Integrated fish-based farming system for North Eastern Region

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Introduction

Fish plays an important role in food and nutrition security by providing livelihood and income for millions of people in India. Currently, India is the second largest producer of fish in the world accounting for around 7.58% of the global fish production. However, as per the estimate, more than 80% of

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global aquaculture production, at present, may be contributed by small to medium–scale fish farmers, nearly 90% of whom live in Asia. These global aquaculture ventures are often family–based activities which are integrated at farm level with crop and livestock farming, where part of the production may be retained for household consumption. In India, small and marginal land holdings together constituted 86.08% of the total holdings (2015–16). Therefore, the future of sustainable agriculture growth and food security depends on the performance of small and marginal farmers. However, the poor economic conditions of these rural folks and lower average land holding in India (< 1.08 ha) prevent them from adopting large–scale and modern farming technologies. Moreover, the rural folk are under–nourished and need a large supplement of animal protein in their diet in addition to new sources of gainful employment.

Modern aquaculture technology certainly yields higher fish productivity (4–8t/ha) but it is also exclusively feed and technology–based which is out of reach from the economically weaker section. It has been found that feed alone accounts for about 60% of production cost and is also not readily available as and when required especially in the North Eastern (NE) region. However, in traditional fish production systems, the feed is generally not used, as a result, the productivity varies from 1.0 to 1.5 t /ha of water area only. Pond fertilization practices using animal wastes are widely used in many countries to sustain productivity at a low cost. In China, the Philippines and even in India, it has been observed that the application of livestock manure improves fish productivity through the production of plankton. In this regard, NE region is blessed with large diversity of livestock population and manure (dung) derived from these animals and birds which are mostly used in agriculture fields for energy–yielding purposes or discarded as such. As per the livestock census 2020, the NE region supports 4.5% of the livestock and 8.1% of poultry population of India. This means availability of livestock manure in plenty, which can be used extensively in animal–based integrated fish culture purposes. However, systematic analysis of the contributions of each component and identification of critical gaps in the production process and thereby improving the fish productivity from a unit area is limited. In the present land and water stress conditions as well as the climate change scenario, integrated farming system can be a better proposition. As per FAO (2000), the potential benefits of integrating aquaculture in smallholder farming systems include i) enhanced rural employment and income through additional or off–season production, ii) improved food security, iii) increased availability of high–value protein food, iv) decreased risk to the farmers through diversification, v) improved water availability and nutrient recycling, vi) environmental benefits through enhanced resource flows, and many others.

Integrated Fish Farming Systems

Integrated fish farming is a diversified and coordinated method of farming system, where agriculture, horticulture and animal husbandry are integrated along with the fish culture in order to achieve higher production and economic sustainability.

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The main objective of this farming system is to recycle wastes or by–products (faeces, urine and uneaten feeds) generated from one unit as inputs to fish culture in the form of fertilizer, feed etc. to achieve higher productivity and to reduce the cost of production. The integrated fish farming system can be grouped into two broad areas 1). Agriculture–based integrated farming and 2). Animal–based integrated farming system. At present average fish production in India is around 3.0 t/ha. There is ample scope to realize the synergistic role of livestock in various farming systems and thereby can achieve much higher productivity from livestock–based integrated fish farming.

As fish is the main component in the integration, special attention has to be given to their selection and stocking. In general, in a well–managed fish pond, stocking density can be maintained at 6000 – 8000 nos./ha (40% surface feeder, 30% bottom feeder, 20% column feeder, 10% grass carp). It is better to avoid excess stocking as this will not only decrease the growth rate of fish but also create stress for the fish and become susceptible to diseases. The stocking size of fish should be 10–15 cm in length. Yearling or stunted ones are always preferred in comparison with fresh seeds as they are relatively hardy. Besides, few important and desirable criteria for selection of species for integrated fish farming are mentioned below:

i. The selected species should be compatible with each other and fast growing.

ii. The species and their combined ratio should be adjusted according to the amount of feedstuff

and manure expected to be made available by the other sub-system.

iii. Selected fish should be hardy and resistant to common diseases and parasites.

iv. The species should be able to tolerate low oxygen levels and high organic content in the water, especially in the case of rice-fish integration.

Indian major carps (rohu, catla, mrigal), exotic carps (grass carp, silver carp and common carp), minor carps like batta, gonius and air-breathing species like magur, singhi, are most suitable for integrated fish farming. However, the availability of fish seed is the major problem especially of air-breathing species for incorporation into the integrated farming system mode. Some common integrations practises in India are:

Fish cum Agriculture Systems	Fish cum Livestock Systems
▲ Fish cum Paddy culture	▲ Fish cum Cattle farming
▲ Fish cum Makhana / Water chestnut	▲ Fish cum Goat Farming
▲ Fish cum horticulture and fruit	▲ Fish cum Duck Farming
▲ Fish cum mushroom production	▲ Fish cum Poultry Farming
▲ Sewage-based fish farming	▲ Fish cum Pig Farming
	▲ Fish cum Buffalo Farming

A brief description of a few important integrated farming systems suitable for NE Region is mentioned below

Rice cum fish farming

Both rice and fish play an extremely important role in food security and livelihoods of rural populations, especially for the people of NE Region. It is one of the viable techniques as this technique is better than rice monoculture in terms of resource utilization, diversity, productivity, and both the quality and quantity of the food produced. In agricultural production system, chemical usage, as a pest control measure, encourages chemical pollution in the ecosystem, pesticide-induced outbreaks, human health hazards, etc. But the introduction of fish into the paddy fields has been shown to reduce the need for pesticides, increase the farm household income, and diversify agriculture production. Apart from this, rice-fish farming also upgrades soil nitrogen, phosphorous, aeration of water, pest control, etc. which are beneficial for the integration, apart from 7.0 -9 % increase in rice yield. Studies at ICAR RCER, Patna also revealed 4.36%, higher rice production and overall 26.1% higher revenue from rice-fish integration. A study by Rautaray (2012) from Assam reported 11.5 t/ha rice equivalent yield from rice-fish which is higher than sole rice cropping with 3 to 4 t/ha yield and double rice cropping with 7 to 8 t/ha yield. This system is still extensively followed in the Apatani Plateau of Arunachal Pradesh where farmers are getting 30% higher economic return from the rice-fish culture in comparison to exclusive rice cultivation.

Makhana-Fish-Water Chestnut integration

Makhana (Euryale forex) and water chestnut (Trapa natans) -fish integration is a unique system of integration and a potential area for the water-logged regions of NE region. Both are floating macrophytes, commercially grown in the littoral parts of the floodplain wetlands of Bihar. They are extensively found in Bihar, Assam, Manipur and a few other states. However, not much information is available on this integration from the NE region. Being designated as one of the most healthy food, there is a lot of scope for the development of makhana-based fish integration even in the NE region. However, variety selection, post-harvest scope, marketing etc. have to be taken care of before full-scale integration. At present ICAR RCER, Patna has developed a few systems where both makhana and fish can be reared together.

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Pig-cum-Fish Farming

As per the 20th Livestock census, NE region has around 0.42 million pig population which accounts for around 46% of the Indian pig population. Among different integrations, pig and fish integration is the most important, profitable and popular farming system, especially in the NE region. The major advantages of this type of farming system are: a) Pig manure is an efficient fertilizer and feed for fish. It contains almost 60% of undigested matter. Pig houses can be constructed in the pond bund itself and no additional feed and fertilizer can be applied to the fish. As two different production units exist in the same location, the cost of production is low fetching higher returns. After 6 months, older pigs with 50–70 kg are sold out and fresh young piglets are introduced in the pig house. Generally, for a one-ha water spread, 30–40 piglets are required in one set. Hence, in a year, about 70–80 piglets will be required. From this integration, fish production of 3.5–5.0 t/ha could be achieved in a year and two sets of piglets can be harvested having a total yield of about 3.0–4.0 tonnes in a year. An experiment conducted by ICAR in collaboration with ICAR-NRC on Pig on integrated pig-fish farming in large rain-fed pond in Assam showed better profitability (B:C ratio of 2.58).

Cattle-cum-Fish Integration

The NE region possesses around 13.4 million cattle population and their dung is extensively used as fertilizer in agriculture and allied sectors. It is decomposing easily and helps in production of copious quantities of plankton in fish ponds. By cattle-fish integration, cost of fish culture is reduced to about 40–50% as there is no necessary for feeding fish. Cow shed should be nearer to the pond (or on the pond dyke) and a manuring ditch can be prepared to collect the dung and urine together for regular application to the fish pond. Four to five cattle are enough to meet the fertilizer requirement of a one-hectare pond. Similarly, cattle also produce around 2400–3000 litre of milk per cattle per annum. In general, milking cattle require around 30–40 kg of green fodder, about 4–6 kg of dry fodder and 4–6 kg concentrate feed (~ 20% protein). This amounts to 9.0 to 11.0 tonnes of grass/yr, and part of this fodder requirement can be met out by growing fodder crops in the pond dyke itself. Cattle excreta can also be effectively used for biogas production and biogas produced can be used for fuel purposes and digested slurry can be used as manure in the fish pond itself. Biogas slurry is generally applied in fish ponds @ 15,000 to 30,000 litre/ha/yr. It has low oxygen demand, therefore, is much safer than raw cattle dung. With proper management practice, fish production of 3.0–5.0 t/ha could be achieved in a year from cattle fish integration.

Duck-cum-Fish Farming

Duck cum fish farming is another important farming system and is popular among farming communities of the NE region. NE Region harbour around 46% of the country's duck population. Duck houses are generally constructed either above the pond or it can be constructed in the pond embankment. Every day the duck dropping and leftover feeds are collected and applied in the fish pond. Duck dropping is an efficient fertilizer and facilitates optimum plankton growth. Moreover, the duck movement aerates the pond water and also churns the bottom which helps in mineralization. Apart from that it feeds on insects, tadpole larvae, molluscs, and weeds and maintains a healthy environment. This integration reduces input expenditure in fish culture by 60%. Generally for one ha water spread, 400–550 ducklings are required. For maintaining ducklings, a daily ration of 100g feed/bird/day should be provided. Duck should be introduced in the pond when fishes attain a length of around 10–15 cm. In duck cum fish farming, estimated production of 3.5–4.5 t/ha of fish is easily achievable in a year in addition to 20000 to 25000 nos. of eggs and about 450 kg of duck meat. This gives additional income to the farmers and cuts the cost of feed and fertilizer significantly.

Poultry-cum-Fish Farming

The growing production of chicken eggs and broiler meat

has increased the availability of organic waste on a large scale. This organic waste especially deep litter can be very efficiently used in fish production purposes as chicken manure is a very good fertilizer. Many fish farmers now construct chicken sheds near pond areas and use the litter as a supplement for fertilizer and feed for the fish. Like duck dropping, poultry dropping is also an excellent bio-fertilizer. Chicken houses @ 0.3-0.5 m2 /bird are constructed and generally, 8-week chicks are reared after vaccination against viral diseases and after prophylactic treatments. These chicks attain egg-laying age in 24 weeks and continue egg-laying for up to 2 years. After 2 years, the birds are sold out and fresh chicks are introduced into the house. Generally, for a one-ha water spread area, 500-600 chicks are required. For maintaining chicken, a daily ration of 100g feed/bird/day should be provided. It takes generally six months to develop and mature litter. Fully built-up litter are stored in the gunny bags and applied @ 50 kg/ ha/ day. Estimated production of 4.0-4.5 t/ha of fish and 40000 – 60000 nos. of eggs and about 500 kg of chicken meat can be obtained in a year. This integration reduces input expenditure substantially.

Goat-cum-Fish Integration

Goat cum fish is a co mparatively new integration wherein goat manure is used as a source of fertilizer for the fish pond. The goat house can be made on the pond embankment or nearby area. On average, a Black Bengal goat requires 1.08-1.40 tonnes of green fodder per annum besides 25.0-30.0 kg of broken rice and 40.0-45.0 kg of wheat bran per annum. The live weight of Black Bengal goats could be achieved in the range of 11.5-14.5 kg/yr. Under this system fish productivity of 2.5-3.5 t/ha could be achieved. In such a system, a farmer can sell fish/goats at any time if he is confronted with distress. On average, 55-75 nos. of goats are sufficient to fertilize one hectare of the fish pond. As goat manure is capsule type, better results can be derived by soaking the manure overnight and applying it the next day.

Conclusion

The integrated farming system is considered more resilient to climate change; hence, more emphasis has been given to the popularisation of this eco-friendly farming system in recent times. Location-specific and resource-based integrated farming can be an important avenue for improving livelihood and income, especially for marginal and poor farmers. The beauty of this system is that if one source of income compromises, the farmer will always have a second source for sustainability and survival. Though several studies have been carried out, there is still ambiguity in many aspects like quality and quantity of organic manure to be applied, stocking density of livestock and fish under different integrations, productivity under the different agro-climate zone, water quality conditions, quality of the end products etc. Studies at ICAR Research Complex for Eastern Region, Patna has demonstrated that integrating livestock production along with the fish can enhance fish production (3.0-4.5 tonnes/ha) significantly. However, haphazard and excessive use of manure can also be detrimental, and unfavourable environmental conditions like persistent cloudy days, very low water temperature, low dissolved oxygen etc. can cause significant economic loss to the farmers. In conclusion, it can be stated that integrated fish farming has the ability to increase overall production and income sustainably. The synergistic role played by different components can have the ability to withstand even climate-related issues and there-by can play a significant role even in decreasing greenhouse emissions.◆◆◆

SMART AGRI POST

RNI No. DELENG/2015/6581919843 Volume : 07 | April 2023 | Issue 09

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Printed, Published and Owned by Pravash Chandra Pradhan

Printed at ISKAAR ART PRESS, B-145 DDA, OKHLA PHASE 2, DELHI-110020 and Published at 111/9, 3rd Floor, Ali Apartment, Kishangarh, Vasantkunj, New Delhi-110070,

Editor: Pravash Chandra Pradhan

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