Economics of aquaculture feeding practices: Punjab, India

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Debnath, M., Nandeesha, M.C., Dhawan, A., Anand, V., Paul, A. & Roy, M. 2007. Economics of aquaculture feeding practices: Punjab, India. In M.R. Hasan (ed.). Economics of aquaculture feeding practices in selected Asian countries. *FAO Fisheries Technical Paper.* No. 505. Rome, FAO. 2007. pp. 99–119.

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

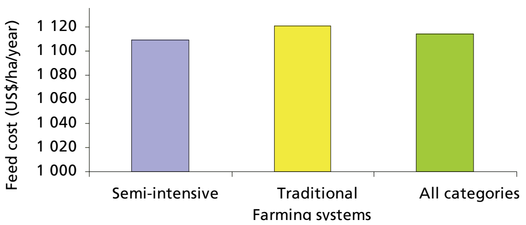
Species	Semi-intensive			Traditional			All categories		
	No.	Price/ piece	Total cost	No.	Price/ piece	Total cost	No.	Price/ piece	Total cost
Rohu	6 820	0.014	96.37	6 518	0.011	72.67	6 669	0.013	84.29
Catla	2 713	0.013	36.23	4 179	0.009	36.2	3 446	0.011	38.23
Mrigal	6 190	0.013	82.66	4 607	0.011	51.37	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**

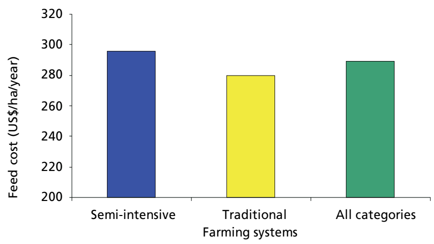
TABLE 21
Average annual power cost (US$/ha) by type in different farming systems

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

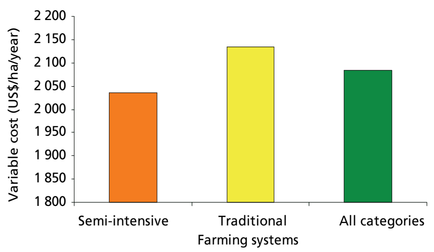


TABLE 22
Average annual fixed cost (US$/ha) by type and category of respondents

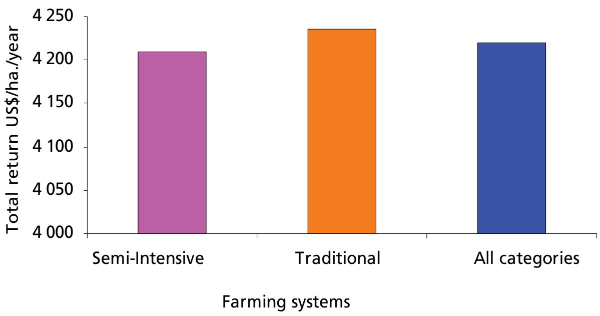
Item	Semi-intensive	Traditional	All categories
A. Depreciation of buildings	8.0	6.6	7.3
B. Depreciation of truck/pick-up van	3.1	0.7	1.9
C. Depreciation of pump	5.6	6.2	5.9
D. Land use cost	278.3	266.4	273.5
E. Other depreciations	1.2	-	0.6
Total	**296.2**	**279.9**	**289.2**

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).

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 6
Benefit–cost ratio obtained form different farming systems

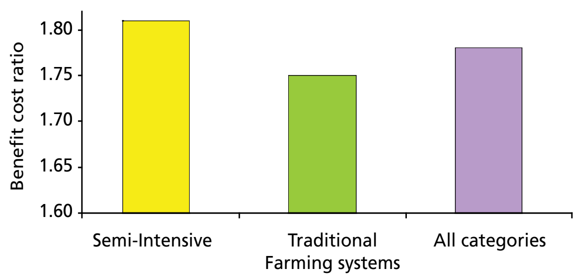
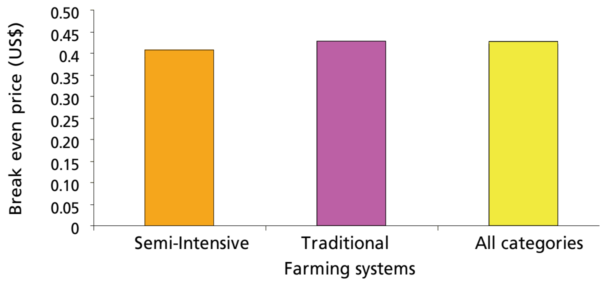


FIGURE 7
Break-even price for fish production in different farming systems



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

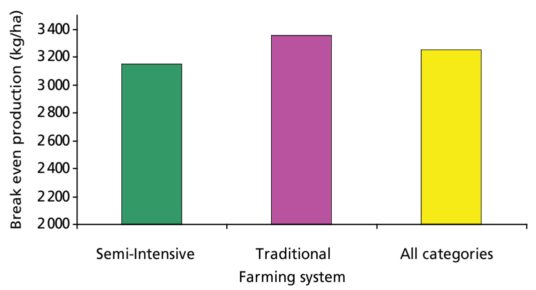
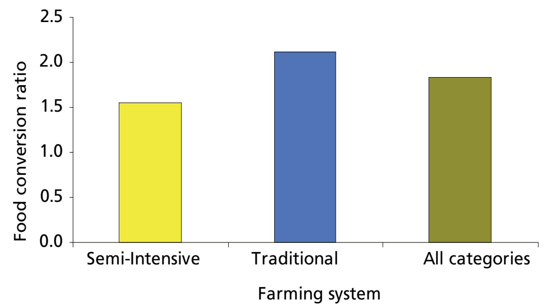


FIGURE 9
Food conversion ratio obtained in different farming systems



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.

ACKNOWLEDGEMENTS

The authors are grateful to the farmers for providing the information. Authorities of the Guru Angad Dev Veterinary and Animal Sciences University provided support of their staff to carry out this survey by making all the local arrangements. Similarly, the staff of the Central Agricultural University were able to work during odd hours to complete the task of data analysis and we are grateful to the authorities for the support. Dr Mohammad R. Hasan, Fishery Resources Officer of FAO provided all the necessary support to complete the study by extending necessary linkage. The opportunity provided to Mr Manidip Roy to participate in the workshop held in Bangkok has helped to many ways to complete this task.

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