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Comparative Analysis of Fish Culture Methods in Village Ponds of Gujarat

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Abstract

Freshwater aquaculture in Gujarat is mainly focussed on village ponds which are leased to the farmers. The state has 6860 village ponds comprising an area of 0.22 lakh ha contributing up to 9% of the inland fish production of the state. The study aimed at evaluating economic analysis of three different types of aquaculture practices *viz.*, zero-fed, bag-fed and cage cum pond integrated aquaculture production systems. Resource use efficiency indicators such as water-use index, calcium carbonate index, nitrogen-use index and energy efficiency were used to compare the aquaculture methods. The results indicated that output can be improved with system diversification. The percentage of additional net income achieved in cage cum pond integrated aquaculture production system as compared to zero-fed and bag-fed aquaculture production systems are 163.17 and 33.25% respectively. Constraints faced by farmers in upgrading their aquaculture practices were also documented. Non-availability of seed was found to be the major constraint.

Keywords: Village pond aquaculture, cage cum pond integrated culture system, resource use, benefit-cost ratio

Introduction

Aquaculture is a fast-growing sector for meeting the increasing demand for food fish supply and several developments have taken place in aquaculture practices the world over. It helps in generating income and is an enterprise for the rural people (Edwards, 2000). India is targeting 13.3 million metric tonnes of fish production from aquaculture by 2050 (CIFA, 2015) and this calls for managing aquafarms to produce fish at the desired levels.

The inland fish production of Gujarat state was estimated at 1.18 lakh metric tonnes during 2017-18 (DAHDF, 2018). Of this, the production from ponds and tanks was 9313 mt, which formed 8% of the total inland fish production of the state (Anon, 2016). The state has huge potential freshwater resources comprising 6860 village ponds covering an area of 0.22 lakh ha which can be utilized for fish farming.

Village ponds are leased to fish farmers for a period of ten years. The traditional fish farming practised was extensive aquaculture where not much attention was paid to management practices. Aquaculture was primarily zero-fed aquaculture in village ponds where the fish culture is carried out by enhancing primary production of the pond with minimal investment. Farmers stock advanced fingerlings in ponds and do not pay much attention to feeding and other management practices. About 25% of the fish farmers use low cost feed ingredients such as rice bran, groundnut oil cake, mustard oil cake etc. and mostly bag-feeding is practised, especially for culturing carps (Nandeesha, 1995; Murthy, 2002).

In ponds having water depths greater than 2 m pre-stocking and other management measures including stocking, feeding and disease treatment are difficult as these cannot be drained. To overcome this, cage culture has been introduced as an option. Cage-cum-pond integration system is a novel model developed for increasing productivity of pond aquaculture system (Mandal et al., 2014; Yang Yi,

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1999, Yang Yi & Lin, 2001, David et al., 2005, Waidbaicher et al., 2006). Integration of cage and pond culture was introduced on a trial mode in selected village ponds along several districts of Gujarat with one or two cages provided on lease to farmers having village ponds of considerable depth and area greater than 2 ha.

The three systems: zero-fed, bag-fed and cage-cum-pond integrated production system are different in terms of inputs used and the output produced. Comparison of fish farms based on management and feeding practice is needed for refining the culture practice (Pillay, 1997; Mishra, 1997; Ahmad, 2007). This study attempts to investigate the economic advantages of the system and explores the possibilities of adoption of cage culture over regular culture practice in village ponds. Indicators to reveal the resource-use efficiency in different culture practice were also assessed. Social characteristics of fish farmers and their constraints in adopting new technologies are identified and documented.

Materials and Methods

Five districts of Gujarat namely Ahmedabad, Anand, Kheda, Vadodara and Bharuch districts were selected for studying zero-fed and bag-fed village pond aquaculture systems. Data on various inputs used during the farming and economics of the aquaculture practices was collected from twenty village ponds (Thrusfield, 1995). The study was conducted for one year of culture period during 2017-18. Among the selected twenty village ponds, ten were zero-fed and the other ten were bag-fed. Zero-fed village ponds were those where no feeding practice was followed whereas in bag-fed system, feeding was done through bags placed or hung at different points of the pond. This was also compared with the integrated cage cum pond aquaculture where semi-intensive culture of fishes was done in cages and extensive farming of fishes in the remaining area.

Cages of 6x 4x 4 m^3 size were stocked with Pangasius (*Pangasianodon hypophthalmus*) fingerlings of 40-50 g at the rate of 30 nos/ m^2. Open ponds were stocked with Indian Major Carps and exotic carps with a stocking density of 5000 nos/ha. Partial harvesting and stocking of the ponds were done by maintaining the stocking density @ 5000 nos/ha. Resource-use efficiency indicators for three production system was computed as per Boyd et al. (2007) by using following formulae

$$\text{Water-use index } (m^3/t) = \frac{\text{Water used } (m^3)}{\text{Fish production (t)}}$$

$$\text{Calcium carbonate index (kg/t)} = \frac{\text{Lime (kg) x Neutralizing value (\%)/100}}{\text{Fish production}}$$

$$\text{Nitrogen-use index (kg/t)} = \frac{\text{Nitrogen in fertilizer and feed}}{\text{Fish production}}$$

$$\text{Energy efficiency (kW.h/t)} = \frac{\text{Electrical power (hp) x Duration (hr) x 0.745 kW/hp}}{\text{Fish production (t) x 0.9}}$$

Comparison based on economic analysis was done to study the returns from each aquaculture system. The seed cost and selling market prices prevailing in Gujarat were utilized for the study.

Net Income = Total expenditure – Gross income

Benefit cost ratio = (Gross income / Total expenditure per crop)

Various constraints faced by fish farmers in adopting modern farming practices were documented and analysed. Five focus group discussions were held at the farmer's field as per Chang & Zepeda (2007); Haggan et al. (2007). The farmers were requested to score each of the constraints they faced in a scale of 10 based on the extent of economic losses and the cumulative mean for each was plotted as a kite diagram. The constraints are classified into five categories namely, water availability, seed availability, poaching, social problems and need of training.

One-way ANOVA was carried out to test the significance difference between aquaculture methods and Duncan's multiple range test was used for post hoc analysis. The efficiency data are expressed as mean±SE.

Results and Discussion

The social characteristics of fish farmers practising aquaculture in village ponds (Table 1) revealed that majority (48%) of them belonged to age group 40-50 and 63% of them completed primary education. Agriculture was the primary occupation of 68% of farmers. Also 73% of fish farmers took only one village pond at a time on lease.

The details of inputs used and the corresponding resource-use efficiency parameters of zero-fed village ponds, bag-fed ponds and cage cum pond integrated systems are given in Table 2 and 3 respectively.

These ponds were managed by stocking and harvesting with no other management intervention. There was no feeding and fertilization of ponds. Occasional liming and treatment was done incase of absence of primary production and disease occurrence. Major harvesting was done before monsoon, so that escape of fishes due to overflow may not lead to losses. In the absence of watch and

Table 1. Social characteristics of fish farmers practising aquaculture in village ponds (N=24)

Particulars	Categories	% contribution
Age of farmers	30-40	14.65
	40-50	48.23
	Above 50	37.12
Education	Primary	62.95
	Secondary	23.64
	Higher studies	13.41
Main occupation	Agriculture	68.24
	Business	23.36
	Aquaculture	8.4
No. of leased ponds	One	72.9
	Two	11.8
	More than two	15.3

Table 2. Details of the inputs used for culture practices

Inputs	Zero-fed aquaculture production system	Bag-fed aquaculture production system	Cage cum pond integrated aquaculture production system
Feed (kg)	-	1975 ± 286.61 (GNOC & Rice bran)	2260 ± 279.28 (pellet feed)
Urea (kg)	63.75 ± 19.96	50 ± 16.04	54 ±16.73
Lime (kg)	375 ± 75.59	253.75 ± 96.20	345 ± 87.32

Table 3. Resource use efficiency indices in zero-fed, bag-fed and Cage cum pond integrated aquaculture production system

Particulars	Zero-fed aquaculture production system	Bag-fed aquaculture production system	Cage cum pond integrated aquaculture production system
Water use index (m3/t)	9031 ± 2201^{c}	6988 ± 865^{b}	2929 ±144^{a}
$CaCO_3$ index(kg/t)	337 ± 98^{c}	180 ± 80^{b}	102 ± 29 ^{a}
Nitrogen use index (kg/t)	24.5 ±5.9^{a}	81.4 ± 18.3^{C}	40.9 ± 7.2^{b}
Energy efficiency (kW.h/t)	-	105 ± 23^{a}	462 ± 108^{b}

*Values within same row having different superscripts are significantly different.

ward, poaching caused severe loss to the investment.

In the absence of pre-stocking management, advanced fingerlings or yearlings of 150-200 g weighing 450 kg were stocked. There were losses on account of predation by carnivorous species like *Notopterus chitala*, *Wallagu attu* etc. which either entered accidentally through inlet canals or were stocked deliberately. The values of gross fish yield and survival were 1163±262 kg/year and 56.4±6.8% respectively, much lesser compared to bag-fed village ponds and integrated cage cum pond systems. Harvesting also comprised of weed fishes weighing 12.6±3.2 kg/year consisting of *Amblypharyngodon mola*, *Chela labuca*, *Puntius longicaudatus, Esomus danricus*, etc.

Water-use index for zero-fed system was estimated at 9031 m^3 t^{-1} which meant nine million litres of water was needed to produce one tonne of fish, which appears very high. Because of minimal input, the other indices are of less relevance in zero-fed systems. The total expenditure per crop in this system was estimated at Rs. 94,500/- per year. The benefit cost ratio after every crop with low level of management worked out to 1.47.

Feeding and regular fertilization of the ponds was practised including liming at regular intervals. Bag-feeding was done by hanging the bags containing mixture of groundnut oil cake (GNOC) and rice bran. Replacement of GNOC with mustard oil cake and soya bean oil cake was also tried.

Netting in order to remove the large and predatory fishes was carried out before stocking. Proper screening of inlet water source was done to ensure that no predatory or unwanted weed fishes entered the pond. Pre-stocking management like liming and fertilization was done after monsoon to obtain high yield from the crop. Fingerlings of size 80-120 g were stocked at the rate of 5000 ha^{-1}. Partial harvesting was done 3-4 times in a year when good market price prevailed.

Water-use index improved in bag-fed system with an average value of 6988 m^3/t. Also, there was less energy requirement of 105 kW h t^{-1} mainly for pumping during stocking and lowering the water depth during harvesting.

The total expenditure per crop was estimated at Rs. 1.14 lakhs per year in bag fed culture system. An estimated investment of Rs. 48,000/- per year was made for feeding which resulted in additional gain of 97.5% in the net income as compared to zero-fed system. The benefit-cost ratio for bag fed village ponds was estimated to be 1.78.

In this system feeding was carried out daily in cages at the rate of 3-5% of the body weight. There was no feeding in the pond outside the cages. The excess feed and faecal matter from the cage enhanced the primary production and acted as source of nutrition for fishes outside the cage. Weekly cleaning of cages was done to remove clogging in the nets. Net of the cages needed to be changed once in two months. Stocking density of ponds was maintained at the rate of 5000 nos ha^{-1} and 30 m^{-2}in the cages. The net fish yield obtained in cage was 1280 kg per 100 m^2 which was very high compared to zero-fed and bag-fed methods. The total expenditure per crop in the system was estimated at Rs. 3.15 lakhs per year. The total fish production in cage cum pond integrated culture system per year was 3420±168 kg ha^{-1} gaining a net profit of 1.2 lakhs. The percentage of additional net income compared to zero-fed system and bag-fed system are 163.17% and 33.25% respectively. The benefit cost ratio which was estimated at 1.38 is lower than the above two systems; because of the initial investment on capital cost like installation of cages (Table 4).

Though cage culture is promoted by the fisheries department, it is necessary to demonstrate and provide training to farmers. Many of the beneficiaries were found to be unaware of the fish production possibility in cages. Moreover, there is a lack of confidence among progressive farmers to take up the new model of farming.

Sea and reservoirs remain the main focus of cage culture in India. The utilization of large village ponds for cage culture has been ignored. Policy makers of Gujarat explored the possibility of cage culture in village ponds. Cage culture is attractive due to its advantages of less investment cost, safety from predators and ultimately high yield of fish with good economic returns (Joseph et al., 2009).Cage culture has changed the long-established fish-farming structures and was one of the reasons for fisheries development in China (BAO TONG 1994).

The study revealed that water-use index decreased by 67.66% and 58.09% in cage cum pond integrated system compared to the zero-fed and bag-fed system respectively. Also feed conversion ratio,

Table 4. Economic analysis of zero-fed, bag-fed and Cage cum pond integrated aquaculture production system

Particulars	Zero-fed aquaculture production system (Per ha)	Bag-fed aquaculture production system (Per ha)	Integrated pond cum cage aquaculture production system (Per ha)
Investment per year (Leasing, pre-stocking & depreciation on cage materials)	Rs. 10,000	Rs. 10,000	Rs.70,000
Seed cost	Rs.64,500	Rs. 36,000	Rs. 40,000
Feed Cost	-	Rs. 48,000	Rs. 1,55,700
Miscellaneous	Rs. 20,000	Rs. 20,000	Rs. 50,000
Total expenditure per crop	Rs. 94,500	Rs. 1,14,000	Rs. 3,15,700
Gross income	Rs. 139560	Rs. 2,03,000	Rs. 4,34,285
Net Income	Rs. 45,060	Rs. 89,000	Rs. 1,18,585
Benefit cost ratio	1.47	1.78	1.38
% of additional net income	-	97.5% *	163.17%*
			33.25% **

*Percentage of additional net income with respect. to zero feeding based aquaculture production system
**Percentage of additional net income with respect. to bag feeding based aquaculture production system

calcium carbonate index, nitrogen-use index was lesser in cage cum pond integrated culture system. However, more energy was used for aeration, pumping water and reducing the depth. As per Boyd et al. (2007) water use index for water shed ponds are in the range of 6500-10,000 m^3/t, the integrated cage cum pond aquaculture has reduced the water use index to 2929 ± 144 m^3/t.

Datta et al. (2014) reported 32.12 % additional gross income with cage cum pond integrated system (*Channa punctatus* in cages and carps in open pond) as compared to pond without cage. Several earlier studies had also reported that the waste and unused feed from cages enhanced the growth of filter feeding fishes in open ponds (Lin, 1990, Yang Yi & Lin, 2001; Asaduzzaman et al., 2006). Thus the nutrient input from formulated feed is effectively recycled in integrated cage cum pond aquaculture where feed dependant fishes are grown in cages intensively and filter feeders are grown in open pond with natural food (Lin & Yi, 2003). Kumar et al. (2017) evaluated the comparative performance of *Pangasianodon hyopthalmus* culture in ponds at Pench and cages installed at Dhasai reservoir in Maharashtra. The benefit-cost analysis suggests adoption of cage culture as it is more profitable than pond culture. Kipkemboi et al. (2007) stated 11% per household of socio-economic improvement in integrated agriculture-aquaculture production system in Lake Victoria wetlands (Kenya)

Perception on constraints faced by the farmers in adopting new technologies is shown in Fig. 1. Constraints expressed by farmers include lack of seed availability, water availability including depth of the pond, need for training and demonstration, poaching and other social problems. Among these, non-availability of good quality seed appeared to be a major constraint; the farmers had to procure seeds mainly from West Bengal and Andhra Pradesh at high cost including air freight. Adjacent users of water from village ponds mainly for agriculture during summer cause shortage of water and mostly lead to high turbidity. Social problem such as acceptance of the fish farmers in the community due to either the type of occupation or verbal teasing is also one among the constraints. The farmers opined that proper guidance and encouragement coupled with training and demonstration would help in improving the farming methods and their risk-taking ability. Lack of proper watch and ward causes huge poaching of the cultured species by the local people there by resulting in huge losses. With regard to the culture of carps in cages, they expressed their view that pangasius grew better than carps in confined environment such as cages.

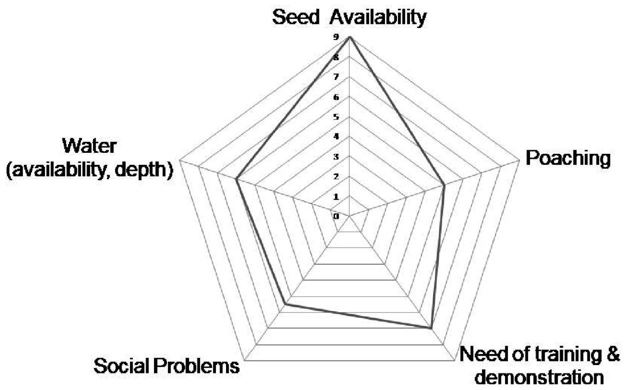

Fig. 1. Constraints faced by fish farmers in adopting new technologies

The present findings recommend utilization of water resources like undrainable village ponds by adopting an integrated model with little management rather than extensive farming. Proper counselling and providing training to farmers would improve the output from such undrainable ponds. Due to difficulty in management and considering the adverse environmental effect it may bring, high level of intensification may not be desirable. Cage culture is an effective technology for intensification as well as maximum use of water resource.

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