the annual average cost of feeds per hectare was valued at US$511 (Table 25). As expected intensive farms incurred the highest feed cost at US$1 110 while semi-intensive and traditional farms reported relatively lower annual average feed costs per hectare at US$282 and US$140, respectively. Intensive farms

TABLE 23
Average annual cost (US$/ha) of labour, by type of operation and category of respondents

Type of operation	Intensive			Semi-intensive			Traditional			All categories		
	Hired	Family	Total	Hired	Family	Total	Hired	Family	Total	Hired	Family	Total
A. Pre-stocking												
1. Excavation	13	0	14	34	23	57	8	3	11	18	9	27
2. Cleaning	18	4	23	20	5	25	25	8	32	21	6	27
3. Dikes repair/construction	8	5	13	7	1	8	3	7	10	6	4	10
4. Fertilizer application	0	0	0	6	0	6	0	0	0	2	0	2
5. Procurement of feed ingredients	1	1	2	4	1	6	0	2	2	2	1	3
6. Transport of feed ingredients	2	0	2	1	2	4	0	3	3	1	2	3
8. Storage of feed ingredients	3	1	3	0	0	0	0	0	0	1	0	1
Subtotal	45	11	56	72	34	105	36	22	58	51	22	73
B. Post-stocking												
1. Feed application	15	28	43	0	10	10	5	1	7	7	13	20
2. Sampling/netting for growth observation	16	0	16	29	0	29	0	0	0	15	0	15
3. Watchmen/caretaker	185	0	185	185	74	260	343	276	620	238	117	355
4. Harvesting	12	2	14	11	3	14	9	4	13	11	3	14
5. Marketing	1	1	2	1	1	2	3	5	8	2	2	4
Subtotal	229	31	260	227	88	315	361	287	648	273	135	408
All operations	275	42	317	299	121	420	397	309	706	323	157	481

Note: US$1.00 = P51.00

incurred huge expenditures in the purchase of commercially manufactured feeds at US$833 while semi-intensive farms only spent an average of US$105 for the same item which correspondingly accounted for 75 and 37 percent of their total feed costs. Traditional farms did not purchase commercially manufactured feed. Regardless of farm category, about 62 percent of the total feed costs were allocated for commercially manufactured feeds. These figures indicated that as the farms move from semi-intensive to intensive feeding operations, the cost of commercial feeds became a major cost item. It may be argued that cash requirements became a constraining factor when a fish farmer decides to intensify his feeding practice.

Among supplementary feeds wheat bran/flour and rice bran were the major cost items with average costs per hectare of US$82 and US$41, respectively. Among traditional farms the average cost of wheat bran/flour and rice bran combined represented 66 percent of their total feed cost. It is also interesting to point out that the cost of aquatic plants (which was considered as an essential feed item among traditional farms) was low at only US$15 per hectare.

Miscellaneous input/other variable costs

Miscellaneous input costs (Table 26) associated with fish farm operations included the cost of electricity, gasoline and other rental cost of equipment.

TABLE 24
Annual quantity and cost (US$/ha) of stocking (fingerlings) by type of species and category of respondents

Stocking/species	Intensive			Semi-intensive			Traditional			All categories		
	Average no. of pieces	Price/ piece	Total cost	Average no. of pieces	Price/ piece	Total cost	Average no. of pieces	Price/ piece	Total cost	Average no. of pieces	Price/ piece	Total cost
A. First stocking												
1. Milkfish	3 655	0.037	135	2 415	0.039	93	1 711	0.040	68	2 594	0.038	99
2. Prawn	8 360	0.002	18	6 302	0.003	21	6 458	0.002	15	7 040	0.003	18
All species	12 016	0.013	153	8 716	0.013	114	8 169	0.010	83	9 634	0.012	117
B. Second stocking												
1. Milkfish	3 190	0.036	113	1 597	0.038	61	1 238	0.039	48	2 008	0.038	74
2. Prawn	6 554	0.002	14	5 855	0.003	19	6 227	0.002	15	6 212	0.003	16
All species	9 744	0.013	127	7 452	0.011	81	7 465	0.008	62	8 220	0.011	90
C. Third stocking												
1. Milkfish	1 443	0.036	53	69	0.034	2	104	0.039	4	538	0.037	20
2. Prawn	1 111	0.002	2	217	0.002	0	0	0.000	0	443	0.002	1
All species	2 553	0.022	55	286	0.010	3	104	0.038	4	981	0.021	21
D. Fourth stocking												
1. Milkfish	430	0.025	11	0	0.000	0	0	0.000	0	143	0.025	4
2. Prawn	0	0.000	0	0	0.000	0	0	0.000	0	0	0.000	0
All species	430	0.026	11	0	0.000	0	0	0.000	0	143	0.028	4
E. All stockings												
1. Milkfish	8 717	0.033	291	4 080	0.037	151	3 053	0.039	120	5 284	0.034	187
2. Prawn	16 025	0.002	34	12 373	0.003	36	12 685	0.002	30	13 695	0.002	33
All species	24 742	0.013	325	16 454	0.011	187	15 738	0.009	149	18 978	0.012	221

Note: US$1.00 = P51.00

TABLE 25
Annual average quantity and cost of feeds by type of feed and category of respondents, per hectare

Type of feeds	Intensive			Semi–intensive			Traditional			All categories		
	Qty (kg)	Unit cost (US$/ kg)	Total cost (US$)	Qty (kg)	Unit cost (US$/ kg)	Total cost (US$)	Qty (kg)	US$/kg	Total cost	Qty (kg)	Unit cost (US$/ kg)	Total cost (US$)
A. Commercial pellet	3 278	0.254	833	435	0.241	105	0	0.000	0	1 238	0.248	313
B. Supplementary feeds												
1. Rice bran	543	0.100	54	188	0.117	22	421	0.112	47	384	0.110	41
2. Wheat bran/flour	869	0.122	106	802	0.118	94	401	0.111	45	691	0.118	82
3. Aquatic plants/ green grass	223	0.038	9	416	0.039	16	388	0.040	15	342	0.039	13
4. Noodles	301	0.243	73	21	0.235	5	12	0.235	3	111	0.241	27
5. Snail meat/sulib	816	0.043	35	714	0.056	40	609	0.050	30	713	0.049	35
Subtotal	2 753	0.109	277	2 139	0.113	177	1 831	0.110	140	2 241	0.112	198
All feed types	6 030	0.184	1 110	2 576	0.109	282	1 831	0.076	140	3 479	0.147	511

Regardless of farm category, the annual average costs of electricity and gasoline per hectare were estimated at US$11 and US$28 per hectare, correspondingly. The cost of electricity was highest among traditional (US$12) and intensive farms (US$12). Expenses on gasoline were only reported by intensive and semi-intensive farms with respective annual average costs per hectare of US$64 and US$20. Gasoline expenses were used for motorized banca(s) and pumps, used by semi-intensive and intensive farms. Noticeably, traditional farms (which were financially hard-up) use non-motorized banca(s) and did not incur cost in gasoline.

TABLE 26
Average quantity and cost (US$) of miscellaneous inputs/other variables by type and category of respondents, per hectare and year

Item	Intensive			Semi–intensive			Traditional			All categories		
	Duration of use (months)	Unit cost/ month	Total cost	Duration of use (months)	Unit cost/ month	Total cost	Duration of use (months)	Unit cost/ month	Total cost	Duration of use (months)	Unit cost/ month	Total cost
1. Electricity	12	1.00	12.0	12	0.58	7.0	11	1.09	12.0	11.7	0.89	10.4
2. Gasoline	12	5.33	64.0	12	1.67	20.0	0	0	0	8.0	3.50	28.0
Subtotal	24		76.0	24		27.0	11		12.0	19.7		38.4
3. Other rental cost			0			1.0			1.0			0.7
Total			76.0			28.0			13.0			39.0

Note: US$1.00 = P51.00

3.6 Total production costs

The annual average aquaculture production cost per hectare was highest among intensive farms at US$1 975. This was followed by traditional which incurred an average production cost per hectare at US$1 249. Semi-intensive farms recorded the lowest production cost per hectare at US$993. Regardless of farm category, the average total production cost per hectare amounted to US$1 406. Of which, total variable costs accounted for 89 percent of the total, implying that the scale of operation will have a major impact on the magnitude of the cost of production. As expected, the major cost item for intensive farms was the cost of feeds which was estimated at US$1 110 which represented 56 percent of the total production cost per hectare. Among traditional and semi-intensive farms, labour costs accounted for a largest proportion of their total production costs per hectare at 57 percent and 42 percent, respectively (Table 27). Regardless of farm categories, the cost of feeds accounted for 36 percent of the total cost while labour cost represented 34 percent of the total cost. Among intensive farms, the costs of fingerlings and labour respectively represented 16 percent and 16 percent of the total while fixed cost accounted for only 7 percent. In the case of semi-intensive farms, the cost of feeds, and fingerlings accounted for 28 percent and 19 percent, correspondingly. For traditional farms, the cost of fingerlings and feeds accounted for only 12 and 11 percent of the total cost, respectively.

FIGURE 12
Intensive: cost of production (%)

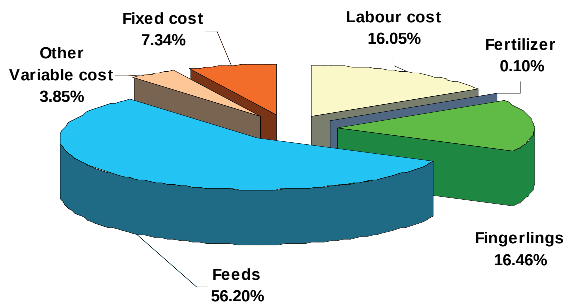


FIGURE 13
Semi-intensive: cost of production (%)

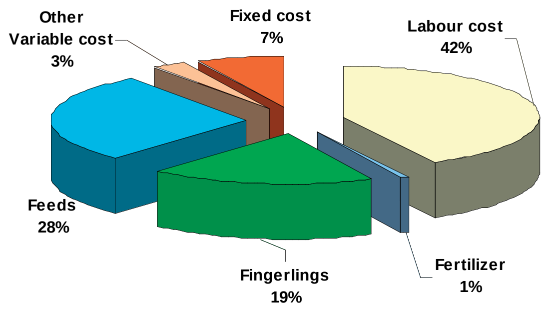


FIGURE 14
Traditional: cost of production (%)

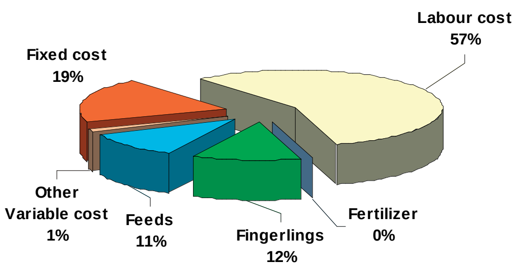
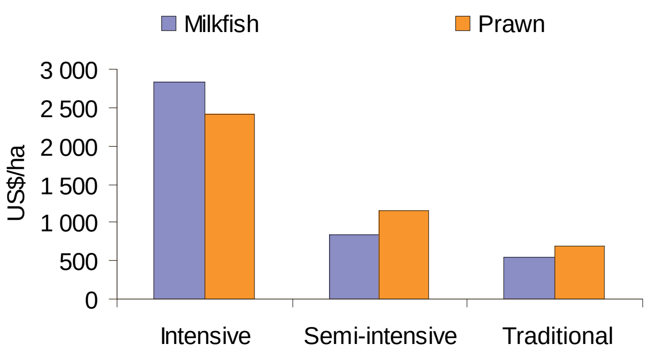


FIGURE 15
Gross revenue by species and by farm category



3.7 Gross revenues

For all farms, the average annual gross revenues per hectare was valued at US$2 831. Intensive farms reported the highest average annual gross revenues at US$5 252 followed by semi-intensive farms at US$1 994 while traditional farms had the least at US$1 247 (Tables 28 and 29). The high gross income figure among intensive farms was due to high volume of harvested milkfish (3 012 kg) and prawn (340 kg). The average annual milkfish and prawn production per hectare for semi-intensive farms were lower at 882 kg and 152 kg, correspondingly. The least productions of milkfish (578 kg) and prawn (87 kg) were recorded by traditional farms. Table 29 also indicates the respective recovery rates as measured in terms of the ratio of the number of pieces of fish species harvested to the total fish species stocked. In terms of milkfish production, intensive farms recorded the highest recovery rate of 89 percent while semi-intensive and traditional farms recorded lower recovery rates of 79 percent and 80 percent, correspondingly. Recovery rates in prawn productions were estimated at only 25 percent among intensive farms while semi-intensive and traditional farms registered relatively lower recovery rates of 17 percent and 10 percent, respectively.

For all farms, the proportion of gross income derived from milkfish is almost similar to prawn production. The proportion of gross income derived from prawn production was slightly higher than milkfish production at 58 and 56 percent, for semi-intensive and traditional farms respectively. Among intensive farms, 53 percent of the gross revenues were generated from milkfish production.

3.8 Comparative analysis of economic and financial indicators

3.8.1 Gross margins

Gross aquaculture margins are derived by deducting total variable cost of production from the total gross revenue. Fixed investments (costs) are considered as sunk costs and may not be recovered in the very short-term period of at least one cropping season. The annual average gross aquaculture margin per hectare was highest for intensive fish farm operators (US$3 422) compared with those of semi-intensive farms (US$1 072). A very low margin of US$238 was computed among traditional farms (Table 29). Due to very low fish farm yields, traditional farms were unable to generate revenues to recover their total costs (both cash and non-cash). However, the figures include family labour valued at US$309 per hectare. This wage rate derived from average skilled labour wages in the study area. Regardless of farm category, the annual average gross aquaculture margin per hectare was US$1 577.

FIGURE 16
Gross margin by farm category

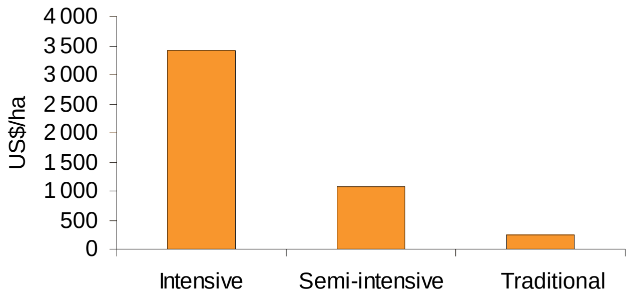


TABLE 27
Total cost (US$/ha) by item and category of respondents

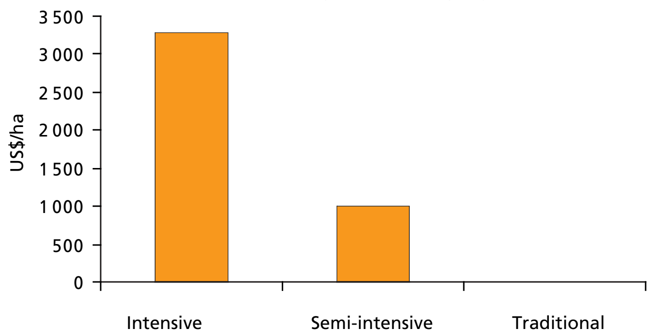
Item	Intensive		Semi-intensive		Traditional		All categories	
	Amount/ year	%	Amount/ year	%	Amount/ year	%	Amount/ year	%
A. Variable costs								
1. Labour cost	317	16.0	420	42.3	706	56.5	481	34.2
2. Fertilizer	2	0.1	5	0.5	0	0.0	2	0.2
3. Fry/fingerlings	325	16.4	187	18.9	149	12.0	221	15.7
4. Feeds	1 110	56.2	282	28.4	140	11.2	511	36.3
5. Miscellaneous input/other variable costs	76	3.9	28	2.8	13	1.0	39	2.8
Subtotal	1 830	92.6	922	92.9	1 009	80.8	1 254	89.2
B. Fixed Costs								
(i) Land use cost/rent	136	6.9	59	6.0	218	17.5	138	9.8
(ii) Depreciation	9	0.5	12	1.2	22	1.8	14	1.0
Subtotal	145	7.4	71	7.1	240	19.2	152	10.8
Total	1 975	100.0	993	100.0	1 249	100.0	1 406	100.0

Note: US$1.00 = P51.00

3.8.2 Net margins/returns

Intensive farms revealed the highest net returns (US$3 277/ha) relative to semi-intensive (US$1 001/ha) and traditional (US$-2/ha) farms. The average net returns per hectare was estimated at US$1 425. It is interesting to note that traditional farms were unable to generate positive returns against variable and fixed costs. This was partly explained by the fact that

FIGURE 17
Net returns by farm category



fixed investments (i.e. nipa huts and bancas) have been incurred before the current aquaculture production season. It must be noted that all fixed investments are incurred by the lessee themselves and hence reflected in their cost estimates.

FIGURE 18
Net returns to land by farm category

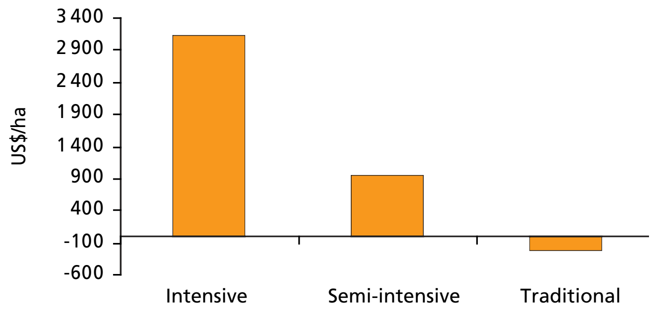
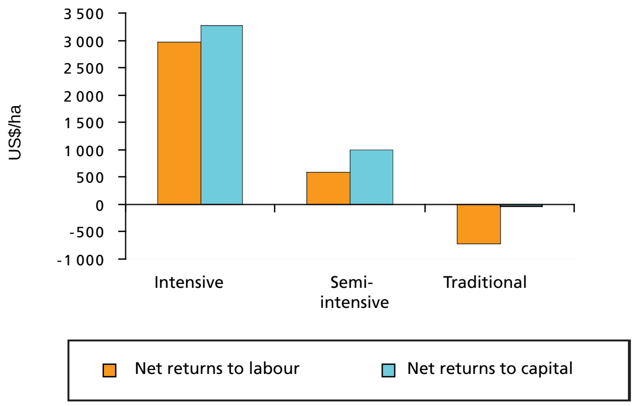


FIGURE 19
Net returns to labour and capital by farm category



3.8.3 Returns to labour, land and capital

Net returns per hectare to land, labour and capital among intensive farms yielded favourable figures of US$3 140, US$2 960 and US$3 262, correspondingly. This means that the investment made by the intensive farms on land capital, labour and fixed assets generated favourable returns. Among semi-intensive farms, net returns to land, labour and capital were respectively estimated at US$942, US$581 and US$994. On the other hand, traditional farms recorded negative returns to land, labour and capital, which imply that investments made by traditional farms on land, labour and capital were not fully recovered due to low farm productivities. Nevertheless, traditional farms were still in operation since investments made in labour were mostly in the form of non-cash family labour and the fixed investment were considered as sunk costs.

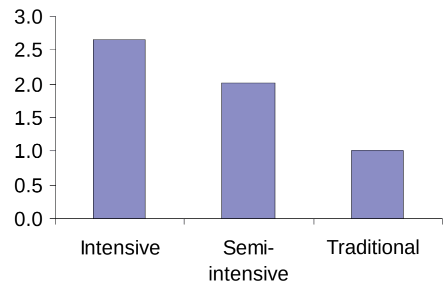
3.8.4 Gross and net total factor productivity

Gross total factor productivity (e.g. benefit cost ratio) provides a ratio of gross revenue to the total cost of production which implies that a ratio of 1.0 means that the operation was at break-even position. The gross total factor productivity of 2.66 and 2.01 were estimated for intensive and semi-intensive farms, respectively. This indicates that the intensive farms were able to recover US$2.66 per US$1 spent while semi-intensive farms generated a return of US$2.01 per US$1 spent. Traditional farmer gross total factor productivity was 0.998 suggesting that they were at about break-even in their aquaculture operations. In terms of net total factor productivity, intensive farms (1.66) and semi-intensive farms (1.01) were able to register favourable figures while traditional farms yielded a slightly negative net factor productivity coefficient of –0.002. The figures imply that among intensive and semi-intensive farms, the net returns to a peso spent on the factors of production relative to total cost was recovered. Traditional farms were unable fully to recover the costs of their investments.

3.8.5 Break-even prices

Break-even prices were estimated for both milkfish and prawn species by directly assigning cost items intended for the production of a given species (e.g. snail meat as input to the production of prawn and bread as input to the production of milkfish) and by appropriating the cost of other items such as labour and common feeds based on the weighted cost of stocking ratio between milkfish and prawn.

FIGURE 20
Gross total productivity by farm category



For intensive farms, the estimated break-even prices of US$0.51, and US$1.26 per kg were respectively estimated for milkfish and prawn productions. These estimated break-even prices were respectively 82 percent and 143 percent lower than the prevailing market prices of milkfish and prawn (Tables 29 and 30). These figures imply that intensive farms can absorb significant price changes and still achieve profitability.

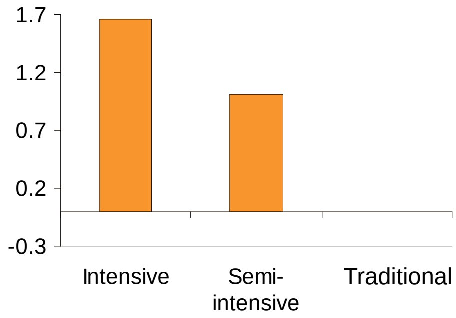
TABLE 28
Annual gross revenues (US$/ha) by harvest and species and category of respondents

Item	Intensive			Semi–intensive			Traditional			All categories		
	Quantity (kg)	US$/kg	Total returns	Quantity (kg)	US$/kg	Total returns	Quantity (kg)	US$/kg	Total returns	Quantity (kg)	US$/kg	Total returns
A. First harvest												
1. Milkfish	1 373	0.95	1 299	604	0.95	572	324	0.94	303	767	0.94	724
2. Prawn	165	7.23	1 195	74	7.88	586	45	7.99	357	95	7.65	713
All species	1 538	1.62	2 494	679	1.71	1 158	368	1.79	660	862	1.67	1 437
B. Second harvest												
1. Milkfish	966	0.94	908	264	0.93	247	237	0.94	222	489	0.94	459
2. Prawn	140	7.12	997	75	7.37	553	42	7.99	334	86	7.44	628
All species	1 106	1.72	1 905	339	2.36	800	278	2.00	556	575	1.89	1 087
C. Third harvest												
1. Milkfish	509	0.94	479	14	0.93	13	18	0.98	18	180	0.94	170
2. Prawn	34	6.57	226	2	7.45	18	0	0.00	0	12	6.75	81
All species	544	1.30	705	16	1.94	31	18	1.00	18	193	1.30	251
D. Fourth harvest												
1. Milkfish	164	0.88	144	0	0.00	0	0	0.00	0	55	0.88	48
2. Prawn	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00	0
All species	164	0.88	144	0		0	0		0	55	0.87	48
E. All harvests												
1. Milkfish	3 012	0.93	2 830	882	0.94	831	578	0.95	542	1 491	0.93	1 401
2. Prawn	340	6.97	2 418	152	7.57	1 156	87	7.99	691	193	7.28	1 422
All species	3 352	1.57	5 248	1 034	1.92	1 988	665	1.85	1 233	1 683	1.68	2 823
F. Biomass carried in from previous year	88	0.04	3	153	0.04	6	339	0.04	13	193	0.04	8
Gross revenues	3 439	1.99	5 252	1 187	2.15	1 994	1 004	2.25	1 247	1 877	2.07	2 831

Note: US$1.00 = P51.00

In the case of semi-intensive farms, the estimated break-even prices for milkfish (US$0.72/kg) and prawn (US$2.38/kg) were also lower than the prevailing respective market prices of US$0.94/kg and US$7.57/kg. Specifically, the estimated break-even prices were 31 percent (for milkfish) and 218 percent (for prawn) lower than the

FIGURE 21
Net total factor productivity by farm category



prevailing market prices. These also imply that the semi-intensive farms are somewhat insulated from downward output price movements.

Traditional farms require higher break-even prices for milkfish and prawn at US$1.22/kg and US$6.24/kg, respectively. In the case of milkfish, the estimated break-even price had already exceeded the prevailing market price (US$0.95/kg) by 28 percent. The break-even price for prawn was lower than the actual market price by 28.04 percent. These figures imply that traditional farms performed below par in terms of break-even price for milkfish but has performed well in as far as prawn production was concerned.

3.8.6 Break-even production

A major basis in evaluating the soundness of a business operation such as aquaculture production is to determine their levels of productivities in relation to their break-even productivity levels. The break-even productivity level considers the farm's total production cost in relation to the prevailing output prices.

As shown in Tables 29 and 31, the break-even production per hectare for milkfish and prawn among intensive farms was estimated at 1 669 kg and 61 kg, respectively. Given their current production per hectare levels of 3 012 kg for milkfish and 340 kg for prawn, intensive farms exceeded their break-even productivity level by 80 percent and 453 percent for milkfish and prawn, correspondingly. These results suggest a very good actual production levels vis a vis their respective levels of production to break-even.

Among semi-intensive farms, the break-even production levels per hectare of 674 kg (for milkfish) and 48 kg (for prawn) were derived. Their actual production levels of 882 kg (for milkfish) and 152 kg (for prawn) were 31 percent and 218 percent higher than their respective break-even levels of production. In the case of traditional farms, the computed break-even production levels for milkfish and prawn were pegged at 742.47 kg and 67.94 kg respectively. The actual level of milkfish production per hectare among traditional farms was 22.15 percent below the break-even production level while their average prawn production level at 87 kg was 27 percent above its estimated break-even production.

The break-even analysis on productivity levels implies that as commercial feeding intensifies, the consequent high yields rationalize their adoption. Both intensive and semi-intensive farms were able to register productivity levels that exceeded break-even productivity levels while traditional farms due to their non-adoption of commercial feeding practice, were slightly below their break-even level of productivity for milkfish production.

TABLE 29
Summary of assessed financial and economic indicators by farm category, per hectare

Item*	Intensive	Semi-intensive	Traditional	All categories
A. Total cost (US$)[1]	1 975	993	1 249	1 406
B. Total variable cost (US$)[2]	1 830	922	1 009	1 254
C. Total fixed cost (US$)[3]	145	71	240	152
D. Total gross revenue (US$)[4]	5 252	1 994	1 247	2 831
E. Gross margin (US$)[5]	3 422	1 072	238	1 577
F. Net margin/returns (US$)[6]	3 277	1 001	–2	1 425
G. Net returns to land (US$)[7]	3 140	942	-220	1 287
H. Net returns to labour (US$)[8]	2 960	581	-707	944
I. Net returns to capital (US$)[9]	3 262	994	-26	1 410
J. Gross total factor productivity[10]	2.659	2.007	0.998	2.014
K. Net total factor productivity[11]	1.66	1.01	– 0.002	1.01
L. Break-even price[12]				
Milkfish (US$)	0.51	0.72	1.22	0.64
Prawn (US$)	1.26	2.38	6.24	2.36
M. Break-even production[13]				
Milkfish (kg)	1 669.5	674.2	742.5	1 026.8
Prawn (kg)	61.3	47.7	67.9	62.5
N. Recovery rate (%)[14]				
Milkfish	0.89	0.79	0.80	0.83
Prawn	0.25	0.17	0.10	0.17

Note: US$1.00 = P51.00
[1]Total costs = variable costs + fixed costs
[2]Sum of costs of fertilizer, feeds, fingerlings, hired and family labour, electricity, and other variable costs
[3]Sum of fees, lease, interest, rental, depreciation
[4]Value of total aquaculture outputs
[5]Total gross revenue less total variable costs
[6]Gross aquaculture margin less fixed costs
[7]Net margin/returns less land rent
[8]Net margin/returns less cost of labour
[9]Net margin/ returns less 10 percent of fixed investments
[10]Gross revenue divided by total costs
[11]Net margin/returns divided by total costs
[12]Total costs divided by total production; assumption: total cost for milkfish = 50 percent of total cost, total cost for prawn = 50 percent of total cost
[13]Total costs divided by average price ; assumption: total cost for milkfish = 50 percent of total cost, total cost for prawn = 50 percent of total cost
[14]No. of fish species in pieces harvested divided by number of fish species in pieces stocked

TABLE 30
Comparison of actual price and break-even price by species and by farm category

Category/species	Break-even price (US$/kg)	Actual price (US$/kg)	Actual price as of % of break-even price per kg
Intensive			
Milkfish	0.51	0.93	182
Prawn	1.26	6.97	553
Semi-intensive			
Milkfish	0.72	0.94	131
Prawn	2.38	7.57	318
Traditional			
Milkfish	1.22	0.95	78
Prawn	6.24	7.99	128
All categories			
Milkfish	0.64	0.93	145
Prawn	2.36	7.28	308

TABLE 31
Comparison of actual production and break-even production (kg/ha) by species and by farm type

Category/species	Break-even production (kg/ha)	Actual production (kg/ha)	Actual production as of % of break-even production per hectare
Intensive			
Milkfish	1 669.45	3 011.94	180
Prawn	61.26	339.70	555
Semi-intensive			
Milkfish	674.23	882.19	131
Prawn	47.74	151.70	318
Traditional			
Milkfish	742.47	578.03	78
Prawn	67.94	86.53	127
All categories			
Milkfish	1 026.83	1 490.72	145
Prawn	62.47	192.64	308

3.9 Production problems

3.9.1 Enabling production factors

The fish farm respondents cited use of commercial feeds (52 percent) and improved water quality (52 percent) as the most important factors that needed to be addressed to increase production (Table 32). It is interesting to point out that the majority of traditional farm-respondents (70 percent) were aware that they needed to engage in commercial feeding in order to increase farm yields. Intensive farms (40 percent) and semi-intensive farms (45 percent) still feel that their commercial feeding intensities needed to be enhanced to achieve relative higher yields.

TABLE 32
Enabling factor to increase production by category of respondents

Enabling factor*	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Use of commercial feed	8	40	9	45	14	70	31	52
High stocking density	4	20	5	25	7	35	16	27
Quality of fry	4	20	0	0	0	0	4	7
Better management	0	0	1	5	0	0	1	2
Disease control	0	0	0	0	1	5	1	2
Improved water quality	12	60	10	50	9	45	31	52

*Multiple responses

In terms of water quality, a respective 60 percent, 50 percent and 45 percent of the intensive, semi-intensive and traditional farms recognized the need to improve the water quality of their ponds a means of further improving their fish crop yields. Around one quarter of the respondents also cited the need to increase their stocking to be able to increase their yields. The quality of the acquired fry has been a moderate concern of intensive farms (20 percent).

3.9.2 Disabling production factors

Lack of capital was a major constraint among traditional farmers (80 percent) which is perhaps the principal reason why they do not engage in commercial feeding practices. Financing the cost of land rent as well as the labour cost, particularly when hiring watchmen/caretakers and supplementary feed items were the major constraints among traditional farmers. In the case of intensive and semi-intensive farms, polluted water was a moderate concern when seeking to improve productivity as mentioned by 25 percent and 15 percent of the respondents, respectively (Table 33).

3.9.3 Other problems

The high cost of commercially/industrially manufactured feeds was a major concern among traditional (90 percent) and semi-intensive farms (45 percent) (Table 34). While traditional farm respondents readily recognized the importance of commercial feeding, the high cost per given unit prohibited them from purchasing these feeds. The high cost of feeds also encroached upon the buying decisions of semi-intensive farmer-respondents to utilize the optimum amounts of this feed type in their production operations.

TABLE 33
Disabling factors to increase production by category of respondents

Enabling factor	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Lack of capital	1	5	2	10	16	80	19	32
Limited knowledge	1	5	1	5	0	0	2	3
Polluted water	5	25	3	15	0	0	8	13
Natural calamities	0	0	1	5	1	5	2	3

TABLE 34
Problems concerning use of industrially manufactured pelleted feeds by category of respondents

Problems	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
High price	2	10	9	45	18	90	29	48
Affect small fishes	0	0	1	5	1	5	2	3

The unstable market prices for milkfish and prawn were reported by 57 percent of respondents. This problem was more pronounced among intensive farms (75 percent) since they sold relatively larger volumes of harvested fish crops in the market (Table 35). Since production decisions (e.g. investment decisions) were made based on the current market prices of output, any downward fluctuation in the market would affect the profitability/viability of the aquaculture business.

TABLE 35
Problems concerning marketing of fish by category of respondents

Problems	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Transportation	1	5	0	0	0	0	1	2
Storing/icing/packaging	4	20	2	10	0	0	6	10
Unstable market price	15	75	9	45	10	50	34	57

3.10 Statistical analysis

Regression analysis using the general theoretical model relating net profit (NP) with both economic and non-economic predictors was undertaken. The best-fit models were identified based on the estimated values of R^2 and F statistic. High R^2 values imply that the variation in net profit as the dependent variable is largely explained by the independent variables (e.g. predictors) included in the regression model.

3.10.1 Profit models for milkfish production

Results of the regression analysis are summarized in Table 36 and 37. In the case of milkfish production, there were two models of regression equations identified. The first model relates net profit in milkfish production (NPm) with stocking rate, recovery rate and total cost of all feeds. The second model includes stocking rate, recovery rate and cost of commercial feeds as predictors of the net profit in milkfish production. The first model yields an R^2 value of 93 percent while the second model provides an R^2 value of 90.8 percent. These high values imply that the predictors of the model account for at least 90 percent of the variation of net profit in milkfish production. The regression equation for model 1 indicates that stocking rate and the total cost of feeds are significant at one percent while recovery rate is significant at 5 percent. The computed standardized coefficients indicates that a one percent increase in stocking rate and cost of feeds shall respectively result in increase of 0.478 percent and 0.509 percent increase in the net profit for milkfish production. In addition, a one percent increase in the recovery rate of milkfish stocked shall contribute to a 0.104 percent increase in profit.

In the case of the second regression model, the *t* values for stocking rate and the cost of commercial feeds are significant at the 1 percent level while the computed *t* value for recovery rate is significant at 5 percent level. The estimated standardized coefficients imply that a 1 percent increase in stocking rate, the cost of commercial feed application and recovery rate shall correspondingly increase net profits for milkfish production at 0.543, 0.434 and 0.099 percent.

Both regression models indicate that stocking rates and the total cost of commercial feeds/all feeds are the major predictors of the net profit in milkfish production as manifested by their high beta coefficients. Recovery rates can also influence net profit variation but to a lesser degree. It was also found out that regression models incorporating other non-economic valuables such as education, fish farming experience, training attended, age, yielded lower R^2 values and insignificant *t* values even at the 10 percent level.

TABLE 36
Summary of results for regression model 1 in milkfish production

Model	Unstandardized coefficients		Standardized coefficients		Level of significance
	B	Std. error	Beta	t	
(Constant)	–1 390.04	480.152		–2.895	0.006***
$Srate_m$	0.211	0.029	0.478	7.290	0.000***
ALL FEED_$cost_m$	1.309	0.167	0.509	7.821	0.000***
$RecRate_m$	1 409.303	544.071	0.104	2.590	0.013***

Dependent variable: net profit in milkfish production
R^2 = 93%; F = 203.70***
***significant at 1%; **significant at 5%
Regression equation:

$$NPm = \alpha + 0.478\ Srate_m + 0.509\ ALL\ FEED\_cost_m + 0.104\ Rec\ Rate_m$$

Where:
NP_m = Net profit in milkfish production (US$/ha)
$Srate_m$ = Stocking rate in milkfish (pieces/ha)
$RecRate_m$ = Recovery rate in milkfish (percent)
ALL FEED_$cost_m$ = Feed cost in milkfish (US$/ha)

TABLE 37
Summary of results for regression model 2 in milkfish production

Model	Unstandardized coefficients		Standardized coefficients	T	Level of significance
	B	Std. error	Beta		
(Constant)	–1 265.430	554.768		–2.281	0.027***
$Srate_m$	0.239	0.032	0.543	7.362	0.000***
$RecRate_m$	1 342.554	625.614	0.099	2.146	0.037**
$CommFC_m$	1.268	0.214	0.434	5.925	0.000***

Dependent variable: milkfish_returns
R^2 = 90.8%; F = 150.448***
***significant at 1%; **significant at 5%
Regression equation:

$$NPm = \alpha + 0.543\ Srate_m + 0.099\ Rec\ Rate_m + 0.434\ CommFC_m$$

Where:

NP_m = Net profit in milkfish production (US$/ha)
$Srate_m$ = Stocking rate in milkfish production (pieces/ha)
$Rec\ Rate_m$ = Recovery rate in milkfish production (percent)
$CommFC_m$ = Cost of commercial feeds in milkfish production (US$/ha)

3.10.2 Profit models for prawn production

The best fit models identified for prawn production relates; to (1) net profit for prawn production (NP_p) with stocking rate and recovery rate for prawn production, and (2) Net profit for prawn (NP_p) production with stocking rate, cost of stock and total area.

Model 1 has an R^2 value of 94.7 percent and an F value of 104.97 while model 2 has an R^2 value of 80.20 and an F value of 35.18 (Tables 38 and 39). Both F values are significant at one percent level. All t values for both models are significant at one percent level. In the case of model 1, the stocking rate has a higher beta coefficient (0.859) then recovery rate (0.289) which implies that the former shall be able to contribute to a larger increase in the net profit in prawn production. Nevertheless, improving the production environment to achieve a higher recovery rate for stocked prawn should also contribute to an increase in net profit for prawn production.

In the case of model 2, the recovery rate for prawn cost of prawn stocks and total area of operation are found to be statistically significant as predictors of net profit for prawn production. The estimated regression coefficients (beta) suggest that a one percent increase in recovery rate and cost of prawn stocked shall result in an increase in net profit for prawn production by 0.668 percent and 0.752 percent, respectively. On the other hand, increasing total area of operation by one percent shall reduce net profit by 0.362 percent.

The regression models that relate net profit in prawn production with other non-economic variables including age, fish farming experience and education, did not yield statistically significant results.

TABLE 38
Summary of results for model 1 on prawn production

Model	Unstandardized coefficients		Standardized coefficients	t	Level of significance
	B	Std. error	Beta		
(Constant)	–3 347.718	651.020		–5.142	0.000***
Srate_m	0.165	0.013	0.859	12.989	0.000***
RecRate m	6 762.894	1 547.435	0.289	4.370	0.000***

Dependent variable: prawn_returns
R^2 = 94.7 %; F = 104.37***
***significant at 1%;
Regression equation:

$NP_m = \alpha + 0.859\ Srate_p + 0.289\ Rec\ Rate_p$

Where:

NP_p = Net profit in prawn production (US$/ha)
$Srate_p$ = Stocking rate in prawn production (pieces/ha)
$RecRate_p$ = Recovery rate in prawn production (percent)

TABLE 39
Summary of results for model 2 on prawn production

Model	Unstandardized coefficients		Standardized coefficients	t	Level of significance
	B	Std. error	Beta		
(Constant)	–3 725.420	813.274		–4.581	0.000***
$RecRate_p$	12 913.523	2 343.304	0.668	5.511	0.000***
$cost\_stock_p$	89.301	10.466	0.752	8.533	0.000***
Total area	–85.452	28.806	–0.362	–2.966	0.006***

Dependent variable: net profit in prawn production (US$ per ha)

R^2 = 80.20 %; F = 35.186***
***significant at 1%;
Regression equation:

$NP_m = \alpha + 0.668\ RecRate_p + 0.752\ cost\_stock_p - 0.362\ Total\ area$

Where:

NP_p = Net profit for prawn production (US$/ha)
$Rec\ Rate_p$ = Recovery rate for prawn production (percent)
$Cost\_stock_p$ = Cost of stock for prawn production (US$/ha)
Total area = Total area of fishponds (ha)

3.10.3 Aggregate profit model

Regression analyses were also conducted to relate total profit (e.g. combined net profits in milkfish and prawn production) with economic and non-economic variables. Two models were identified as the best fit by aggregating the net profit for both fish species. The first model relates aggregated net profit with stocking rate and recovery rate and yielded an R^2 value of 87.3 percent and an F value of 78.833 which is significant at one percent level. The second model identified relates aggregated net profit with stocking rate, recovery rate and total feed cost. The R^2 value of 86.9 percent was derived while its value of 46.32 is significant at one percent level.

The t values of both models are significant at one percent level except for total cost of feeds (e.g. model 2) which is not statistically significant even at 10 percent level. For both models stocking rates yielded high beta coefficients than did recovery rates suggesting that a strategy designed to increase profitability of aquaculture production could focus on stocking rate. Nevertheless, recovery rate and feeding strategies (as measured by total investment in feed cost) should also be given attention.

TABLE 40
Summary of results for model 1 in milkfish and prawn production

Model	Unstandardized coefficients		Standardized coefficients	t	Level of significance
	B	Std. error	Beta		
(Constant)	–5 408.650	923.355		–5.858	0.000***
$Srate_{all}$	0.185	0.016	0.837	11.220	0.000***
$RecRate_{all}$	7 865.495	1 655.180	0.355	4.752	0.000***

Dependent variable: Net profit (US$/ha)
R^2 = 87.3 %; F = 78.33***
***significant at 1%;
Regression equation:

$NP_{mp} = \alpha + 0.837\ Srate_{all} + 0.355\ Rec\ Rate_{all}$

Where:

NP_{mp} = Net profit in milkfish and prawn production (US$/ha)
$Srate_{all}$ = Stocking rate in milkfish and prawn production (pieces/ha)
$RecRate_{all}$ = Recovery rate in milkfish and prawn production (percent)

TABLE 41
Summary of results for model 2 in milkfish and prawn production

Model	Unstandardized coefficients		Standardized coefficients		Level of significance
	B	Std. error	Beta	t	
(Constant)	–3 268.297	1 155.217		–2.829	0.010***
$Srate_{\_all}$	0.158	0.021	0.924	7.586	0.000***
$RecRate_{all}$	3 311.196	1 471.872	0.225	2.250	0.035**
ALL $FEED_{\_cost}$	0.904	0.567	0.163	1.595	0.126

Dependent variable: Net profit (US$/ha)
R^2 = 86.9 %; F = 46.32***
***significant at 1%; ** significant at 5%
Regression equation:

$NP_{mp} = \alpha + 0.924\ Srate_{all} + 0.225\ Rec\ Rate_{all} + 0.163\ ALL\ FEED_{\_COSt}$

Where:

NP_{mp} = Net profit in milkfish and prawn production (US$/ha)
$Srate_{all}$ = Stocking rate in milkfish and prawn production (pieces/ha)
$RecRate_{all}$ = Recovery rate in milkfish and prawn production (percent)
ALL FEED_cost = total cost of feeds

4. CONCLUSIONS AND RECOMMENDATIONS

Results of the study imply that adoption of commercial feeding through the use of industrially-manufactured pelleted feed has indeed benefited intensive and semi-intensive farms in terms of higher yields as measured in kilograms of milkfish and prawn production. Traditional farms suffered from poor production levels relative to other farms solely because they stuck to a feeding practice that was less effective in improving the weights of the fish species at the time of harvest. However it must be pointed out that traditional farmers in the study area simply used supplemental feeds as it is and no effort was noted to improve the feed quality by cooking and/or other simple processing techniques and mixing of different feed ingredients. Except for the adoption and non-adoption of commercial feeds, the feeding technologies during the grow-out periods for all farm categories are almost similar. Likewise, since the farm conditions of the study areas are geographically similar, it has emphasized the definitive edge of commercial feed users in terms of increasing their production per given area.

Higher levels of milkfish and prawn production among intensive and semi-intensive farms have consequently triggered their high levels of financial and economic indicators. Estimated gross revenues, gross margins, income above variable costs, net returns on land, labour and capital, gross and net factor productivities have reached levels that are considered financially and economically sound. In addition, the break even price and production figures of both the intensive and semi-intensive farms have been largely exceeded by the prevailing market prices and actual production performances for both milkfish and prawn outputs. Traditional farms on the other hand, did not perform as sound business entities based on similar standard measures of financial soundness, and may be considered merely as subsistence aquaculture farm operations.

However, it must be emphasized that traditional farm operators are cognizant of the positive effects of commercial feeds in their business operations, but their decisions not to adopt the technology is lack of funds. As cited, the aquaculture production venture is an expensive business proposition due to the high cost of land rent, labour, and feeds. As the business operation progresses from traditional to semi-intensive and intensive operations, the burden shifts from financing the costs of labour and land rent to the cost of feeds. Feed cost has been a major cost item among intensive farms. Despite the technological accessibility of the traditional aquaculture farmer-respondents, lack of capital has prevented them from engaging in the more lucrative venture of adopting commercial feeding practices. Provision of credit facilities particularly to traditional farms and the development and eventual production of low cost pelleted feeds (e.g. farm/home-made aquafeeds) are deemed to be important elements in a strategy to break the barrier to improved feeding practice.

The results of the regression analyses as reflected in the values of R^2 and F and t statistic suggest that stocking rate, recovery rate, cost of commercial feeds and total feed cost are statistically significant predictors of the behavior of net profit in milkfish production. Increasing the percentage of these predictors shall increase profitability in milkfish production. Profitability in prawn production is statistically explained by stocking rate, recovery rate, total area of operation, and cost of stock. For aggregated data, stocking rate, recovery rate and total feed cost are the major predictors of the profit for both milkfish and prawn productions. In addition, the values of the standardized beta coefficients suggest that varying the stocking rate and recovery rate should largely influence the behavior of the net profit of aquaculture production.

In the light of the findings of this study, the following are the study's recommendations to enhance the financial and economic soundness of aquaculture production in the study area:

1. promote and advocate the use of farm-made aquafeeds to enable semi-intensive and traditional farms improve their production and income levels by improving their current feeding practices;
2. lobby for the provision of credit assistance to the poor aquaculture farms to address single most important reason why the majority of the farmers failed to adopt commercial/improved feeding practices;
3. implement an action-research type of programme that integrates the institutional-technical and-socio-economic post harvest and marketing aspects of aquaculture production in the various geographical conditions in the Philippines as a more effective way of maximizing the benefit that can be derived from adopting farm-made aquafeeds; and
4. based on the results of (3), design and implement an aquaculture programme in the Philippines to address the plight of poor aquaculture farms in particular and to improve the overall performance of the aquaculture subsector of the Philippine Fishery Sector.

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APPENDIX

Appendix A: Regression

Variables entered/removed[b]

Model	Variables entered	Variables removed	Method
1	recovery rate milkfish, ALL FEED_cost, srate_mlkfsh[a]	.	Enter

a. All requested variables entered.
b. Dependent variable: milkfish_returns

Model Summary

Model	R	R Square	Adjusted R square	Std. Error of the Estimate
1	0.964	0.930	0.925	342.745 910 598 758 800

Predictors: (constant), recovery rate milkfish, ALL FEED_cost, srate_mlkfsh

ANOVA

Model	Sum of squares	df	Mean square	F	Level of significance
1 Regression	71 803 069.077	3	23 934 356.359	203.740	0.000[a]
Residual	5 403 838.925	46	117 474.759		
Total	77 206 908.002	49			

Predictors: (constant), recovery rate of milkfish, ALL FEED_cost, srate_mlkfsh
Dependent variable: milkfish_returns

Coefficients

Model	Unstandardized coefficients B	Std. Error	Standardized coefficients Beta	t	Level of significance
1 (Constant)	–1 390.039	480.152		–2.895	0.006
srate_mlkfsh	0.211	0.029	0.478	7.290	0.000
ALL FEED_cost	1.309	0.167	0.509	7.821	0.000
Recovery rate of milkfish	1 409.303	544.071	0.104	2.590	0.013

a. Dependent variable: milkfish_returns

Economics of aquaculture feeding practices: Thailand

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SUMMARY

The general objective of the study is to assess the economic implications of adopting various feeding practices in aquaculture production in Thailand. The case study provides a comparative analysis of three different categories of feeding systems/practices as applied in catfish aquaculture; namely: (1) traditional; (2) semi-intensive; and (3) intensive. The study covers analysis using input output economic models relating net profit to economic variables (e.g. input and output prices) and production function/regression analysis to test the validity and inter-relationship between costs and non-economic variables under different farming system (e.g. recovery rate, stocking rates and quantity of feeds).

The principal species grown comprise hybrid catfish (*Clarias gariepinus* x *C. macrocephalus*), largely grown on a single species crop rotation system (3 cycles per annum), with stocking densities of between 230 000 (semi-intensive) to 450 000 (intensive) fingerlings per ha.

Intensive farms consume an average of 92 160 kg of feed per ha per year. Semi-intensive farms on the other hand, consume 199 681 kg of feed per ha per year which is about 2.2 times more than the rate or intensity of feeding by intensive farms. For traditional farms, average feed consumption is estimated at 158 500 kg/ha/year. The consumption rate of industrial feeds was 64 903 kg/ha/year (semi-intensive farms), 92 160 kg/ha/year (intensive farms) and 2 516 kg/ha/year (traditional farms). Semi-intensive farms used poultry by-product feeds as supplementary feeds, while traditional farms primarily used poultry by-products as their main feed.

The annual average aquaculture production cost per ha was highest among intensive farms at US$55 842. This was followed by semi-intensive which incurred an average production cost per ha at US$47 460. Traditional farms recorded the lowest production cost per ha at US$33 924. As expected, the major cost item for intensive farms is the cost of feeds which was estimated at US$48 713 which represents 87 percent of the total production cost per ha. Also, among semi-intensive and traditional farms, feed costs accounted for the largest proportions of their total production costs per hectare at 81 percent and 72 percent, respectively.

The annual average gross aquaculture margin per ha was highest for intensive fish farm operators (US$40 877) compared with those of semi-intensive farms (US$17 217) and traditional farms (US$9 890).

Gross total factor productivities of 1.71, 1.31 and 1.23 were estimated for intensive, semi-intensive and traditional farms, respectively. In terms of net total factor productivity, intensive farms (0.71) and semi-intensive farms (0.31) were able to register favorable figures while traditional farms yielded a net factor productivity coefficient of 0.23. The estimated break-even prices among intensive farms were 43 percent lower than the prevailing market prices of catfish. In the case of semi-intensive farms and traditional farms, the estimated break-even prices for fish (US$0.57/kg and US$0.55/kg) were also lower than the prevailing respective market prices of US$0.75/kg and US$0.67/kg.

Intensive farms and semi-intensive farms exceeded their break-even production levels by 42 percent and 24 percent for catfish. The actual level of fish production per ha among traditional farms was 19 percent below the break-even production level. The high cost of commercially/industrially manufactured feeds has been a major concern among intensive and semi-intensive farmers. While traditional farm respondents readily recognized the importance of commercial feeding, its high cost prohibited them from purchasing these feeds. In the same manner, the high cost of feeds likewise encroached upon the buying decisions of semi-intensive farmer-respondents to utilize the optimum amounts of this feed type in their production operations. However, the results of the study show that adoption of commercial feeding has benefited intensive and semi-intensive farms in terms of higher yields.

Estimating a production function calls for accurately measured data on output and inputs. Of the seven explanatory variables in model only four, feed cost, fingerlings, labour, and survival rate, were statistically significant. Cost of fingerlings was a more powerful explanatory variable with the high partial output elasticity. Higher levels of catfish production among intensive and semi-intensive farms have been triggered by the acceptance of higher input costs. As such, their estimated coefficients, gross revenues, gross margins/income above variable costs, net returns, net returns on land, labour and capital, gross and net factor productivities were at levels that are financially sound. In addition, the break even price and production figures for both the intensive and semi-intensive farms were exceeded by the prevailing market prices.

1. INTRODUCTION

1.1 Background

Freshwater aquaculture in Thailand started a long time ago. Initially only a few species were raised, such as common carp (*Cyprinus carpio*), snakeskin gourami/sepat siam (*Trichogaster pectoralis*) and sutchi catfish (*Pangasianodon hypophthalmus*). Such cultures were operated solely on a small scale and were confined to the area around Bangkok. In the early 1950s, other species, i.e. grass carp (*Ctenopharyngodon idella*), walking catfish (*Clarias batrachus*) and snakehead murrel (*Channa striata*), were introduced and traditional fish culture extension programs were implemented. Within a short period of time, a large number of ponds were constructed. Several idle swamps were converted and operated by farmers. From 1963 onwards, fish culture rapidly developed, partially as a result of a breakthrough in artificial breeding by hormone injection. At present, more than 15 species of fish and invertebrates are cultured. The most important freshwater aquaculture species in Thailand are Nile tilapia (*Oreochromis niloticus*), hybrid catfish *(Clarias gariepinus x C. macrocephalus*), Java barb (*Barbonymus gonionotus*), sepat siam, sutchi catfish and snakehead murrel contributing nearly 86 percent in quantity and over 75 percent in value[1].

According to the latest data available (2003), freshwater fish culture amounted to 361 100 tonnes, valued at US$401 millions (US$1.00 = 32.88 Thai Baht (B). In 2003, fish from freshwater inland aquaculture were harvested from 333 537 farms that comprised a total culture area of 111 903 ha. While output from this subsector in quantity and value contributed only about 9 percent to the country's total fish production, it reflects an increasing trend over the past two decades, with an annual average increase, in the period 1977–2003, of 10.4 percent and 15.3 percent in quantity and value, respectively.

The pattern of fish culture in Thailand, either monoculture or polyculture, varies according to species raised. Monoculture is commonly practiced for carnivorous species such as hybrid catfish, walking catfish and snakehead, and other species, such as sutchi catfish, marble goby (*Oxyeleotris marmorata*) and giant freshwater prawn (*Macrobrachium rosenbergii*). Polyculture is generally practiced for raising herbivorous species, namely, Nile tilapia (*Oreochromis niloticus*), Java barb, and common (*Cyprinus carpio*) and Chinese carps.

1.2 Rationale

Aquaculture production as practiced 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 practice/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. A technology that provides reasonable financial incentives to the fish farmers will easily be adopted than technology which does not. This case study is expected to shed light on the economics of the various feeding practices in Thailand.

1.3 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 Thailand.

Specifically, this country case study is aimed at:

(i) conducting a survey of twenty (20) aquaculture farms in each of three (3) different categories or systems of feeding practices, using a pre-tested questionnaire;

(ii) processing and analysing 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 cots),
   - c) income (gross revenue/gross margin),
   - d) production problems,
   - e) returns on investments (including labour, land and capital),
   - f) break-even Analyses (break-even price, break-even production),
   - g) factor productivities,
   - h) statistical analysis of production function, and
   - i) suggestions/recommendations;

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

[1] Excluded are giant freshwater prawns, frogs and soft shell turtles; they contributed about 94 percent in quantity and 93 percent in value.

2. GENERAL APPROACH AND METHODOLOGY

2.1 Comparative analysis

The case study provides a comparative analysis of three different categories of feeding practices/systems; namely: (1) traditional; (2) semi-intensive; and (3) intensive. To minimize variation in terms of fish species being produced, the comparative analysis of the various feeding practices was undertaken primarily for hybrid catfish (*Clarias gariepinus* x *C. macrocephalus*) although traditional farms stocked some other species (redfin pacu, Nile tilapia, sepat siam and giant gourami) in small proportions.

In the context of the study, traditional practices refer to a feeding system where the feeds utilized in the fish farms are sourced or developed locally and are not sold or distributed commercially. Fish farms based on traditional feeding practice generally use farm-made aquafeed and/or supplementary diets consisting of mixture of locally available feed ingredients. Farms with intensive feeding practices depend largely on commercially manufactured pelleted feeds while the semi-intensive category refers to a feeding system that combines the two with at least 25 percent of either one being utilized.

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, land and capital; (v) break-even price coefficients; (vi) break-even production coefficients; (vii) gross total factor productivity/benefit cost ratio (BCR); and (viii) net total 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 includes three representative feeding practices or systems for the hybrid catfish *(Clarias gariepinus x C. macrocephalus*) farms. Each feeding system was analyzed based on a survey of 20 replicate farms. A total of 60 fish farms represented the sample size for the country case study. The stratified random sampling (SRS) technique was utilized in selecting the individual sample farm. The SRS was directly applied on a general listing of fish farms obtained from the municipality. The complete listing was obtained from the field office of the Department of Fisheries, Thailand.

2.4 Data processing and analysis

2.4.1 Costs and returns analysis

A tabular analysis was employed to develop the cost and returns for the various feeding systems observed in the study sites. The cost and returns analysis indicated the variable cost categories including feeds, fingerlings, fertilizers, labour, gasoline and electricity. The fixed costs and capital investments were also determined. Information on gross revenues was also determined to address the objectives of the case study. A cross sectional analysis using percent changes and/or growth rates were adopted to determine the relationship of feeding practices with selected impact indicators.

2.4.2 Statistical analysis of production function

While cost and return analysis measures the success and failure of farm business (Kay and Edwards, 1994), the estimation of the production function identifies inputs that influence product yield and shows the efficiency of input use (Shang, 1981).

Three algebraic forms of the production function model were initially estimated to determine their appropriateness and explanatory/predictive power. These were the linear, quadratic, and Cobb-Douglas forms although a wider range could be considered.

The functional form of the catfish production model chosen on its explanatory power is that of an unconstrained Cobb-Douglas production function model (Wattanutchariya and Panayotou, 1982). The specified function is an acceptable representation of the underlying mechanics of the production process.

A Cobb-Douglas production function was employed to estimate the production technology of catfish farming input and output data. Catfish production function result from combining various fixed and variable inputs in a body of water. Seven explanatory variables were hypothesized to explain catfish production. The production function used to be expressed in the following general form:

$Y = f(x_1 , x_2 , x_3 , x_4 , x_5 , \ldots x_n)$

Where; Y = yield

$x_1 \ldots x_n$ = input variables

The basic Cobb-Douglas model specified is

$Y = aX_1^{b1} X_2^{b2} \ldots X_n^{bn}$

$LnY = Lna + b_1LnX_1 + b_2LnX_2 + \ldots + b_nLnX_n$

The explanatory variables (X_i) or inputs are sometimes known as target variables because they are subject to influence by the decision-maker (producer or policy-maker). The production coefficients (b_i) or exponents in the Cobb-Douglas form are the elasticities of production. The b_i terms are actually transformation ratios of the variables input used in production at different quantities.

2.5 Scope and duration of the study

The study was conducted from 15 October 2005 to 14 February 2006. Six provinces in three regions of Thailand were selected as the site of the study. A total of 60 fish farms were analyzed in the study. A total of 20 respondents were interviewed for each of the three feeding categories observed in the fish farms as shown below:

TABLE 1
Sampling locations and categories of farms

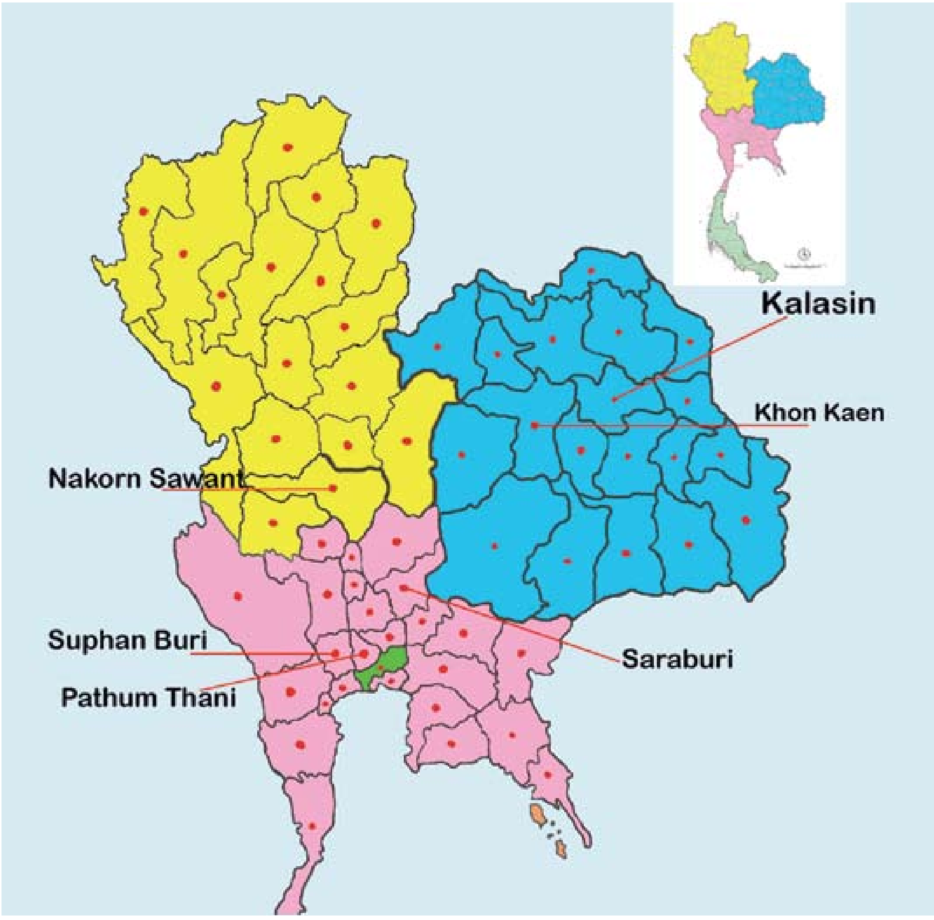
Locations and farms	No. of samples	%
Intensive farms		
Khon Kaen	1	1.67
Kalasin	19	31.67
Semi-intensive farms		
Saraburi	2	3.33
Nakorn Sawan	18	30.00
Traditional farms		
Suphan Buri	4	6.67
Pathum Thani	16	27.67
Total	60	100

3. RESULTS AND DISCUSSION

3.1 Description of the study area

Aquaculture production areas in Thailand are divided into six regions: the north, the northeast, the central plain, the east, the west and the south. Nile tilapia is the number one fish raised in every region, with the exception of the south and the central plain, where hybrid clariid catfish is the most popular species selected for culture. Study sites were selected from six provinces of Thailand (Figure 1). Three provinces are located in the Central-plain region, two provinces in the North-eastern region and one province in the Northern region. The average farm-size observed was largest in the East and the West regions, around 1.2–1.7 ha. The smallest average farm-size of 0.1 hectare was found in the south. Generally, the average size of a farm for inland aquaculture in Thailand is small, at about 0.34 ha per holding.

FIGURE 1
The study site, Thailand



3.2 Description of the respondents

Respondents have an average age of 46 years. Respondents representing semi-intensive and traditional farms have an average age of 48 years while intensive farm and traditional farms respondents are younger with an average of 45 and 46 years, respectively. All respondents from the three farm categories reported similar average household sizes of 4.6. In terms of aquaculture farming experience, semi-intensive and traditional farm respondents reported being in the profession for 9.6 and 7.7 years, respectively. Respondents using intensive feeding systems are less experienced with only 4.5 years (Table 2).

Of the total respondents in the case study, 56 (93 percent) are married and four (7 percent) are single (Table 3). Most of the respondents (77 percent) had completed primary education while a moderate percentage had completed high school (12 percent) and secondary (6 percent) education. By farm categories, those respondents engaged in intensive feeding systems were more formally educated. Fifteen percent of farmers in the intensive farm sector had completed high school education, and a further 15 percent, college education (Table 4).

The above statistics on farming experience and educational attainment appear to have a correlation with the feeding systems adopted by the respondents. The more experienced and formally educated respondents tended to practice the intensive and semi-intensive feeding systems in favor of the traditional method. These demographic characteristics may have influenced the respondents to adopt the use of commercial feeds based on their better awareness of the benefits of adopting the technology.

TABLE 2
Average age, household size, and years in fish farming by category of respondents

Category	Age	Household size	Years in farming
Intensive farms	45	4.9	4.5
Semi-intensive farms	48	3.8	9.6
Traditional farms	46	5.1	7.7
All farms	46	4.6	7.2

TABLE 3
Marital status by category of respondents

Marital status	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Married	17	85	19	95	20	100	56	93
Single	3	15	1	5	0	0	4	7
Total	20	100	20	100	20	100	60	100

TABLE 4
Educational attainment by category of respondents

Education	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Primary	13	65	18	90	15	75	46	77
Secondary	1	5	0	0	2	10	3	5
High school	3	15	2	10	2	10	7	12
College and higher	3	15	0	0	1	5	4	6
Total	20	100	20	100	20	100	60	100

On the average, 71 percent of the respondents claim that fish farming was their major occupation while 23 percent of the respondents were engaged in agriculture, 6 percent were engaged in other activities (fish trading, business and domestic acivities). All respondents from the intensive farming category reported that it was their major occupation while 85 percent and 30 percent of the respondents from semi-intensive and traditional farming categories claimed that fish farming was their major sources of income (Table 5).

TABLE 5
Major occupation by category of respondents

Occupation	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Fish farming	20	100	17	85	6	30	43	71
Fish trading	0	0	1	5	0	0	1	2
Agriculture	0	0	0	0	14	70	14	23
Business	0	0	1	5	0	0	1	2
Housewife	0	0	1	5	0	0	1	2
Total	20	100	20	100	20	100	60	100

3.3 General profile of the farm

The average size of aquaculture farm was estimated at 0.95 hectares. Semi-intensive farms were generally big farms with an average of 1.19 hectares while intensive farms recorded an average size of 0.96 hectares. Traditional farms had the lowest average size of 0.68 hectares. Intensive, semi-intensive, and traditional farms operated on an average number of 9, 6 and 3 ponds respectively with an average area of 0.11, 0.20, and 0.20 hectares per pond. The overall average water depth in the aquaculture farms was 1.82 and 1.58 meters during the dry and wet season cropping, correspondingly (Table 6).

TABLE 6
Number and area of the ponds, and water depth by category of respondents

Items	Intensive	Semi-intensive	Traditional	All categories
Total number of ponds	9.00	6.10	3.35	6.15
Total area of ponds (ha)	0.96	1.19	0.68	0.95
Average area of ponds (ha)	0.11	0.20	0.20	0.15
Rainy season	1.80	1.90	1.76	1.82
Dry season	1.50	1.72	1.52	1.58

About 78 percent of the respondents were single fish pond owners while about 22 percent were single lessees. Statistics on pond ownership indicated that all the respondents from the semi-intensive and intensive farm categories were single owners of the fish farms while only 35 percent of the traditional farmers owned their ponds (Table 7). The average duration of the contract for the ponds leased by the traditional farmers is 12 months. This information may imply that traditional fish farmer-respondents were less well-off compared with the intensive and intensive farmer-respondents. This may have affected their decision to choose the type of aquaculture feeding system based on their respective financial capacity.

TABLE 7
Type of pond ownership by category of respondents

Pond ownership	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Single ownership	20	100	20	100	7	35	47	78
Singly leased	0	0	0	0	13	65	13	22
Total	20	100	20	100	20	100	60	100

Pond operations were being used by all the farmers strictly for fish production. The decision of the respondents to engage in aquaculture production was largely influenced by their perceived profitability as cited by all of the respondents. It is widely known among the fish farm operators that sound knowledge of the aquaculture technology coupled with favorable weather conditions and output prices provided huge returns to investments (Table 8).

TABLE 8
Main factors considered in undertaking fish farming by category of respondents

Factor	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Profitability	20	100	20	100	20	100	60	100
Own consumption	-	-	-	-	-	-	-	-
Total	20	100	20	100	20	100	60	100

3.4 Farm production practices

3.4.1 Stocking strategies

The survey revealed that the majority (74 percent) of the respondents undertook crop rotation (three harvest cycles) using single specie while 13 percent had opted for a monoculture system and 23 percent for polyculture. Crop rotation was practiced by all intensive and semi-intensive farmers. Only 20 percent of traditional farmers resorted to crop rotation (Table 9).

TABLE 9
Aquaculture practices by category of respondents

Aquaculture practices	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Monoculture	-	-	-	-	8	40	8	13
Polyculture	-	-	-	-	8	40	8	13
Crop rotation	20	100	20	100	4	20	44	74
Total	20	100	20	100	20	100	60	100

The average culture period observed by all the respondents was 111 days. However, the culture period varied between the species from 107 days to 150 days (Table 10). Culture periods were also shorter for intensive and semi-intensive farmers.

TABLE 10
Average culture period (days) by type of species and category of respondents

Species	Intensive	Semi-intensive	Traditional	All categories
Hybrid catfish (*Clarias gariepinus* **x** *C. macrocephalus*)	100	95	127	107
Redfin pacu (*Colossoma macropomum)*		-	170	170
Nile tilapia (*Oreochromis niloticus*)		-	150	150
Sepat siam/snakeskin gourami (*Trichogaster pectoralis*)		-	150	150
Giant gourami (*Osphronemus goramy*)		-	150	150
All species	100	95	139	111

The average stocking rate per hectare per crop (the first crop) for hybrid catfish varied from 231 302 pieces for semi-intensive farms to 266 198 and 453 546 pieces for traditional and intensive aquaculture farms, respectively. The overall average of all catfish farms has been pegged at 309 949 pieces (Table 11).

TABLE 11
Average stocking rate (no. per hectare) and stocking size (length in cm) by species and category of respondents

Item	Intensive	Semi-intensive	Traditional
Hybrid catfish			
Stocking rate	453 546	231 302	266 198
Stocking size	2.00	4.53	3.60
Redfin pacu			
Stocking rate	-	-	438
Stocking size	-	-	2.00
Nile tilapia			
Stocking rate	-	-	1 406
Stocking size	-	-	3.00
Sepat siam			
Stocking rate	-	-	13 281
Stocking size	-	-	1.33
Giant gourami			
Stocking rate	-	-	885
Stocking size	-	-	3.00

Stocking sizes for catfish species were determined based only on the length since the respondents failed to account for their weights as payments were made based on the length and not on the weight of the fry/fingerlings. For catfish, the stocking sizes of the fingerlings are reported at 4.53 and 3.60 centimeters long for semi-intensive and traditional farms and 2.00 centimeters long for intensive farms. For catfish farms, the average stocking size of 3.38 centimeters has been a general practice for all farm categories.

3.4.2 Feeding practice

Type of feeds

Farmers used two different types of feeds, namely; (i) industrial or commercial feeds and (ii) poultry by-products (chicken). Industrial feeds were generally used for all fish consumption during the rearing period and were the most expensive type of feed at between US$1.37–2.13 (45–70 baht[2]) per kg. Poultry by-products were considered as supplementary feeds in semi-intensive and traditional farms (catfish, sepat siam) and were moderately priced at about 7 baht per kg. Poultry feed was used during the "grow-out" period. However, industrial feeds were used for intensive farms during the "grow-out" period which cost about 16–30 baht per kg , less than the feed price in rearing period.

All semi-intensive and intensive farmers used commercial/industrial feeds in catfish production Poultry by–products were used as the main feed item for traditional farms. All semi-intensive farms provided their fish species with poultry by-products as supplementary feed. The strategy to use poultry by-products as part of their feeding systems was reportedly a safety measure among semi-intensive farmers in case they are unable to finance the high cost of commercial feeds during the production period. Industrial feed is a floating feed, while poultry by-products is a fast-sinking feed.

TABLE 12
Type of feed used by category of respondents

Feed type	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Industrial feeds[1]	20	100	18	90	-	-	38	63
Poultry by-products and rice bran[2]	-	-	2	10	20	100	22	37

[1]Feed used for catfish, redfin pacu, Nile tilapia, sepat siam and giant gourami
[2]Feed used for catfish and sepat siam

Table 13 indicates that all intensive farms utilized industrial commercial feeds strictly for the rearing of fingerling while 40 percent of the respondents claimed that commercial feeds were used for both the rearing and "grow-out" periods of fish production. Among semi-intensive farms, most of the respondents reported that commercial feeds were intended for both the rearing and "grow-out" periods of their operation.

TABLE 13
Type of feeds used at different stages of rearing by category of respondents

Type of feeds used/stage of rearing	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
1. Industrial feeds[1]								
a. Rearing of fingerling	-	100	-	-	20	100	20	33
b. Rearing of fingerling & on-growing/ grow-out	20	-	20	100	-	-	40	67
2. Poultry by-products and rice bran[2]								
a. On-growing/grow-out	-	-	20	100	20	100	40	67

[1] feeds used for catfish, redfin pacu, Nile tilapia, sepat siam and giant gourami
[2] feeds used for catfish and sepat siam

[2] US$1.00 = B32.88

Frequency and intensity of feeding

The most widely practiced frequency of feeding of industrial/commercial feed was "once a day", as applied on intensive farms. Poultry by-products feed for traditional farms, were likewise fed once daily. In case of semi-intensive farms, both industrial feed and poultry by-products were fed twice daily during the "grow-out" period. All respondents for all three categories of farms (intensive, semi-intensive and traditional) irrespective of type of feeds (industrially manufactured pelleted feed and poultry by-products) used the broadcasting method for feeding.

Table 14 shows the average rate of feeding per hectare by type of feeds and fish farm category. Intensive farms consume an average of 92 160 kg/ha/year. Semi-intensive farms on the other hand, consume 199 681 kg/ha/year which is about 2.2 times more than the rate or intensity of feeding by intensive farms. For traditional farms, average feed consumption is estimated at 158 500 kg/ha/year. The consumption rate of industrial feeds was 92 160 kg/ha/year, 64 903 kg/ha/year and 2 516 kg/ha/year for intensive, semi-intensive and traditional farms respectively. Semi-intensive farms considered poultry by-product feeds as supplementary feeds since they relied more on commercial feeds to satisfy the feeding requirements. Traditional farmers primarily used their own home grown and used this as the main source of feed.

TABLE 14
Amount of feed used (kg/ha/year) by type of feed and by category of respondents

Type of feeds used	Intensive	Semi-intensive	Traditional	All categories
1. Industrial feeds	92 160	64 903	2 516	53 078
2. Poultry by-products	-	134 779	147 920	94 233
3. Rice bran	-	-	8 064	2 688
Total	92 160	199 681	158 500	149 999

3.4.3 Labour utilization and cost

Part time labour were normally hired during pre-stocking operations to excavate, clean and repair dikes and during post-stocking activities particularly harvesting.

Fish pond operations were able to employ an average of 1.0, 3.5 and 2.0 full time employees in traditional, semi-intensive and intensive farms, respectively. On part time basis, these farms were able to employ averages of 4.0, 3.7 and 4.0 workers respectively. The average number of casual employment generated by these farms was 3.0 workers, ranging from 3.5 workers for traditional farms to 3.6 workers for semi-intensive farms (Table 15).

TABLE 15
Average number of labour employed by category of respondents

Labour type	Intensive	Semi-intensive	Traditional	All categories
Full-time labour (no.)	2.0	3.5	1.0	2.2
Part-time labour (no.)	4.0	3.7	4.0	3.9
Total	3.0	3.6	3.5	3.1

Regardless of farm categories, the average total labour utilization per farm per ha per year was estimated at 198 man days. Of which 51 man days were hired and 147 man days were provided by the immediate members of the family. Total labour utilization was 234 man days, 221 man days and 137 man days for intensive, semi-intensive and traditional, farms respectively. However, it is also interesting to note that family labour utilization was highest for the intensive (180 man days) and semi-intensive farms (170 man days) relative to traditional farms (90 man days) (Table 16).

TABLE 16
Average quantity of labour utilized (man-days/ha) by type of operation and category of respondents

Type of operation	Intensive			Semi-intensive			Traditional			All categories		
	Hired	Family	Total	Hired	Family	Total	Hired	Family	Total	Hired	Family	Total
A. Pre-stocking												
1. Excavation	13	-	13	12	-	12	13	-	13	13	-	13
2. Cleaning	1	1	2	2	1	3	-	-	-	1	1	2
3. Dike repair/ construction	-	-	-	-	-	-	-	-	-	-		-
4.Lime application	-	2	2	-	2	2	-	-	-	-	1	1
5. Fertilizer application	-	1	1	-	1	1	-	-	-	-	1	1
6 Others	-	1	1	-	2	2	-	1	1	-	1	1
Subtotal	14	5	19	14	6	20	13	1	14	14	4	18
B. Post-stocking												
1. Feed application	-	175	175	-	164	164	-	89	89	-	143	143
4. Harvesting	40	-	40	37	-	37	33	-	33	37	-	37
Subtotal	40	175	215	37	164	201	33	89	123	37	143	180
All operations	54	180	234	51	170	221	46	90	137	51	147	198

3.5 Fish production costs

3.5.1 Capital investment

The major investment items identified during the survey included the acquisitions of water pumps, building and vehicle truck/pick-up (Table 17). This correspondingly required average investments of US$1 164, US$915 and US$654 per ha. Other minor investments included feed machinery (US$585), fish nets (US$126), balance machines (US$43) and boxes (US$18). It was revealed that traditional farms would not normally invest in buildings and incurred lesser investments in truck/pick-up (US$476) as compared with semi-intensive (US$654) and intensive farms (US$831).

TABLE 17
Average purchase value (US$/ha) of fixed investment by category of respondents

Cost	Intensive	Semi-intensive	Traditional	All categories
A. Buildings	1 919	20	806	915
B. Transport	831	654	476	654
C. Boxes and containers	54	-	-	18
D. Balances	45	35	50	43
E. Feed machinery	-	789	966	585
F. Net	161	120	96	126
G. Water pumps	386	1 061	2 044	1 164
Total	3 396	2 679	4 438	3 505

3.5.2 Variable costs

Variable cost items identified in the case study included the cost of labour, fry/ fingerlings, feed, gasoline and electricity, and other rental costs. Variable costs were more directly related to the scale of operations at any given time.

Labour costs

On a per ha basis, traditional and intensive farms registered high labour costs of US$2 915 and US$2 654 per year, respectively. As expected, the annual labour costs incurred by semi-intensive farms, was significantly lower US$2 043 (Table 18). The proportion of costs allocated for hired labour among traditional and intensive farms were higher at about 87 percent and 75 percent, accordingly. Semi-intensive farms on the other hand, spent about 67.7 percent on hired labour as a proportion to the total cost of labour. The annual cost of labour per farm during pre-stocking operations was higher than post-stocking operations for all farms. The major cost items during the pre-stocking operations included the cost of cleaning and excavation, regardless of farm categories. During the post-stocking operations, the cost of hired labour for harvest activities was the most important labour cost item.

TABLE 18
Average annual cost (US$/ha) of human labour by type of operation and category of respondents

Type of operation	Intensive			Semi-intensive			Traditional			All categories		
	Hired	Family	Total	Hired	Family	Total	Hired	Family	Total	Hired	Family	Total
A. Pre-stocking												
1. Excavation	1 251	0	1 251	906	0	906	2 167	0	2 167	1 441	0	1 441
2. Cleaning	92	11	103	89	50	139	81	1	82	87	21	108
3. Lime application	0	5	5	0	7	7	0	1	1	0	5	5
4. Fertilizer application	0	3	3	0	4	4	0	1	1	0	2	2
5. Others	0	5	5	0	4	4	0	1	1	0	3	3
Subtotal	1 343	24	1 367	995	65	1 060	2 248	4	2 252	1 528	31	1 559
B. Post-stocking												
1. Feed application	0	629	629	0	595	595	0	389	389	0	538	538
2. Harvesting	558	0	558	323	0	323	91	0	91	324	0	324
3. Others	100	0	100	65	0	65	183	0	183	116	0	116
Subtotal	658	629	1 287	388	595	983	274	389	663	440	538	978
All operations	2 001	653	2 654	1 383	660	2 043	2 522	393	2 915	1 968	569	2 537

Cost of stocking

Regardless of farm category, the annual average cost of stocking per ha was US$2 851 of which 99 percent was paid for catfish fingerlings. Traditional farms incurred the largest annual stock acquisition cost of US$3 229 compared with semi-intensive farms (US$2 786/ha) and intensive farms (US$2 546/ha). Annual stocking costs per ha for catfish recorded the highest proportion of the total costs in all farming systems.

The cost of purchase per piece of catfish fingerlings appeared to be slightly lower for intensive farms (US$0.002/piece) relative to semi-intensive (US$0.004/piece) and traditional farms (US$0.008/piece). As claimed, cost per unit decreased as volume of purchase increases (Table 19).

Cost of feeds

The annual average cost of feeds per ha by type and fish farm category are indicated in Tables 20. It shows that intensive farms incurred huge expenditures in the purchase of feed items at US$49 947/ha/year. Semi-intensive and traditional farms correspondingly spent an annual average of US$39 258 and US$25 139 on feed. It is interesting to emphasize that among intensive farms, the total cost of acquiring commercial feeds accounted for 100 percent of the total feed cost. Among semi-intensive farms, the total cost of commercial feeds represented 71 percent of the total feed cost. These figures indicate that as the farms move from semi-intensive to intensive feeding operations, the cost of commercial feeds tends to become a major cost item. It may be argued that cash requirements become a constraining factor when a fish farmers decide to intensify his feeding system.

Miscellaneous input/other variable costs

The miscellaneous input costs associated with fish farm operations included the cost of electricity, fuel and others (Tables 21).

TABLE 19

Average annual quantity and cost (US$/ha) of stocking (fingerling) by type of species and category of respondents

Stocking/species	Intensive			Semi-intensive			Traditional			All categories		
	Number	Price/ piece	Total cost	Number	Price/ piece	Total cost	Number	Price/ piece	Total cost	Number	Price/ piece	Total cost
A. First stocking												
1. Catfish	453 546	0.002	887	231 302	0.004	1 000	266 198	0.008	2 080	317 015	0.004	1 322
2. Redfin pacu							438	0.003	1	146	0.003	0.4
3. Nile tilapia							1 406	0.005	7	469	0.005	2
4. Sepat siam							13 281	0.002	31	4 427	0.002	9
5. Giant gourami							885	0.006	6	295	0.006	2
All species	453 546	0.002	887	231 302	0.004	1 000	282 208	0.005	2 125	322 352	0.005	1 335
B. Second stocking												
1. Catfish	453 546	0.002	887	231 302	0.004	1 000	78 906	0.007	552	254 585	0.003	813
C. Third stocking												
1. Catfish	385 838	0.002	772	184 948	0.004	786	78 906	0.007	552	216 564	0.003	703
All stockings												
1. Catfish	1 292 930	0.002	2 546	647 552	0.004	2 786	424 010	0.008	3 184	788 164	0.004	2 838
2. Redfin pacu							438	0.003	1	146	0.003	0.4
3. Nile tilapia							1 406	0.005	7	469	0.005	2
4. Sepat siam							13 281	0.002	31	4 427	0.002	9
5. Giant gourami							885	0.006	6	295	0.006	2
All species	1 292 930	0.002	2 546	647 552	0.004	2 786	440 021	0.007	3 229	793 501	0.004	2 851

TABLE 20

Average annual quantity and cost (US$) of feeds by type of feeds and category of respondents, per ha

Type of feeds	Intensive			Semi-intensive			Traditional			All categories		
	Quantity (kg)	Price/ kg	Total cost	Quantity (kg)	Price/ kg	Total cost	Quantity (kg)	Price/ kg	Total cost	Quantity (kg)	Price/ kg	Total cost
A. Commercial feeds	92 160	0.542	49 947	64 903	0.431	27 983	2 516	0.415	1 046	53 078	0.487	25 859
B. Supplementary feeds												
1.Poultry by-products	-	-	-	134 779	0.084	11 276	147 920	0.154	22 833	94 233	0.119	11 304
2.Rice bran							8 064	0.156	1 260	2 688	0.156	420
Subtotal	-		-	134 779	0.084	11 276	155 984	0.154	24 093	96 921	0.121	11 724
All feed types	92 160	0.542	49 947	199 681	0.200	39 258	158 500	0.159	25 139	149 999	0.250	37 583

TABLE 21

Average annual quantity and cost (US$) of miscellaneous inputs/other variable by type and category of respondents, per hectare

Items	Intensive			Semi-intensive			Traditional			All categories		
	Quantity	Unit cost	Total cost	Quantity	Unit cost	Total cost	Quantity	Unit cost	Total cost	Quantity	Unit cost	Total cost
1. Electricity (KWH)	85	0.376	32	625	0.376	235	103	0.376	39	271	0.376	102
2. Fuel and oil	383	0.601	230	165	0.601	100	772	0.576	445	440	0.586	258
3. Others	-	-	175	-	-	671	-	-	520	-	-	453
Total	-	-	437	-	-	1 006	-	-	1 004	-	-	813

The annual average cost of electricity and fuel was estimated at US$102 and US$ 258 respectively. Cost of electricity was highest among semi-intensive farms (US$235) relative to intensive (US$32) and traditional farms (US$39). Expenses on fuel were reported by traditional, intensive and semi-intensive farms with respective annual averages of US$445, US$230 and US$100. Fuel expenses occur when farms have a larger area of operation. These are used for motorized machines and pumps.

The total average annual cost for miscellaneous input for semi-intensive, traditional and intensive farms are respectively valued at US$1 006 ha/year, US$1 004 ha/year and US$437 ha/ year.

3.6 Total production costs

The annual average aquaculture production cost per ha was highest among intensive farms at US$55 842 relative to semi-intensive (US$47 460) and traditional (US$33 924) farms. The major cost item for intensive farms is the cost of feeds which was estimated at US$48 713 representing 87 percent of the total. Among semi-intensive farms, feed cost (US$38 883) has been the major cost item accounting for 81 percent of the total. Also, the cost of feed among traditional farms (US$24 499) was likewise considered as a major cost item accounting for 72 percent of the total (Table 22). Regardless of farm categories, the cost of feeds accounted for 81 percent of the total cost while fry/ fingerling cost and labour cost represented 6 percent and 5 percent of the total cost.

For annual fixed costs which includes depreciation of asset, land cost and loan interest, fixed cost per ha was highest among semi-intensive farms at US$2 393 relative to traditional (US$1 927) and intensive (US$1 134) farms.

TABLE 22
Total cost (US$/ha) by item and category of respondents

Item	Intensive		Semi-intensive		Traditional		All categories	
	Amount/ year	%	Amount/ year	%	Amount/ year	%	Amount/ year	%
A Variable costs								
1. Labour cost	2 654	4.75	2 044	4.27	2 914	8.58	2 537	5.5
2. Fertilizer	250	0.45	314	0.66	257	0.75	274	0.6
3. Fry/fingerlings	2 546	4.59	2 786	5.78	3 229	9.59	2 851	6.2
4. Feeds	48 713	87.2	38 883	81.27	24 499	72.2	37 365	81.4
5. Miscellaneous	108	0.19	34	0.07	94	0.28	79	0.2
6. Miscellaneous input/other variable costs	437	0.78	1 006	2.95	1 004	2.96	813	2.1
Subtotal	54 708	98.0	45 067	95.0	31 997	94.3	43 919	96.0
B Fixed costs (depreciation, land & interest)	1 134	2.03	2 393	5.0	1 927	5.68	1 818	4.0
Total	55 842	100	47 460	100	33 924	100	45 737	100

3.7 Gross revenues

The average annual gross revenues per ha, was significantly higher among intensive farms (US$95 585) compared with semi-intensive (US$62 284) and traditional (US$41 887) farms. The high gross income figure among intensive farms was due to the high catfish volume 108 943 kg. The average annual catfish production for semi-intensive farms, was much lower at 82 904 kg, correspondingly. The lowest productions of catfish (60 955 kg) and other fish (1 227 kg) were recorded by traditional farms (Table 23). The high gross revenue figures among intensive and semi-intensive farms are attributed to the adoption of commercial feeding practices which resulted in more production of catfish.

3.8 Comparative analysis of economic and financial indicators

3.8.1 Gross aquaculture margins

Gross aquaculture margin is derived by deducting total variable cost of production from total gross revenue. Fixed costs are considered as sunk costs and may not be recovered in the very short-run period of at least one cropping season. As expected, intensive farms has revealed the highest returns/income above variable cost per ha per year (US$40 877) relative to semi-intensive (US$17 217) and traditional (US$9 890) farms. It is interesting to take note that all categories were able to generate positive returns to variable cost, including profitable but comparatively lower returns for traditional farming (Table 24).

3.8.2 Returns to labour, land and capital

Net returns to land, labour and capital among intensive farms yielded favorable figures of US$39 333; US$37 089 and US$39 403, correspondingly. Among semi-intensive farms, net returns to land, labour and capital are respectively estimated at US$14 364; US$12 780and US$14 556. Traditional farms, recorded low returns to land, labour and capital.

3.8.3 Gross and net total factor productivity

Gross total factor productivity (e.g. benefit cost ratio) provides a ratio of gross revenue to the total cost of production which implies that a ratio of 1.0 means that the operation is at break-even position. The gross total factor productivity of 1.71, 1.31, and 1.23 were estimated for intensive, semi-intensive and traditional farms, respectively. This indicates that the intensive farms are able to recover US$1.71 per US$1 spent while semi-intensive and traditional farms respectively generate returns of US$1.31 and US$1.23 per US$1 spent.

In terms of net total factor productivity, only intensive farms (0.71) were able to register favorable figures while semi-intensive farms (0.31) and traditional farms (0.23) yielded lower coefficients.

3.8.4 Break-even prices

For intensive farms, the estimated break-even prices of was US$0.51/kg. This estimated break-even prices are is 43 percent lower than the prevailing market price of fish. These figures imply that intensive farms can significantly absorb price changes and still achieve profitability.

TABLE 23
Annual gross revenues by harvest and species and category of respondents, per hectare (price of fish and returns are in US$)

Item	Intensive			Semi-intensive			Traditional			All categories		
	Volume (kg)	Price/kg	Total returns	Volume (kg)	Price/kg	Total returns	Volume (kg)	Price/kg	Total returns	Volume (kg)	Price/kg	Total returns
A. First harvest												
1. Catfish	38 363	0.867	33 280	29 365	0.740	21 755	35 329	0.654	23 107	34 352	0.758	26 047
2. Redfin pacu	-	-	-	-	-	-	198	1.500	297	66	1.500	99
3. Nile tilapia	-	-	-	-	-	-	587	0.850	504	196	0.850	168
4. Sepat siam	-	-	-	-	-	-	234	1.261	293	78	1.250	98
5. Giant gourami	-	-	-	-	-	-	208	2.255	469	69	2.250	156
All species	38 363	0.867	33 280	29 365	0.740	21 755	36 556	0.675	24 670	34 761	0.764	26 568
B. Second harvest												
1. Catfish	38 363	0.878	33 712	29 232	0.753	22 003	12 813	0.662	8 488	26 803	0.798	21 401
C. Third harvest												
1. Catfish	32 217	0.889	28 593	24 307	0.762	18 526	12 813	0.681	8 729	23 112	0.805	18 616
All categories	108 943	0.877	95 585	82 904	0.751	62 284	62 182	0.674	41 887	84 676	0.786	66 585

TABLE 24
Summary of assessed financial and economic indicators by farm category, per hectare

Item	Intensive	Semi-intensive	Traditional	All categories
A. Total cost (US$)[1]	55 842	47 460	33 924	45 737
B. Total variable cost (US$)[2]	54 708	45 067	31 997	43 919
C. Total fixed cost (US$)[3]	1 134	2 393	1 927	1 818
D. Total gross revenue (US$)[4]	95 585	62 284	41 887	66 585
E. Gross margin (US$)[5]	40 877	17 217	9 890	22 666
F. Net margin/returns (US$)[6]	39 743	14 824	7 963	20 848
G. Net returns to land (US$)[7]	39 333	14 364	7 829	20 513
H. Net returns to labour (US$)[8]	37 089	12 780	5 049	18 311
I. Net returns to capital (US$)[9]	39 403	14 556	7 519	20 497
J. Gross total factor productivity/benefit cost ratio[10]	1.71	1.31	1.23	1.46
K. Net total factor productivity[11]	0.71	0.31	0.23	0.46
L. Break-even price (US$)[12]	0.51	0.57	0.55	0.54
Average actual market prices (US$)	0.88	0.75	0.67	0.79
M. Break - even production (kg)[13]	63 457	63 280	50 633	57 895
Average actual production level (kg)	108 943	82 904	62 182	84 676
N. Survival rate (%)[14]	64	54	62	61

[1]Total costs = variable costs + fixed costs
[2]Sum of costs of fertilizer, feeds, fingerlings, hired and family labour, electricity, and other variable costs
[3]Sum of fees, lease, interest, rental, depreciation
[4]Value of total aquaculture outputs
[5]Gross revenue less total variable costs
[6]Total gross revenue less total cost
[7]Net margin/returns less land rent payment
[8]Net margin/returns less cost of labour
[9]Net margin/returns less 10 percent of fixed investments
[10]Gross revenue divided by total costs
[11]Net margin/return divided by total costs
[12]Total cost divided by total production
[13]Total cost divided by average price
[14]Number of pieces during harvest/number of pieces during stocking

In the case of semi-intensive farms, the estimated break-even price for fish (US$0.57/kg) are is also lower than the prevailing respective market price of US$0.75/kg. Specifically, the estimated break-even price prices is 24 percent lower than the prevailing market price.

Traditional farms require break-even prices for catfish at US$0.55. The estimated break-even price has already exceeded the prevailing market price (US$0.67/kg) by 18 percent.

3.8.5 Break-even production
A major basis in evaluating the soundness of a business operation such as aquaculture production is to determine their levels of production in relation to their break-even production levels. Break-even production level considers the farm's total production cost in relation to the prevailing output prices.

As shown in Table 24, the average break-even production for all farm categories is estimated at 57 895 kg/ha/year. Given their over-all current performance, aquaculture production exceeded their break-even production level by 32 percent for catfish. These results suggest that regardless of farm category, current farm productivity levels are significantly high enough for a sound aquaculture business in relation to their production costs and prevailing output prices.

By farm category, the respective break-even farm production levels of intensive, semi-intensive and traditional systems are pegged at 63 457 kg/ha/year, 63 280 kg/ha/year, and 50 633 kg/ha/year, respectively. The study revealed that the current fish production performances by intensive, semi-intensive and traditional farms exceeded their respective break-even production levels by 42 percent, 24 percent and 19 percent. The break-even analysis on production level implies that higher yields are a function of improved commercial feeding intensities.

3.9 Production problems

3.9.1 Enabling production factors

The fish farm respondents cited improvement in water quality (37 percent), better management (33 percent) and disease control (33 percent) as the most important factors that need to be addressed to increase production (Table 25). It is interesting to point out that majority of semi-intensive farm-respondents (45 percent) were aware that they needed to engage in commercial feeding in order to increase their farm yields. Intensive farmers (60 percent) and traditional farmers (35 percent) still feel that their improved water quality needed to be addressed in order to achieve higher yields.

TABLE 25
Enabling factors to increase production by category of respondents

Enabling factor*	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
More commercial feed	1	5	9	45	4	20	14	23
High stocking density	1	5	7	35	3	15	11	18
Quality of fry	1	5	2	10	1	5	4	7
Better management	11	55	4	20	5	25	20	33
Disease control	12	60	3	15	5	25	20	33
Improved water quality	12	60	3	15	7	35	22	37

*Multiple response

3.9.2 Disabling production factors

Limited knowledge and water quality was cited as major constraint among intensive farmers (40 percent) to improve production. Lack of capital has been a major constraint among semi-intensive farmers (15 percent) which is perhaps the principal reason why they do not fully engage in commercial feeding practices. In the case of traditional farms, limited feed availability has been a concern to allow for an improvement in production (35 percent) (Table 26).

TABLE 26
Disabling factors to increase production by category of respondents

Disabling factor	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Lack of capital	3	15	3	15	-	-	6	10
Limited feed availability	-	-	-	-	7	35	7	12
Poor market facility	2	10	1	5	5	25	8	13
Limited knowledge	4	20	-	-	-	-	4	7
Poor water quality	4	20	-	-	-	-	4	7
Limited feed availability	-	-	1	5	3	15	4	7
Others	-	-	-	-	3	15	3	5

3.9.3 Other problems

The high cost of feeds has been a major concern among fish farms (Table 27). Also, feed availability has been an important problem for all farms (Tables 28–31).

TABLE 27
Problems concerning industrially manufactured pelleted feeds by category of respondents

Problems	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Procurement	10	50	-	-	1	5	11	18
Availability	7	35	1	5	5	25	13	22
High price	19	95	15	75	19	95	53	88
Others	-	-	-	-	1	5	1	2

Unstable market prices for catfish were reported as a major concern by 85 percent of the respondents. This problem is more pronounced among intensive farms (100 percent) since they have to sell relatively larger volumes of harvested fish crops in the market at one time. Respectively, about 80 and 75 percent of the semi-intensive and traditional farmer-respondents claimed that unstable market prices have been their concern (Table 31). Since production decisions (e.g. investment decisions) are made based on the market prices, any downward fluctuation in the market would affect the profitability/viability of aquaculture business.

TABLE 28
Problems concerning farm-made feed by category of respondents

Problems	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Procurement	-	-	3	15	5	25	8	13
Availability	-	-	9	45	12	60	21	35
High price	-	-	4	20	15	75	19	32

TABLE 29
Problems concerning supplementary feed ingredients by category of respondents

Problems	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Procurement	-	-	1	5	3	15	4	7
Availability	-	-	8	40	7	35	15	25
High price	-	-	5	25	10	50	15	25

TABLE 30
Fingerling related problems concerning by category of respondents

Problems	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Procurement	8	40	1	5	2	10	11	18
Availability	14	70	2	10	2	10	18	30
High price	19	95	4	20	6	30	29	48
Others	-	-	-	-	2	10	2	3

TABLE 31
Problems concerning marketing of fish by category of respondents

Problems	Intensive		Semi-intensive		Traditional		All categories	
	No.	%	No.	%	No.	%	No.	%
Transportation	-	-	1	5	-	-	1	2
Unstable market price	20	100	16	80	15	75	51	85
Very few traders	3	15	-	-	-	-	3	5
Others	5	25	1	5	1	5	7	12

3.10 Statistical analysis of catfish production

3.10.1 Catfish production function model

A Cobb-Douglas production function was employed to estimate the production technology of catfish farming. Input and output data of 60 farms were used. The catfish production function portrays the effects of combining various fixed and variable inputs in a body of water. Seven explanatory variables were hypothesized to explain catfish production. The production function used to be expressed in the following general form:

$Y = f(x_1, x_2, x_3, x_4, x_5, x_6, x_7, D_1, D_2)$

Where; Y = yield (kg)

x_1 = cost of feed (US$)

x_2 = cost of fertilizer (US$)

x_3 = cost of fingerling (US$)

x_4 = cost of fuel (US$)

x_5 = cost of labour (US$)

x_6 = size of fingerling (cm)

x_7 = survival rate (%)

Because the type of farm management are also important in determining yield, dummy variables (D_i) were also included such that: $D_1 = 1$ and $D_2 = 0$ if farm is intensive, $D_1 = 0$ and $D_2 = 1$ if farm is semi-intensive, and $D_1 = 0$ and $D_2 = 0$ if farm is traditional.

The basic Cobb-Douglas model specified as follows;

$$Y = aX_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} X_6^{b6} X_7^{b7}$$

$$LnY = Lna + b_1LnX_1 + b_2LnX_2 + b_3LnX_3 + b_4LnX_4 + b_5LnX_5 + b_6LnX_6 + b_7LnX_7$$

The explanatory variables (X_i) or inputs are sometimes known as target variables because they are subject to influence by the decision-maker (producer or policy-maker). Of the 6 explanatory variables[3] specified in the model are within the control of producers. The production coefficients (b_i) or exponents in the Cobb-Douglas form are the elasticities of production. The b_i terms are actually transformation ratios of the variables input used in catfish production at different quantities. Depending on the need of the study, the basic model can be modified, as reported in the section on result.

The basic function was estimated on per hectare basis. Estimating a production function calls for accurately measured data on output and inputs. Faulty data have often been the source of poor fit and insignificant estimates. Recognizing the importance of accurate data, brief discussions of the variables used in estimating the production function and the problems of measurement are provided.

Total output

Total output refers to the quantities of catfish harvested (in kilograms) during the 2005 production year. This figure includes the catfish that are consumed at home, given away as gifts, and the harvester's and caretaker's shares. The total output, therefore, reflects all marketed as well as non-marketed fish harvested from the pond.

Type of inputs

Inputs can be classified as material inputs, management inputs, and input of field work (labour). Material inputs can be further categorized as either yield-increasing inputs such as fertilizers, or yield-protecting inputs such as pesticides. Besides the material inputs, management inputs and input of field work, other inherent characteristics of

[3] There are cost of feed, cost of fertilizer, cost of fingerling, cost of fuel, cost of labour and size of fingerling

the pond environment, and/or factors affecting its environment such as pond location and weather can be employed to explain catfish output. Again, a working knowledge of these other factors can be invaluable to the catfish producer.

3.10.2 Results of the regression analysis

Production function analysis

Ordinary least squares methods were used to estimate the regression model. The main results of the estimation of the catfish production function for the whole type of management are summarized in Table 32. The estimates of the production coefficients, standard error, and coefficient of determination are also reported. The usefulness of the estimates of the various production coefficients of catfish culture is discussed to provide the reader with a more thorough understanding of the underlying input-output relationships. In general, the levels of statistical significance of the estimated production coefficients are encouraging.

One can interpret the positive production coefficients of the respective inputs as implying that an increase in output of catfish can be accomplished by increasing the intensity of input use. On the other hand, negative coefficients suggest that use of that particular input should be reduced. Of the seven explanatory variables in model only four, feed cost (X_1), fingerlings (X_3), labour (X_5), and survival rate (X_7), were statistically significant at 0.01 confidence levels. This model could explain 83 percent of the variation in yield. Cost of fingerlings was more powerful explanatory variable with the high partial output elasticity (0.4865), which indicates that 10 percent increase in cost of fingerlings (the stocking rate), holding other inputs constant, will increase yield by 4.86 percent.

Dummy variables representing type of farm management were added in model. All dummy variables were significant at the 0.01 level of confidence. This model indicates that there were differences in productivity between types of management.

TABLE 32
Estimation catfish production function (Cobb-Douglas) for Thailand

Variable	Coefficient	Standard error	t-Statistic	Probability	
a	2.5204	1.0964	2.2987	0.0257	**
X_1	0.2359	0.0679	3.4714	0.0011	**
X_2	0.0743	0.0385	1.9305	0.0592	
X_3	0.4865	0.0649	7.4956	0.0000	**
X_4	-0.0069	0.0079	-0.8760	0.3852	
X_5	0.2715	0.1022	2.6570	0.0106	**
X_6	0.0750	0.1612	0.4654	0.6436	
X_7	0.7078	0.1188	5.9571	0.0000	**
D1	0.5325	0.1638	3.2510	0.0021	**
D2	0.4375	0.1509	2.8990	0.0055	**

R-squared	0.8305	Mean dependent variable	11.1189
Adjusted R-squared	0.8000	S.D. dependent variable	0.7612
S.E. of regression	0.3404	Akaike info criterion	0.8338
Sum squared residual	5.7949	Schwarz criterion	1.1829
Log likelihood	-15.0153	F-statistic	27.2144
Durbin-Watson statistics	1.7273	Probability (F-statistic)	0.0000

**Statistically significant at 0.01 confidence levels

3.10.3 Discussion

In general, the Cobb-Douglas equation fitted the data well as indicate by the F-value and R^2. The F-values were highly significant. The R^2 values are also statistically significant.

Their occasional modest values are not unusual in multiple regression analysis using cross-sectional data. Lastly, there appear to be no problems with dominant variables or multi-co-linearity.

In this study, an estimation of the production technology of catfish culture indicated that the main factors influencing yield were: seed cost, feed cost, labour cost, and survival rate.

Because a large purpose of this study was to examine the nature of the input-output relationship and to test the significance of each of the estimates of the production coefficients, all the coefficients will be reported even though some of them are not significant as shown by their low t-values. In all cases there are sufficient degrees of freedom for statistical tests. More than 50 percent of the regression or production coefficients are significant at small probability levels. Errors due to deficient memory recall may have contributed to the presence of some insignificant coefficients.

4. CONCLUSIONS

The study reveals that adoption of commercial feeding has benefited intensive and semi-intensive farms in terms of higher yields as measured in kilograms of catfish production. Traditional farms suffered from poor production levels relative to other farms solely because they stuck to a feeding system that were less effective in improving the weights of the fish species at the time of harvest. Feed costs were a major factor amongst all the farm categories.

Higher production levels of catfish production among all categories have consequently triggered their high acceptable levels of financial and economic indicators. As such, their estimated coefficients, gross revenues, gross margins/income above variable costs, net margins/returns, net returns on land, labour and capital, gross and net factor productivities, all demonstrate strong financial and economic performance.

One of the limitations of this case study is its heavy emphasis on the financial and economic analysis of feeding systems in the study area. As expected, this study did not address the more technical aspects of adopting not only commercial feed application but also the optimum level of stocking rates. Although high weight gains and recovery rates (e.g. number of pieces recovered during harvest vis a vis stocking periods) are generally observed, this was not isolated in terms of the specific impacts that are attributable to commercial feeds and or stocking rates.

Finally, estimating a production function calls for accurately measured data on output and inputs. Of the seven explanatory variables in model only four, feed cost, fingerlings, labour, and survival rate, were statistically significant. Cost of fingerlings was a powerful explanatory variable with high partial output elasticity.

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APPENDIX

Appendix A: Observation and variables for multiple regression (catfish production function)

Observed number	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	D_1	D_2
1	125 000	46 200	38	1 500	300	6 116	2	0.50	1	0
2	101 250	10 557	316	2 700	59	2 331	2	0.75	1	0
3	120 536	38 210	226	3 214	391	2 485	2	0.53	1	0
4	112 500	25 598	264	2 813	207	2 639	2	0.64	1	0
5	140 625	92 127	174	2 813	376	3 016	2	0.80	1	0
6	70 313	44 332	59	1 406	84	2 779	2	0.80	1	0
7	76 563	54 017	86	1 750	145	1 757	2	0.70	1	0
8	78 750	49 017	162	2 625	89	1 934	2	0.48	1	0
9	120 833	96 407	411	2 417	77	1 617	2	0.70	1	0
10	93 750	56 378	186	3 600	238	3 493	2	0.42	1	0
11	118 750	82 009	196	2 078	48	1 832	2	0.90	1	0
12	75 000	42 307	155	1 500	396	1 741	2	0.80	1	0
13	157 500	19 674	232	1 114	130	2 209	2	0.85	1	0
14	109 375	34 577	410	3 656	86	1 613	2	0.78	1	0
15	125 000	24 766	197	2 500	55	2 663	2	0.70	1	0
16	112 500	38 389	240	2 475	108	2 287	2	0.73	1	0
17	93 750	60 453	352	1 969	338	3 558	2	0.50	1	0
18	150 000	42 514	348	5 683	656	2 556	2	0.65	1	0
19	84 375	41 720	174	2 461	656	2 525	2	0.36	1	0
20	112 500	75 004	773	2 564	153	3 938	2	0.60	1	0
21	83 333	11 334	48	2 083	119	2 959	4	0.80	0	1
22	43 750	13 372	234	1 094	226	1 769	4	0.70	0	1
23	112 500	64 547	306	3 125	0	1 785	3.5	0.60	0	1
24	100 000	75 681	234	2 250	182	1 553	3.5	0.53	0	1
25	62 500	73 508	344	2 250	85	2 097	3.5	0.25	0	1
26	65 625	30 342	399	2 344	481	787	7	0.56	0	1
27	112 500	92 273	353	5 063	0	1 703	6	0.40	0	1
28	83 333	58 359	193	3 125	481	1 649	7	0.60	0	1
29	93 750	55 036	534	1 406	73	1 422	3.5	0.67	0	1
30	75 000	37 195	1 313	2 813	0	1 703	3	0.52	0	1
31	67 500	13 171	108	3 375	0	1 022	2	0.40	0	1
32	50 000	54 188	270	2 344	33	927	4	0.32	0	1
33	56 250	52 383	606	2 250	26	2 018	4	0.23	0	1
34	52 500	13 295	675	3 750	16	4 111	2.5	0.30	0	1
35	93 750	29 688	11	1 641	0	3 162	5	0.86	0	1
36	95 000	21 788	28	1 406	0	3 244	10	0.78	0	1
37	61 719	7 222	181	2 930	0	1 766	6	0.33	0	1
38	70 313	13 699	43	3 516	0	2 313	3	0.40	0	1
39	91 250	22 261	392	3 750	281	2 548	3	0.50	0	1
40	187 500	38 323	225	2 765	0	2 349	6	0.67	0	1
41	187 500	55 012	586	7 324	410	5 248	4	0.48	0	0
42	150 000	47 291	469	5 859	495	1 823	4	0.48	0	0
43	206 250	24 688	15	10 828	500	2 683	4	0.79	0	0
44	225 000	36 626	26	9 844	500	2 452	4	0.86	0	0
45	15 417	23 805	361	507	146	1 670	3	0.33	0	0
46	62 500	12 182	875	6 745	104	1 244	5	0.97	0	0
47	12 500	8 459	246	195	174	10 243	5	0.21	0	0
48	27 778	17 135	219	1 563	188	2 649	2	0.59	0	0
49	25 000	11 469	31	5 000	188	2 380	3	0.30	0	0
50	48 438	4 047	64	2 031	21	3 877	5	0.64	0	0
51	21 875	42 078	33	1 953	361	3 964	5	0.28	0	0
52	28 125	20 852	19	1 375	311	895	4	0.45	0	0
53	14 583	37 919	21	1 953	103	3 558	3	0.12	0	0
54	18 750	38 873	24	781	133	3 193	3	0.60	0	0
55	13 555	8 022	1 770	1 516	141	1 892	3	0.20	0	0
56	75 000	35 578	39	3 438	4 575	1 487	2	0.57	0	0
57	63 438	30 813	313	2 891	470	3 719	2	0.57	0	0
58	19 792	22 758	13	673	174	1 023	3	0.64	0	0
59	12 500	5 635	9	260	60	1 241	3	0.80	0	0
60	15 625	6 734	4	3 645	57	3 032	5	0.80	0	0

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

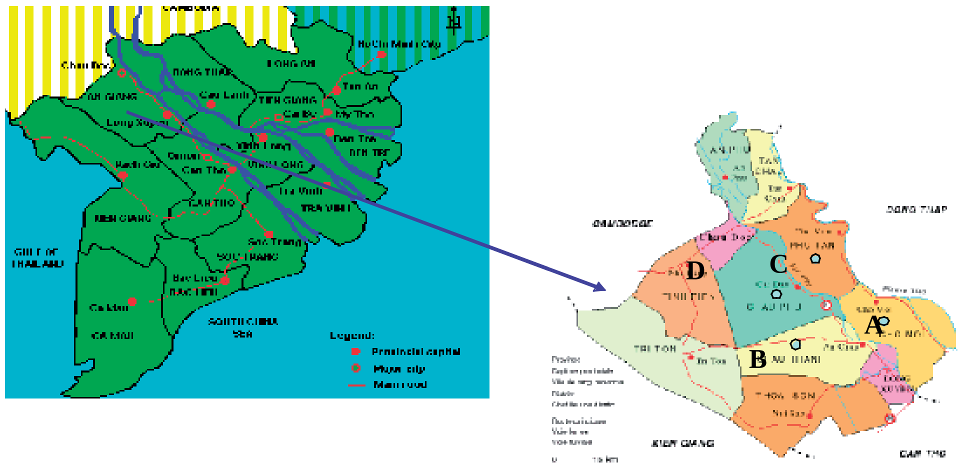
The case study included three representative feeding practices of pond catfish culture in the Mekong river delta, Viet Nam. Twenty farms (or respondents) were interviewed for each feeding system. An Giang province borders on Cambodia and is located along the Mekong river branches in Viet Nam (Figure 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.

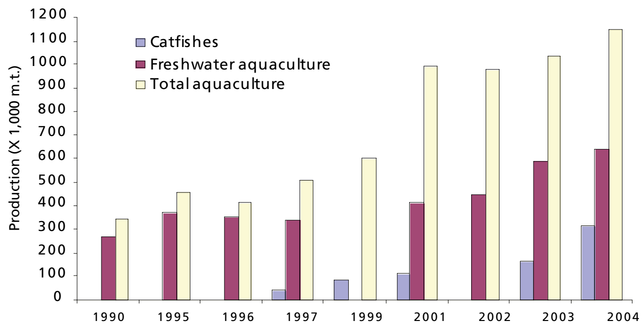
Another major limitation of the study is the nature of data gathering employed (e.g. personal interviews by recall) which may have influenced the overall reliability of the data generated by the study, e.g. data on the size of fingerlings and stocking duration. Finally, the number of samples per category 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.

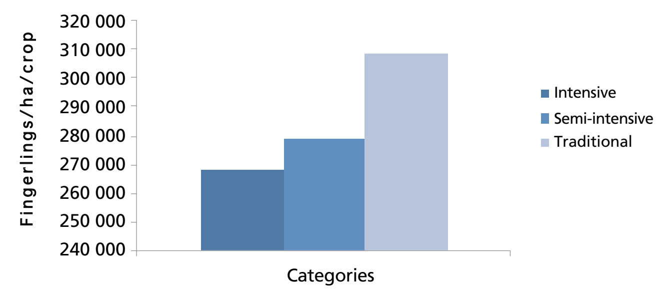
It is interesting to note that all respondents reported that profitability was the main influencing factor in prompting their decision to invest in catfish pond culture. This may support the reasons for the rapid expansion of catfish culture in general or catfish pond culture in particular in the Mekong 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

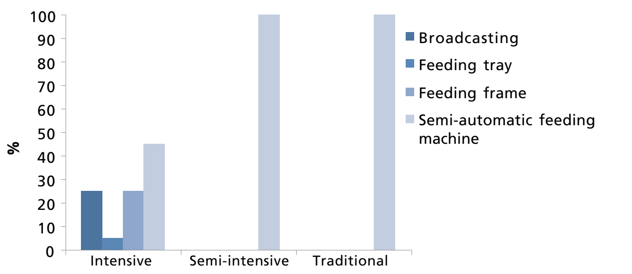
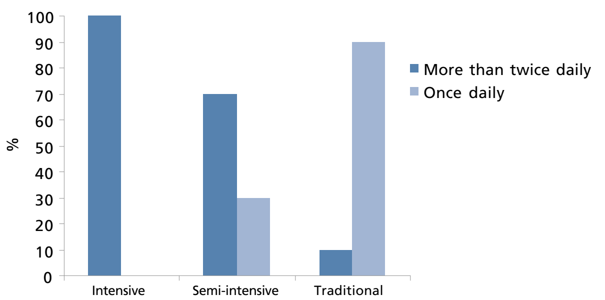


FIGURE 5
Feeding frequency



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

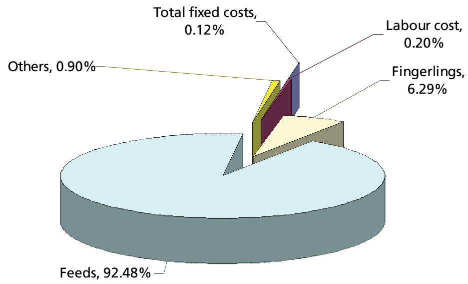


FIGURE 7
Distribution of costs for farms using farm-made and manufactured pelleted feed

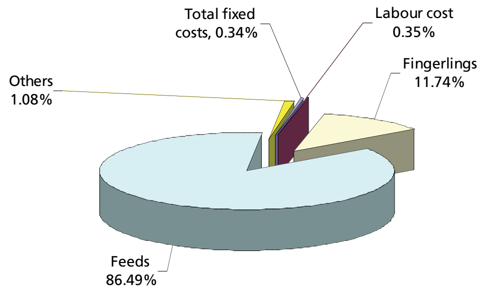
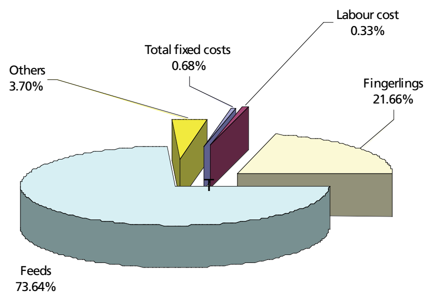


FIGURE 8
Distribution of costs for farms using farm-made feed



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

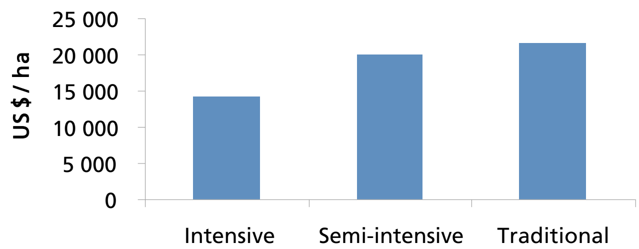


FIGURE 10
Gross aquaculture margin by category

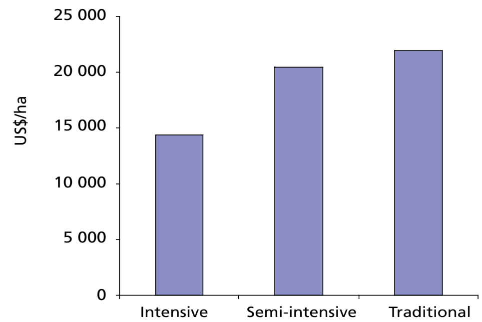


FIGURE 11
Net return to labour by category

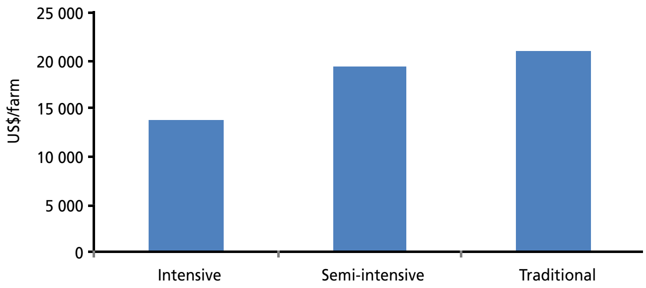


FIGURE 12
Net return to land, labour and capital by category

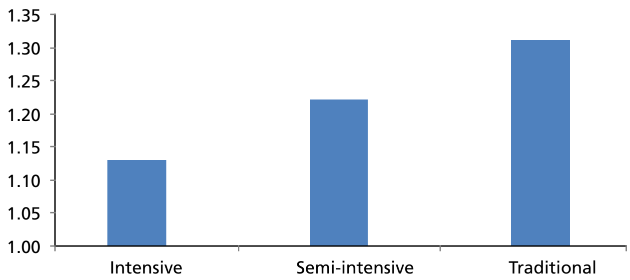
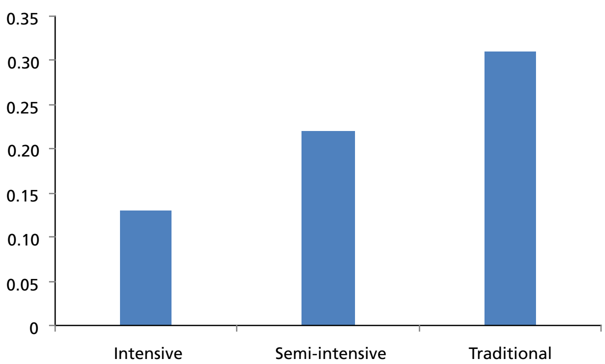


FIGURE 13
Gross total factor productivity by category



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

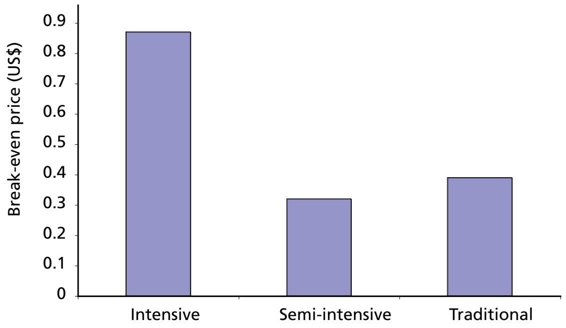


TABLE 19
Problems concerning manufactured pelleted feeds by category of respondents

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)

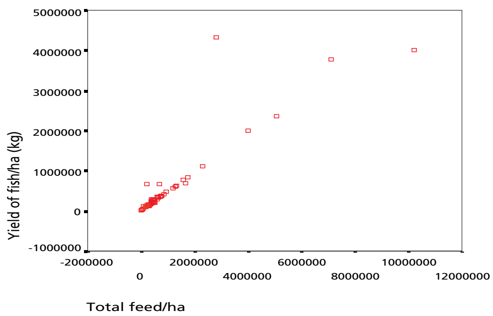


FIGURE 16
Relationship between proportion of farm-made feed to total feed (percent) and fish yield (kg/ha)

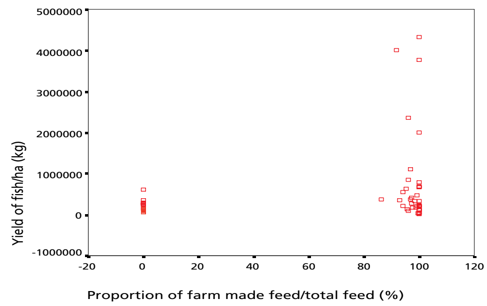


FIGURE 17
Relationship between stocking rate (no. of fish/ha) and fish yield (kg/ha)

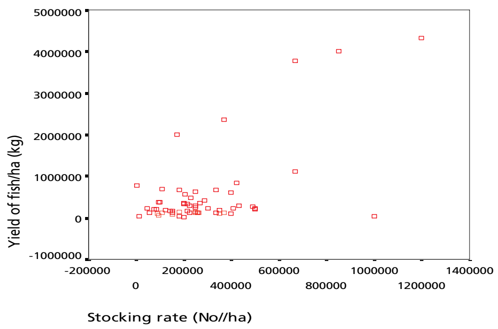


FIGURE 18
Relationship between total fixed costs (US$/ha) and fish yield (kg/ha)

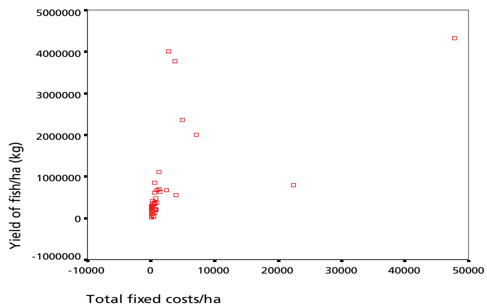


FIGURE 19
Relationship between number of ponds and fish yield (kg/ha)

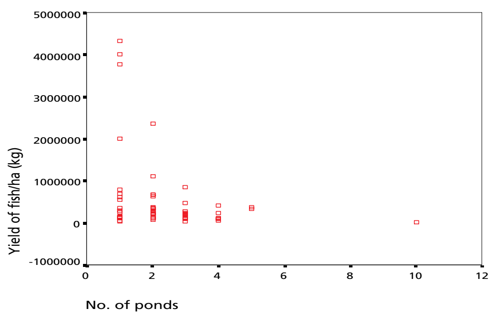
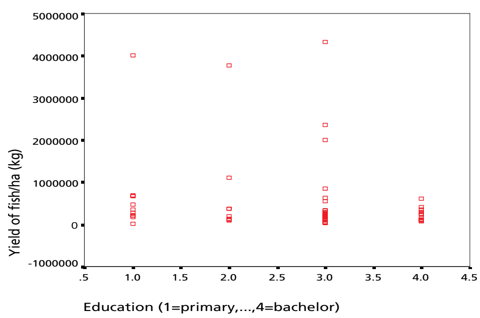


FIGURE 20
Relationship between educational level and fish yield (kg/ha)



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

This technical paper provides an analysis of the economic implications of, and the reasons for, adopting various feeding practices for different fish species and aquaculture systems in Asia. It consists of case studies in six Asian countries (Bangladesh, China, India, the Philippines, Thailand and Viet Nam) and an overall synthesis ending with conclusions and recommendations. The systems studied include extensive/traditional, semi-intensive and intensive farms for a number of different species including sutchi and pangasiid catfishes (Bangladesh and Viet Nam), hybrid catfish (Thailand), carp polyculture (India and China), prawn and milkfish polyculture (the Philippines). The work identifies the principal input costs, assesses the economic rates of return (gross and net margins), returns to labour, land and capital, gross and net total factor productivity, and break-even prices and production. For the most part, intensive farms applying industrial feeds attained the highest economic returns, although not necessarily the highest benefits. In many cases, feed costs were extremely high, accounting for over 80 percent of the total. Feed cost, feeding rate, stocking rate, recovery or survival rate and fertilizer cost were identified as the key variables in influencing production. Use of intensive farming was consistent with strong farmer education and good extension practices. It is expected that the results of these studies will assist in adopting appropriate feed management strategies depending on the availability of inputs and the level of technical know-how of the farmers.

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