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A case study of integrated fish farming in Uttar Pradesh, India: Profitability and Sustainability

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Abstract: Integrated fish farming (IFF) is a sustainable-agriculture technology practiced widely in Asia including India. Amongst all states, Uttar Pradesh is highly rich in fishery resources and fish culture activities. Today many innovative techniques are being practiced for enhancing fish production. Intergraded fish culture is one of them and it is an environment friendly technique to make fish culture in modern mode. In the present study, we have investigated that production and economic viability increases if fish culture is integrated with other live stocks such as prawn farming, and duck keeping. This study on integrated fish farming demonstrated that fish culture along with prawn and duck is economically profitable and fetches high benefits and returns.

Key words: Integrated fish culture, Freshwater, Prawn, Aquaculture, Livestock

Introduction

Fish culture in combination with agriculture or livestock is a unique and beneficial mission and provides a higher farm income, makes available a cheap source of protein for the rural population (Ahmed and Garnett, 2010), increases productivity on small land-holdings and increases the supply of feeds for the farm livestock (ADB, 2005). Fish farming can be combined with agriculture, animal husbandry and irrigation practices which can lead to a better utilization of local resources and ultimately to higher production and net profits. An integrated farming system consists of a range of resource-saving practices that aim to achieve acceptable profits and sustained production levels, while minimizing the negative effects of intensive farming and preserving the environment (Ahmed and Garnett, 2010). Integrated fish farming (IFF) is a sustainable-agriculture technology practiced widely in Asia including India and other regions of the world (Ahmed and Garnett, 2010, 2011). IFF systems typically involve a combination of fish polyculture and integration of agricultural production (livestock and/or crops) with aquaculture, and on-farm waste recycling. Integrated farming is the recycling of animal wastes (faeces, urine and spoiled feeds) to serve as fertilizers, and sometimes as food for raising fish in ponds, enclosures and cages.

Livestock-fish system includes cattle-fish system, pig-fish system, poultry-fish system, duck-fish system, goat-fish system, rabbit-fish system. In this practice, excreta of ducks, chicks, pigs and cattle are either recycled for use by fish or serve as direct food for fish. Hence, the expenditure towards chemical fertilisers and supplementary feeds for fish culture is not only curtailed to the barest minimum but also there is economy of space. Use of wastes in static water fishponds imposes limitations in terms of both species and intensity of culture. Stimulation of natural food webs in the pond by organic wastes can support relatively low densities of herbivorous and omnivorous fish but not a large biomass of carnivorous fish. Livestock-fish production has been mostly adopted by livestock entrepreneurs, often in peri-urban areas, rather than the rural poor. Although several studies have shown that better-off households tend to have more livestock and are more likely to be fish producers (Edwards, 1983; Ahmed *et al*., 1993). Integration can also benefit a range of people. Benefits from livestock-fish integration can be viewed from different levels principally those of producers, intermediaries and consumers. Livestock processing can also provide a wide variety of wastes that vary from dilute washing water to high value meat and blood meal that can be used as fish feeds or feed ingredients (Singh and Mishra, 2001). If enough of these types of feeds are available, high density and intensive production of carnivorous fish species can be supported (Singh and Mishra, 2001). Aquaculture may also provide inputs and other benefits to livestock production. A variety of aquatic plants *e.g.* duckweeds and the aquatic fern Azolla have proven potential as livestock feeds; and invertebrates such as snails and crustaceans can be used for poultry feeds (Kunda *et al.*, 2008).

In an integrated system, livestock and crops are produced within a coordinated framework. The waste products of one component serve as a resource for the other. For example, manure is used to enhance crop production; crop residues and by-products feed the animals, supplementing often inadequate feed supplies, thus contributing to improved animal nutrition and productivity. In integrated fish farming, available water, land, and pond silt can be fully used to increase food supply (Goswami *et al*, 2004). Creation of a micro-ecosystem that recycles resources, reducing organic pollution - for example, livestock and poultry manure are good organic fertilizers for fish farming; pond silt can be used as fertilizer for fodder crops, which can in turn be used to feed livestock, poultry, or fish.

Under this prospective, a case study was undertaken to clinch the benefits of polyculture of carps and prawn integrated with ducklings in a village pond. The production and the additional benefits of such integrated fish farming in rural areas of Varanasi division of Uttar Pradesh have been assessed and the results are presented in this paper highlighting the prospects of such farming.

Fig. 1: Location of the fish pond where study was undertaken

Materials and Methods

This study was conducted in the Ghazipur district of Uttar Pradesh under the Varanasi Division of Fisheries Department. The location of the area where the work was carried out is shown as Fig. 1.

In this study, fish culture fish farm of northern region (Uttar Pradesh) of India was taken for intergraded aquaculture. The water area of the fish pond was 0.91 ha. The fingerlings of Indian major carps *Catla catla*, *Labeo rohita*, and *Cirrihinus mrigala* and exotic carps *Hypopthalmiicthys molitrix, Ctenopharyngodon idella, Cyprinus carpio* (10-12cm size) was stocked @ 10,000/ha. In addition, 15,000-40,000 post larvae of *Macrobrachium rosenbergii* collected from West Bengal was stocked in the same pond. A 100-350 number of ducklings (khakhi Campbell) procured from Hissergatta, Bangaluru were allowed to plunder into the pond.

The annual growth of fish species in terms of wet weight was generated and total biomass was calculated. In additions, expenditure on the feed, cost of fingerlings and ducklings was also raised to calculate over-all economical return of the fish polyculture integrated with ducklings. The gross income obtained after the sale of fish, eggs and ducks were calculated to find out net income.

Results and Discussion

Most of the fresh water resources available in the villages of Varanasi district of Uttar Pradesh were found untapped. Majority of the farmers were unaware of scientific techniques of aquaculture. Polyculture of carps under organic farming were carried out and the growth of fishes revealed that silver carp (*Hypopthalmiicthys molitrix*), grass carp (*Ctenopharyngodon idella*), catla (*Catla catla*), common carp (*Cyprinus carpio*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) attained average weight of 900, 850, 450, 750, 400 and 750g per year respectively. The productivity of the stocked fish fingerlings (at rate of 10 thousand/ ha) was observed to be 2.85 – 3.165 t $ha^{-1}yr^{-1}$.

Mustard oil cake and rice bran were the supplementary feed given to carps whereas banana leaves, wild grasses and berseem were used for feeding grass carp. Fish ponds in the villages were found to remain infested with aquatic weeds like hydrilla, eichhornia, azolla and potamogeton.

A model of duck-fish farming, in the ponds was developed to enhance productivity of land and water through multiple uses of water (Fig. 2). System of polyculture was followed where Khaki Campbell ducklings were stocked @ 76 – 330 No./ha of water area. Ducks started laying eggs at the age of 24 – 26 weeks. The total egg production was 780 – 2150 eggs ha^{-1}. Average weight of eggs was 64 g after 90 days. The fish yield varied from 3 - 5 t/ha in pond and about 2 t/ ha in Trenches. Polyculture of prawn -cum- fish in ponds was observed where we obtained production of 0.31- 0.32 t ha^{-1} of prawn and 3.28 – 3.16 t ha^{-1} of fish. The economics and return was worked out for different combinations of fish with prawn and ducks. The details are presented in Table 1,2.

Fisheries play a very important role in the socio-economic development of the country (Ayyappan, 2011). In recent years, a significant increase has been seen in fish production in the country. India is now the third largest producer of fish and second largest producer of fresh water fish in the world (Ayyappan, 2011). In addition to the high nutritional values of fish, prawn and shrimp also contribute as 20 to 22% of animal protein having less cholesterol with essential amino acids and minerals that are important to humans.

Both livestock and fish production can have better impacts if production systems can be integrated. Benefits are likely to be more equitable and ecologically benign. Benefits of productive integrated livestock-fish accrue to producers, consumers and society in general (Ahmed and Garnett, 2011). The livestock revolution is stretching the capacity of existing production, but it is also exacerbating environmental problems. Diversified systems consist of components such as crops and livestock that coexist independently from each other. In this case, integrating crops and livestock serves primarily to minimize risk and not to recycle resources (ADB, 2005). In an integrated system, crops and livestock interact to create a synergy, with recycling allowing the maximum use of available resources. Crop residues can be used for

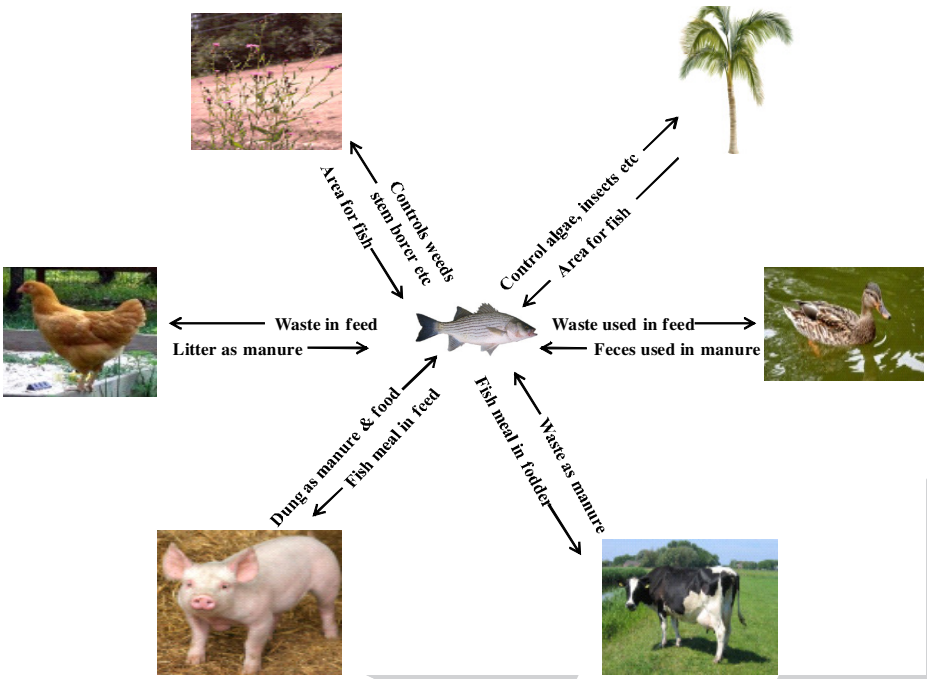

Fig: 2: Integrated fish farming with poultry, piggery, horticulture and dairy

Table - 1: Economical returns from integrating fish culture with prawn

	Year 2003-04	
1.	Expenditure	Rs(₹)
	a. Cost of seed of fish and prawn	2,140
	b. Expenses on the feed and harvesting	26,660
	Total Expenditure	28,800
2.	Income	
	a. from sale of 3025 kg fish@38	1,14,950
	b. from sale of 14.32 kg prawn @270	3,866
	Total income	1,18,816
3.	**Net income**	**90,016**
	Year 2004-05	
1.	Expenditure	Rs. (₹)
	a. Cost of seed of fish and prawn	18,850
	b. Expenses on the feed and harvesting	27,660
	Total Expenditure	46,510
2.	Income	
	a. from sale of 3280 Kg fish@40	1,31,200
b.	from sale of 310 Kg prawn @230	71,300
	Total income	2, 02,500
3.	**Net income**	**1,55,990**
	Year 2005-06	
1.	Expenditure	Rs.(₹)
	a. Cost of seed of fish and prawn	40,850
	b. Expenses on the feed and harvesting	29,000
	Total Expenditure	69,850
2.	Income	
	a. from sale of 3165 kg fish@40	1,26,600
	b. from sale of 320 kg prawn @230	73,600
	Total income	2,00,200
3.	**Net income**	**1,30,350**

Table - 2: Economical return from integrating fish culture with ducks

	Year 2004-05	
1.	Expenditure	Rs(₹)
	a. Cost of chicks	1900
	b. Cost of fish seed	850
	c. Cost of feed	27760
	Total expenditure	30510
2.	Income	
	a. Sell of 3280 Kg fish @40	131200
	b. Sell of 780 eggs @1.50	1170
	c. Sell of 300 chicks @16	4800
	Total Income	137170
3.	**Net income**	**106660**
	Year 2005-06	
1.	Expenditure	Rs(₹)
	a. Cost of chicks	nil
	b. Cost of fish seeds	850
	c. Cost of feed	29500
	Total expenditure	30350
2.	Income	
	a. Sell of 3280 kg fish @40	126600
	b. Sell of 780 eggs @1.50	3225
	c. Sell of 300 chicks @16	24000
	d. Sell of 250 duck @ 125	31250
	Total Income	185075
3.	**Net income**	**154725**

animal feed, while livestock and livestock by-product production and processing can enhance agricultural productivity by intensifying nutrients that improve soil fertility, reducing the use of chemical fertilizers (Ahmed and Garnett, 2010). A high integration of crops and livestock is often considered as a step forward, but small farmers need to have

sufficient access to knowledge, assets and inputs to manage this system in a way that is economically and environmentally sustainable over long term. Therefore, it is necessary to satisfy consumers' demand, improving availability of nutritional food and direct income opportunities, besides alleviating environmental stress (ADB, 2005).

The duck droppings has been found to containing 25 percent organic and 20 percent of inorganic substances, with a number of elements like carbon, phosphorus, potassium, nitrogen, calcium, etc. Ducks were stored in the warehouses, at a rate of 15 to 20/m^2. About 15-20 days old ducklings are generally selected. The number of ducks can be between 100 and 3,000 / ha depending on the duration of farming and manure requirements. The rearing period of fish is generally one year and low population density of 20,000 / hectares. Fish production 3000-4000 kg / ha / year was obtained in the culture of fish with duck. Besides that, eggs and duck meat are also obtained in good amount on annual basis. About 300 ducks are sufficient to fertilize a pond of one hectare. The system resulted in a net income of R. 77,500 / - per year per hectare. However, due to the difficulty in marketing of eggs and duck meat, the system is not very common in the Varanasi division of the state of Uttar Pradesh.

According to Billard *et al*. (1990), the amount of organic matter which can be recycled in ponds as fertilizers is up to 5g C m^2d^{-1}, corresponding to 100 kg of dry manure ha^{-1} d^{-1} and the expected production in polyculture (common carp and silver carp) may reach 30 kg ha^{-1} d^{-1} without feeding the fish. Such a yield is much higher than classical animal production on land. According to Pillay (1980), the basic principles involved in integrated farming are the utilization of the synergetic effects of inter-related farm activities, and the conservation, including the full utilization, of farm are wastes. It is based on the concept that "there is no waste", and "waste is only a misplaced resource which can become a valuable material for another product" (FAO, 1977).

M. rosenbergii can grow (an average of 600 kg ha^{-1}) in waters of 15 g L^{-1} and therefore has been found an appropriate species for cultivation (Jain and Diwan, 2002). Polyculture of freshwater prawns with carps has been practiced although it performs well in monoculture (Nandeesha, 2003). Although hatchery seed is now available in plenty, its quality is variable. Selvaraj and Kumar (2003) predicted that production of freshwater prawn in India could rise to 50 000 tonnes by 2010 provided quality seed is made available to the farmers. Polyculture of freshwater prawns with other species continues to attract the interest of the farmers. This study showed that this form of polyculture of carps, prawn and ducks has the potential to maintain the performance of fish production at levels significantly high (2,942 kg ha^{-1} and 2,769 kg ha^{-1} in polyculture) with similar average final weight. However, 1367 kg ha^{-1} has been reported in shrimp monoculture and the figure dropped to 951 kg ha^{-1} in polyculture (ADB, 2005). Moreover, the average weight of shrimp was significantly different (55 g in monoculture and 31g in polyculture). It would be interesting to compare the results of these two different productions.

Kurup and Ranjeet (2002) surveyed 122 farms in 1998-2001 in Kuttanad, India (the 'rice bowl' of Kerala), 75 polders used for growing *M. rosenbergii*, alternating with rice. Twenty farms practicing monoculture and 55 polyculture with shrimp grew major Indian carp and catla (*Catla catla*) and rohu (*Labeo rohita*), and grass carp (*Ctenopharyngodon idella*). These authors reported yields of 95 to 1297 kg ha^{-1} of prawns in monoculture, compared with 70 to 493 kg ha^{-1} shrimp and from 200-1200 kg ha^{-1} of fish in polyculture. Income generation indicates that the monoculture was generally more convenient than the polyculture but the economical returns in case of polyculture are more attractive. It is thus concluded that the freshwater prawn culture is a useful way to increase income and employment. Kurup, Ranjeet and Hari (2002) provide further information to confirm this issue, describing it as a form of "eco-friendly" aquaculture.

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