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SURVEY ON THE POTENTIALITIES OF INTEGRATED FISH FARMING, ITS ECONOMIC AND MAJOR CONSTRAINTS FACED BY THE MARGINAL AND SMALL FARMERS IN SINGRAULI, MADHYA PRADESH, INDIA

Vishal Kumar, Ranjit Shaw and Radha Chaube*

Department of Zoology, Institute of Science
Banaras Hindu University, Varanasi (Uttar Pradesh), India.

**Corresponding author*: chauberadha@rediffmail.com

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Abstract: Increase in human population, poor economic conditions of the farmers and the increasing demand for fish, have compelled the planners, in the recent past, to adopt Integrated Fish Farming systems (IFFs) in South East Asian countries including India. IFFs refer to the production, integrated management, and comprehensive use of aquaculture, agriculture, and livestock, with an emphasis on aquaculture. Since the IFF system involves lower cost and is environment friendly, it is economically sustainable and is being freely adopted. The aim of this study was therefore to investigate the economic importance of IFFs. In this study, different culture practice sites in the Singrauli district of Madhya Pradesh in India were selected and a survey was conducted among the farmers with the help of a prepared questionnaire. This study was conducted in order to explore the various parameters to evaluate the potential of IFFs. Results of the assessment showed a significant potency of this integrated system in increasing the yield for the farmers. Additionally, the plausible major constraints faced by the marginal and small farmers are outlined here, to advocate for the ways to eliminate them for generating more income from this integrated system of farming.

Keywords: Aquaculture, Economic constraint, Integrated fish farming, Marginal farmers.

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INTRODUCTION

In the last decade, aquaculture has been the fastest-growing food production sector (Gjedrem and Baranski, 2009). For decades, Asia has been the epicentre of aquaculture production, with Asian countries accounting for more than 90% of overall aquaculture production, with China being the world's largest producer (Gangadhara *et al.,* 2016). In India, inland water in the form of ponds, lakes, and tanks with potentialities of fish culture is approximately 2.34% of the total area of the country. Many of the water reservoirs remain either unused or not properly used for fish culture due to the lack of adequate scientific know-how. Aquaculture holds a significant position in the agricultural economy (Hu *et al.,* 2020). As per the demand, the commercial fish farming business allows for large supplies of fish (Gjedrem and

Baranski, 2009). Catching fish from the wild cannot always fulfil the demand of consumers hence in such cases commercial fish farming can meet up this demand. One can easily raise the fishes in tanks until they are ready for selling or marketing and they don't need the wide capture of wild fish. Farmed fish will become an even more important source of protein foods in the future than they are now. Therefore, commercial fish farming helps in preserving natural ecosystems (Abdelrahman *et al.,* 2017).

Small and marginal farmers account for 82 percent of farmers in India, with an acreage of less than 2 hectares. Farmers have a critical part to contribute in the Indian economy. Monocropping is practised by the majority of these farmers. Monoculturing (non-integrated system) yielded discouraging results, prompting the development of an integrated farming system (IFS) method that provides appropriate revenue, employment, nutritional security, and is environmentally sustainable (Kiran Reddy *et al.,* 2020).

Integrated fish farming (IFF) incorporates two or more than two production technologies running simultaneously on a parallel footing to boost each other's farming (Petersen *et al.,* 2002). These results to increase the total productivity, additional employment, reduced investment in fish farming, enhanced efficiency in resource utilization, and reduced risk through diversification of crops (Kumaresan *et al.,* 2009; Ayyappan *et al.,* 2006). It is imperative that fish production per unit area has to be increased to minimize the effective cost and thereby mitigate the world's 'protein-hunger' especially that of the developing countries. One such means has been adopted in which a combination of some form of animal husbandry with fish farming has been successfully employed. It is economically viable and profitable, environmentally suitable, and benefit giver of the diversification of production (Panwar *et al.,* 2018; Hildingstam, 1977), as being represented in figure 1.

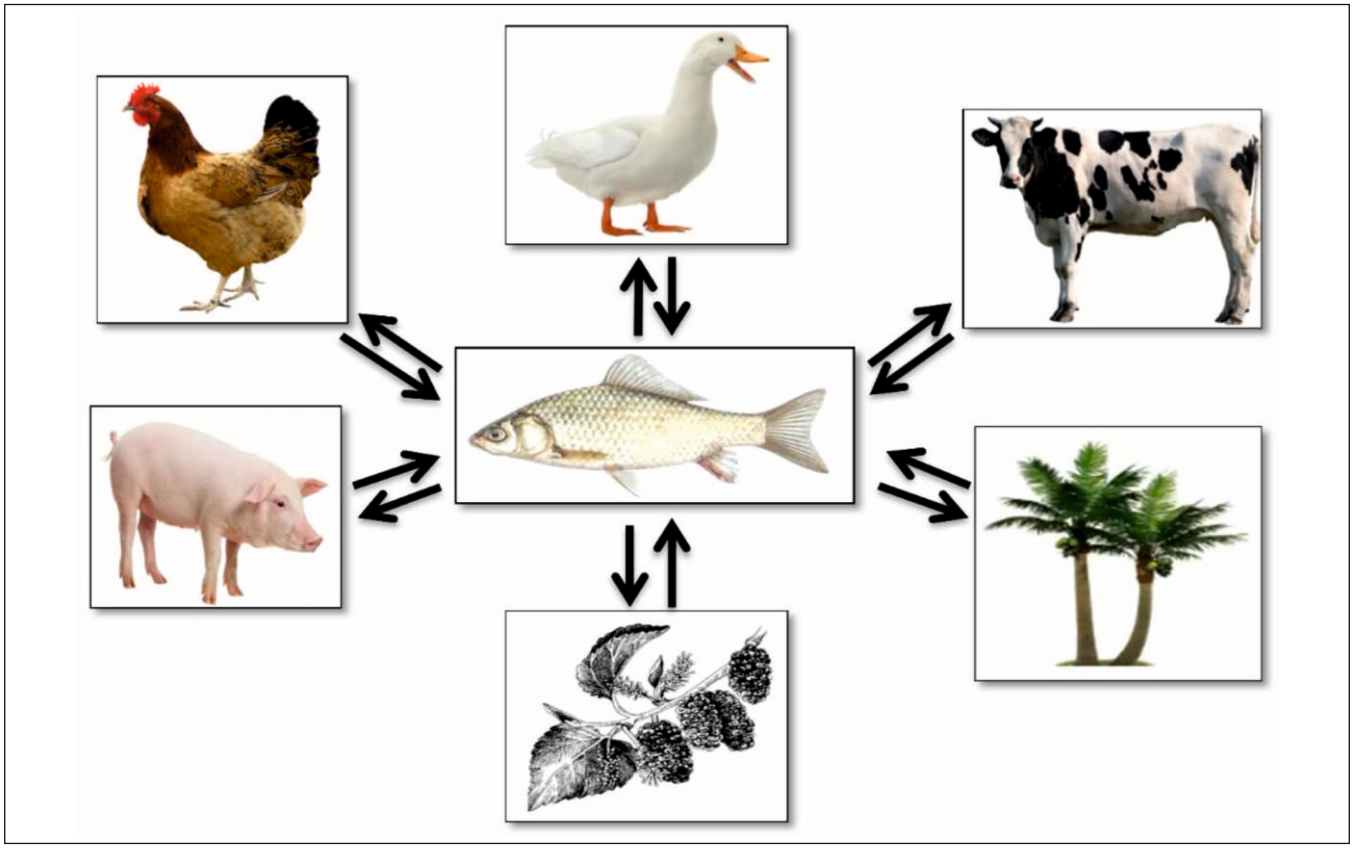

Fig.1: **Diagrammatic representation of Integrated Fish Farming (IFF) which includes fish culture unit, livestock, poultry, horticulture, sericulture system, etc. The logical integration of different farming systems maximizes the use of land and the recycling of wastes and by-products, reduces feed and fertilizer costs, and sustains a balanced ecosystem.**

In general, the IFF systems can be categorized into two principal groups: aquaculture-agriculture integration, and aquaculture-livestock integration.

In aquaculture-agriculture integration, following farming are practiced:

a) Rice-fish integrated farming
b) Rice-azolla-fish integration
c) Fodder-cattle-fish integration
d) Horticultural-crop-fish integration, and
e) Mulberry-silkworm-fish integration.

In aquaculture-livestock integration, following farming are practiced:

a) Fish-duck, integrated farming
b) Fish-cattle, integrated farming
c) Fish-poultry, integrated farming
d) Fish-pig, integrated farming
e) Fish-goat/sheep, integrated farming.

When compared to the wild fishes, some of the farm-raised fish species are healthier and more delicious (Segner *et al.,* 2012). Fishes are generally fed a wide variety of nutrient and protein-enriched foods or pellets on commercial fish farms. Thus, farm fish become healthier than wild fish (Segner *et al.,* 2012). There are indeed various types of fish species all over the world. So, desired species can be selected for fish farming business. For these groups of rural folks in India, cattle raising is a way of life and the application of cattle manure for fertilizing fish ponds is an ancient practice (Singh *et al.,* 2012). Consequently, fish dairy integrated farming is easily adopted by farmers.

In recent years, food security, livelihood security, water security as well as natural resources conservation and environment protection have emerged as major issues worldwide; developing countries are struggling to deal with these issues and also have to contend with the multiple burden of climate change, anthropogenic activities, biodiversity threats and globalization (Portner and Peck, 2010; Kao *et al.,* 2020; Ng'onga *et al.,* 2019; Prakash and Verma, 2022). It is acceptable across the globe that sustainable development is the only way to promote rational utilization of resources and environmental protection without hampering economic growth (Ashok, 2021). Developing countries around the world are promoting sustainable development through sustainable agricultural practices, which will help them in addressing socio-economic as well as environmental issues simultaneously (Cooke *et al.,* 2016).

The harmonic connections between socio-economic conditions, agricultural production, and regional environmental conditions are necessary for the development of a diversified economy (Gebru, 2021). Within the broad concept of sustainable agriculture 'Integrated Farming Systems' hold a special position as in this system nothing is wasted, the by-product of one system becomes the input for other (Srinivasan, 2017). Integrated farming is an integrated approach to farming as compared to existing monoculture approaches (Ayyappan *et al.,* 2006). It refers to agricultural systems that integrate livestock and crop production (Othman, 2004).

Moreover, the system helps poor small farmers, who have very small landholding for crop production and a few heads of livestock to diversify farm production, increase cash income, improve quality and quantity of food produced, and exploitation of unutilized resources (Lauria *et al.,* 2018). Adopting new methodologies, good risk animal husbandry practices, current and innovative farming techniques in animal husbandry practices, as well as Integrated Farming systems in animal husbandry practices, can help livestock farmers boost their income (Shukla *et al.,* 2020). Two of the famous types of IFFs *i.e.*, Cattle cum fish farming and Poultry cum fish farming are represented in figures 2 and 3 respectively. Considering the relevance of IFF in the livelihood of every segment of the Indian population in the provision of food, employment opportunities, and recirculation of waste for maximum utilization, this paper outlines the importance, along with the economic benefits of integrated fish farming.

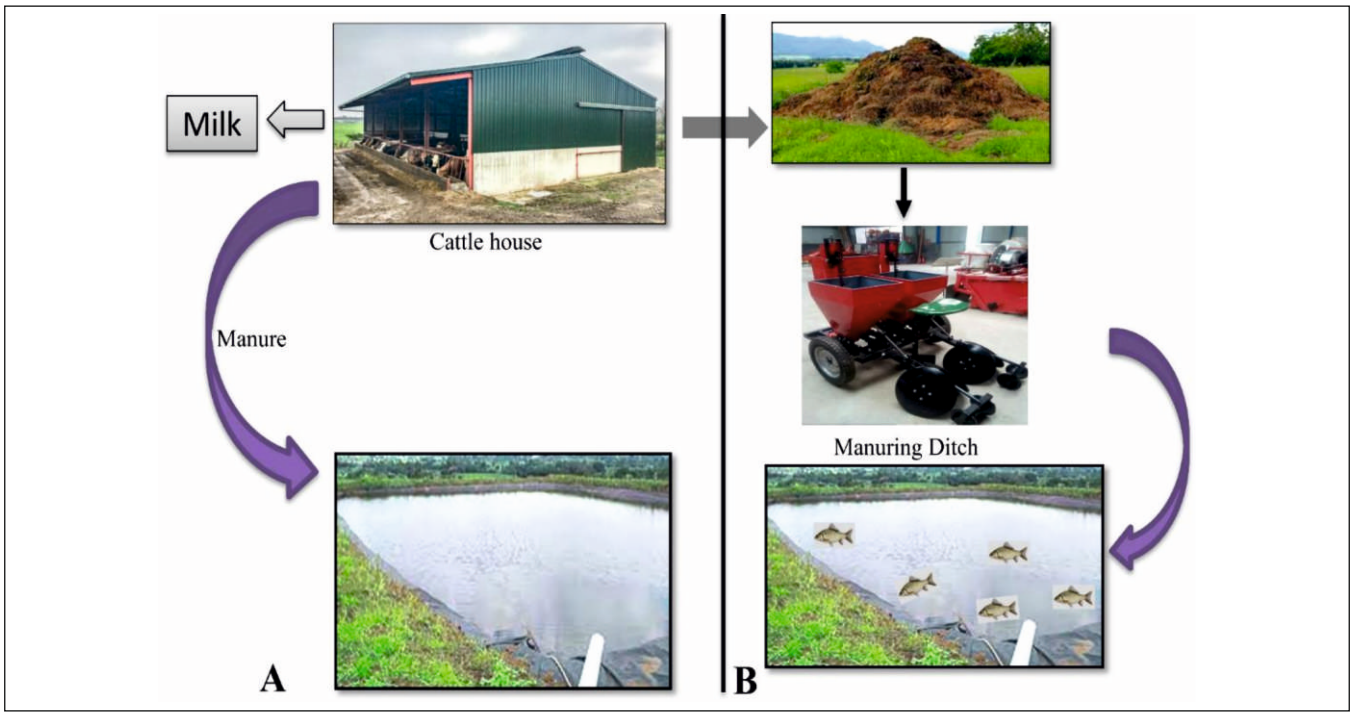

Fig. 2: Cattle cum fish farming. A) Cattle are reared on pond banks for milk and dung (serve as manure for ponds), and their waste is drained straight into the pond. The expense of fish farming is cut in half with this approach; B) The cowshed is built near the ponds to facilitate cow dung processing easier. The cows' faeces and urine together are collected in a manuring ditch.

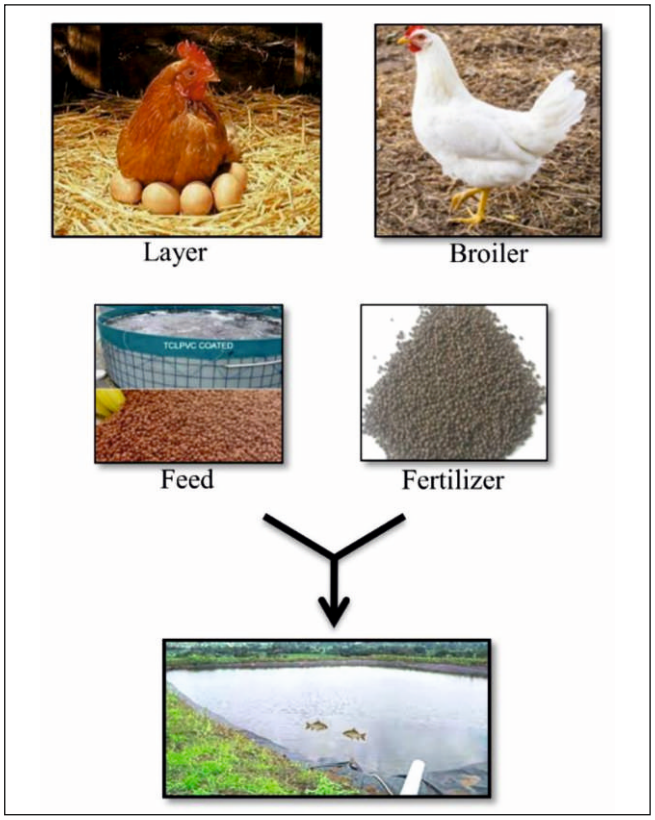

Fig. 3: Poultry cum fish farming. Poultry production for meat (broilers) or eggs integrates well with fish farming, lowering fertilizer and additional feed costs.

MATERIALS AND METHODS

An investigation was carried out on integrated fish farms of Singrauli district of Madhya Pradesh in India, as shown in figure 4. The two fish farms Chitrangi farm and Rampur farm were selected for the survey. The layout of the three farms is shown in figure 5. The survey was conducted using a prepared questionnaire and interviewed with the fishermen. Informed consent was obtained from all the interviewees. Digital tablets and smart phones were used to record data, to collect spatial information on the farm location, and to take photographs of the farms and their components. This investigation was carried out during the year 2021. The questionnaire was developed based on several survey studies performed earlier (Chowdhury *et al.,* 2021).

RESULTS AND DISCUSSION

The most common aquaculture species (presented in table 1) observed in most of the farms were Indian Major Carps (IMCs). Additionally, exotic carps such as common carp, grass carp, and silver carp were farmed in the fish farms and other Cat fish species (Magur and Pangasius) were grown too. The weight at harvest of fish was 500-1000 g (average wt. 800 g).

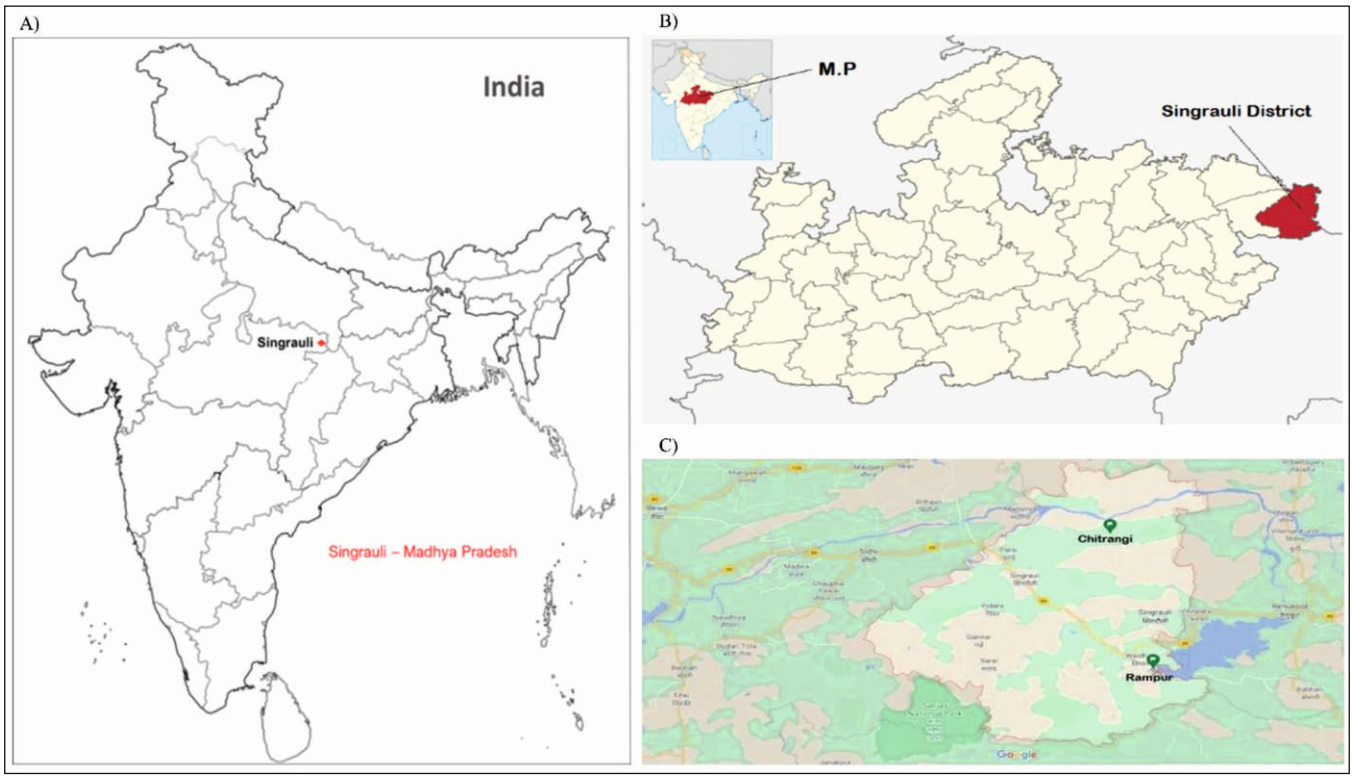

Fig. 4: A) & B) shows the Political map of India and the state of Madhya Pradesh showing the location of Singrauli district respectively; C) represents the map of Singrauli district, showing the two farms surveyed (marked in green tag- Chitrangi farm and Rampur farm).

Fig. 5: Layout of the three fish farms at Singrauli district of Madhya Pradesh. A) Chitrangi's cattle cum fish farm site; B) Chitrangi's poultry cum fish farm site; C) Rampur's poultry cum fish farm site.

The table 2 presents the comparison of the types and quantity of fish species produced from two different types of fish farming systems i.e., Cattle cum fish farming system and the Poultry cum fish farming system.

The table 3 presents a comparative economic evaluation of the different types of integrated fish farming. Additionally, table 4 shows the total expenditure, total income, and net profit (Rupee) by the farmers in the three surveys.

The surveys conducted at different locations of the Singrauli district of Madhya Pradesh showed that a sufficient number of people are dependent on the integrated fish farming system for their livelihood. In addition to this, women's participation was also observed in the work, supporting her family. The farmers who were involved in this beneficial way of farming earned revenues from various sources, which encompassed different commodities, being generated from the dairy, fishery, and poultry

Table 1: List of types of fish species farmed in the cattle and poultry cum fish farming in Singrauli district of Madhya Pradesh.

Sl. No.	Common Name	Scientific Name
	Indian Major Carps (IMCs)	
I.	Catla	*Catla catla*
II.	Rohu	*Labeo rohita*
III.	Mrigal	*Cirrhinus mrigala*
	Exotic Carps	
I.	Common Carp	*Cyprinus carpio*
II.	Grass Carp	*Ctenopharyngodon idella*
III.	Silver Carp	*Hypopthalmichthys molitrix*
	Cat Fishes	
I.	Magur	*Clarias batrachus*
II.	Pungas	*Pangasius pangasius*

Table 2: List of fish species produced, along with their individual quantities in two different fish farming systems.

Names of fish species harvested	Quantity harvested (Kg/Acre/Year)	
	Cattle cum Fish Farming System	Poultry cum Fish Farming System
Rohu	375	440
Catla	450	500
Mrigal	270	250
Common Carp	420	512
Grass Carp	270	135
Silver carp	500	390
Pangasius	500	413
Magur	90	375
Total	**2875**	**3015**

units of the farm. A plethora of fish species were produced on the farms as represented in the table 2. The comparison of the types and quantity (weight in kg/acre/year) of fish species produced from two different types of fish farming systems *i.e.*, the Cattle cum fish farming system and the Poultry cum fish farming system are represented in figure 7. The graph clearly shows that different quantities of fish species were harvested from two different fish farms. Additionally, it is clear that some fish species are harvested in large quantities in one type of farm than the other, for instance, 375 kg/acre/year of Magur was harvested from the poultry cum fish farm whereas only 90 kg/acre/year of Magur was harvested from the cattle cum fish farm.

Table 3: Cost-benefit Analysis of the three surveys.

Items		First survey (Cattle cum fish culture)	Second survey (Poultry cum fish culture)	Third survey (Poultry cum fish culture)
		Amount in INR	Amount in INR	Amount in INR
A)	**Components of Expenditure**			
a)	Construction cost of Pond, Water Supply Channel, Installation of Tube well/Renovation/Lease Amount	30,000	28,000	40,000
b)	Electricity and Water Charges	17,500	30,000	60,000
c)	Cost Price of 2,000 (in first survey) and 3000 (in second and third survey) Fish Seeds*	3,000	6,000	6,000
d)	Construction cost of Shed for Cattle Animals (Rs.1,50,000/- for 10 years), poultry sheds (Rs. 1,00,000/- for 10 years in second survey and Rs. 1,50,000/- for 10 years in third survey)	15,000	10,000	15,000
e)	Purchase price of 5 Jersey Cows (Rs.80,000/- for 5 years), 300 chicks in second survey and 550 chicks in third survey	16,000	6,000	8,500
f)	Cost of 18,000 kg feed for Cattle animals, 10,000 kg Poultry feed in second survey, and 13,000 kg Poultry feed in the third survey*	2,36,000	1,00,000	1,30,000
g)	Medicine charges for Animals & Fishes	10,000	10,000	10,000
h)	Labour Charges	40,000	10,000	40,000
	Total Expenditure	**3,67,500***	**2,00,000***	**3,09,500***
B)	**Components of Income**			
a)	Selling price of Fish @Rs. 80/Kg*	2,40,000	1,76,000	1,75,000
b)	Selling price of Milk @Rs. 60/litre, Eggs @Rs. 6/piece in second survey and Eggs @ ~Rs. 3.5/piece in third survey*	6,00,000	1,00,728	4,15,625
c)	Selling price of young ones of cows /meat of poultry bird (200 kg and 500 kg in second and third survey respectively)	45,000	16,000	55,000
	Total Income	**8,85,000***	**2,92,728***	**6,45,625***
C)	**Net Profit** [Total Income (B) – Total Expenditure (A)]	**5,17,500***	**90,000***	**3,36,125***

[*Note: - The amount may vary depending on the productivity and market price of a pond and cattle/poultry inputs or by-products].

Also, different sources of water such as groundwater, rainwater, and reservoir water were utilized in the farming systems. Various sorts of feeds were supplied into the pond to feed the fishes such as kitchen scraps, groundnut oil cake, etc. Most of the farms used fishing nets, hooks,

Table 4: Analysis of the total expenditure, total income and net profit (Rupees) by the farmers in the three surveys:

	Survey-1	Survey-2	Survey-3
Total Expenditure	3,67,500	2,00,000	3,09,500
Total Income	8,85,000	2,92,728	6,45,625
Net Profit	5,17,500	90,000	3,36,125

and mosquito nets to harvest the fish. Thus, some farms did partial harvests, i.e., harvested only part of the fish in the ponds each time, while most of the farms harvested all the fish from the pond. On surveying, it was evident that the farmers attempted to manage all the works of the farm by themselves along with their family members and occasionally used to hire staff in the farm.

Most importantly, the quantity of harvest was extremely huge, which contributed to generating a lump amount of profit annually. The majority of the harvest, whether it was fish, meat, eggs, milk, or other products, was used for commercial purposes, with a tiny percentage used for personal consumption. Unlike in the past, when farmers were not aware of beneficial harvesting methods, various strategies to increase yield/output, and helpful harvesting methods, this survey revealed that at least two of the farms received technical assistance and specialist advice from the district administration and fisheries department when starting and running the farm. Fewer farms received technical assistance from the Central Institute of Freshwater Aquaculture (CIFA) and Kishan Vigyan Kendra, Local Successful Fish Farmers, and neighbouring farmers. The major constraints faced by the farmers was also found and noted, in the hopes of eliminating them. Some issues were consistent across the three surveys, such as predatory birds, losses due to theft, a lack of assistance and resources for pond construction, and poor water quality. Farmers did not follow appropriate feeding strategies due to a lack of information, resulting in low primary and secondary production as a result, poor environmental management, fish diseases were also a concern.

Evaluation of the economies of the farms showed that various components of both expenditures, as well as incomes, were involved in the farming system. Construction of necessary units, purchases of farm's essential commodities, medicine charges, and labour charges incurred respective amounts of expenditures. Similarly, income was created from a variety of sources, including the sale of eggs, fish, animal meat, dairy animal milk, and young ones in the market. The data clearly showed that a sufficient and large amount of net profit (Rs. 5,17,500, Rs. 90,000 and Rs. 3,36,125 in the first, second and third farm respectively) was generated with the help of this integrated system. The first and third farms, as shown in figure 6, produced significant amounts of net profit annually. This could be due to the effective use of available resources as well as the application of beneficial technologies. Furthermore, both of them obtained technical support from the relevant authorities, for instance, District Fisheries Department and sought advice when beginning and operating the farms, resulting in higher net revenues (in lakh) than the second farm, which received no such assistance.

The basic principle involved in integrated farming is the utilization of the synergetic effects of inter-related farm activities and the conservation, aiding the full utilization of farm 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' (Soni *et al.,* 2014; Csavas, 1991). Beneficiaries from the integrated fish farming system can either be direct or indirect. The direct beneficiaries include dependents (family members) and indirect beneficiaries include buyers who buy fish from the ponds, neighbors, or even extended relatives. Nearly all the farmers in our survey had sources of income other than aquaculture, mainly in agriculture and livestock. Less than 10% of farmers also generated income from handicraft, coal production, and carpentry.

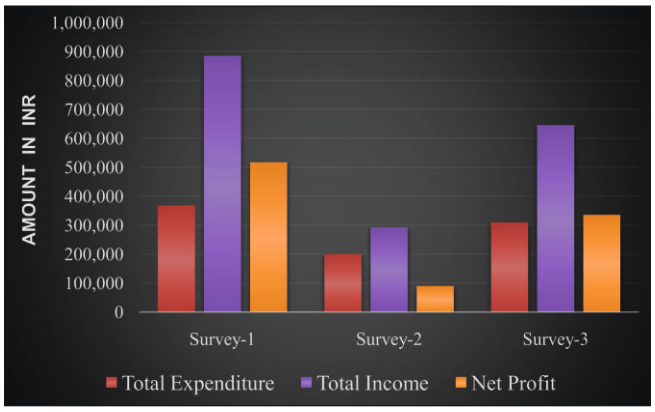

Fig.6: Cost-benefit analysis of the three surveys conducted at Singrauli district of Madhya Pradesh.

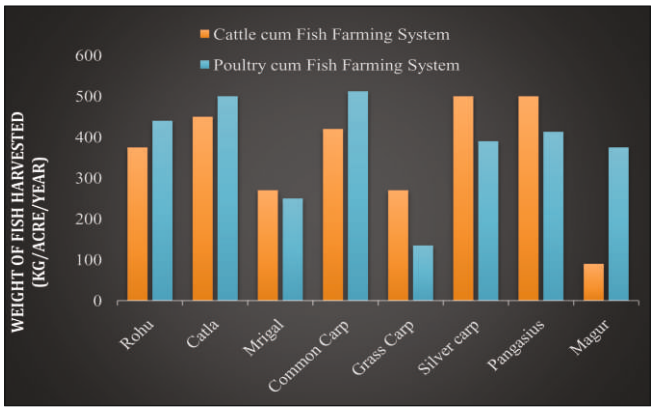

Fig. 7: Comparison of the types and weight of fish species (in kg/acre/year) produced from two different types of fish farming systems.

The most common supplementary feed supplied was rice bran, vegetables, and food scraps. Fewer farms used prepared feed. Other feed sources were primarily cattle manure and poultry manure. Most of the ponds were fertilized with manure.

Integrated fish cum poultry farming is practiced in many countries of the world more particularly in Asia. Poultry-fish farming combines the production of poultry animals such as chickens, ducks, and geese with the production of fish (Tokrisna,1995). Such integrated farming is not only an efficient way of recycling farm wastes (Gupta *et al.,* 2012) but also yields high economic returns (Gabriel *et al.,* 2007). The integration of aquaculture with poultry results in more efficient use of resources(Ramanathan *et al.,* 2020). The costs associated with pisciculture operation are reduced by approximately 70% when integrated with chicken. It is because fish farming recycles chicken wastes and spilled chicken feed as food and fertilizer for the fish (Panwar *et al.,* 2018). Consequently, supplemented food and fertilizer is hardly required and thus it is not provided.

Birds are reared to produce eggs and meat. Birds raised for meat are called broilers and that for eggs are called layers. Scientific poultry management aims at maximizing returns with minimum expenditure and minimum inputs (Gabriel *et al.,* 2007). Integration of fishes with poultry farming has several advantages. Integrated fish farming is an important part of integrated pest management as well (Berg, 2001; Halwart and Gupta, 2004). Fishes are important in the control of disease-carrying aquatic weeds and algae (van De *et al.,* 2012). Fish also consume flies, snails, and insects, which can aid in the control of mosquitoes that spread malaria and other water-borne infections (Matteson, 2003). The chicken houses constructed on ponds maximize the use of land needed for other purposes. Hygienic conditions are better in the chicken houses constructed over ponds, as the feces fall directly into the pond's water. Chicken excreta fertilize the pond and boost planktonic bloom (Tokrisna, 1995).

When all the data were included, the average yield in the fish farms was 2,200 kg/Acre. This is considerably a higher value for Composite Fish Culture where the expected yield is only up to 2,000 kg/Acre. Most of the fish farms produce less than 1500 kg/year and the average farm production is 900 kg/year. By collecting all the data from both Live-stock Fish Farming, it can be concluded that the harvested production in the integrated farming system was 2,200kg /Acre. This demonstrates the economic importance of an integrated fish farming system (Gabriel *et al.,* 2007). It is one of the most viable, reliable, and profitable farming systems available (Panwar *et al.,* 2018). It creates numerous job opportunities, reduces input, and boosts output, and thus improves economic efficiency (Chaubey *et al.,* 2018). This method has a significant potential for increasing productivity and improving the socio-economic condition of our society's weaker

sections (Panwar *et al.,* 2021). This effort makes a significant contribution to the economic empowerment of many families, particularly in rural areas (Soni *et al.,* 2014). It allows farmers to be productive all year long and fully maximize their output (Gabriel *et al.,* 2007). Its significance to improving food security and self-sufficiency is detailed in more detail here. Given the country's current economic condition, farmers must engage in a results-oriented farming system that will provide and sustain sufficient food security (Gurjar and Swami, 2019).

In India, protein food is somewhat expensive, a problem that must be addressed soon given the country's limited resources. IFF, as a food-production foundation that incorporates agricultural cultivation, livestock rearing, and fish farming, gives optimism in this direction (Garcia and Rosenberg, 2010). As a result, the scope of IFF can be rather broad (Gurjar and Swami, 2019). The fish farm not only provides enough fertilizer to create a huge number of fish, but it also produces meat, milk, eggs, vegetables, and other products by effectively exploiting the water body, water surface, land, and pond silt to enhance the amount of food accessible for human use. This method of farming also makes the farmers self-sufficient. Integration is appropriate for impoverished farmers who have a consistent low spending pattern for food and other dietary requirements (Ogello *et al.,* 2013). The diversified structure of an IFF makes more jobs available than in the unitary system of fish farming (Gebru, 2021).

Depending on the sort of integration used, the time is well utilized in other farming chores, making the system all-encompassing. Crops such as vegetables are reaped constantly even during the dry season in fish cum crop cultivation because water from the pond is used to sufficiently irrigate the fields. Farmers are involved in one or more farming activities throughout the year, making them self-sufficient and productive all year (Gabriel *et al.,* 2007). Thus, intelligent integration of different farming systems improves full land utilization and recycling of wastes and by-products, reduces feed and fertilizer operations costs, and maintains a balanced environment (Mynavathi and Jayanthi, 2015).

On surveying, it became evident that constraints in availing credit from formal sources for fish farming were compelling farmers to take loans from informal sources like money lenders at a very high rate of interest and to overcome this problem, various schemes are operated in India to help farmers out such as National Mission for Sustainable Agriculture (NMSA) which is based on Crop Based Integrated Farming System as well as a Livestock-based Integrated Farming Systems. However, the farmers need to be educated and made aware of all these beneficial schemes so that they can utilize the schemes to their benefit. Despite technological support, scientific fish farming has yet to be adopted widely. In India, village-level ponds are the mainstay of the aquaculture industry which is managed by people who are generally from the lowest strata of the rural community.

Out of several constraints, it was found that legal limitations are one of the major constraints that the farmers had to face. The majorities of fishermen do not own ponds and are pond-less. Little and marginal farmers own only small ponds if any at all. Because the huge ponds are controlled by state governments or panchayats and leased on a short-term basis, the lessee is unable to develop the water area due to tenurial insecurity. Multiple ownership, public easement rights, and other structural rigidities obstruct the development of private waters. Because of the short-term lease tenure, the leasing arrangements have often been devoid of development. The vast majority of water bodies, notably in eastern India, are privately held, with bipartite lease arrangements based on market forces. As a result, equivalent to agricultural lands, tenancy law is urgently needed (Saha and Paul, 2018).

The survey explored the major constraints that farmers might face in this integrated fish farming system, which should be a focus for future research so that new techniques can be devised to help farmers avoid losses. Last but not least, there are societal limits to consider. Poisoning with pesticides or weedicides for personal gain, as well as the unlawful removal of fish crops (poaching),

are serious productivity deterrents in the fish farming industry. This can most likely be addressed by raising public awareness about the issue and making the legislation of the nation more rigorous.

CONCLUSIONS

Fishery-based farming is beneficial in increasing income, employment opportunities and increasing food supply. Farmer can get fresh, nutritious, and balanced food for a healthy lifestyle. Promotion of this system acts as a climate-resilient technology, utilization of available organic matter and nutrients for the production of crops, and improvement in soil health for sustainability within the system. Implementation of an integrated farming system would ensure minimization of risk, recycling of wastes and residues, integration of profitable enterprises, optimum utilization of all resources, maximization of productivity, and profitability. Thus, IFF has initiated a new way towards the improvement of the financial condition of the farmers. Multicommodity integrated farming systems involving livestock farming and pisciculture maximize production through recycling of wastes, proper utilization of resources which yields higher returns to the farmers. There is also a need to generate awareness amongst the farmers, banking systems, as well as youth to promote the IFS and increase the availability of credit for the different farming components. There is also a need for the preparation of profitable bankable projects for the particular agro-climatic zone as per the market and need of small and marginal farmers. In terms of production choices, rates, and sizes, IFF differs from one area to the next. It is more economical than a unitary farming system since it spreads financial risk due to its various and diversified nature in fish, animal, and crop production. It can increase food availability, so improving food security, and generate more employment for the country's teeming unemployed.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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