Integrated aqua-agri-livestock system in brackishwater ponds as a farming livelihood model for coastal communities

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The integrated aqua-agri-poultry-goat farming system established in brackishwater aquaculture pond

Introduction

Integrated farming system (IFS) is a farming approach that helps conserve agrobiodiversity, provides food security, enhances ecosystem services, maintains environmental quality and also achieves sustainability. Integrated fish farming (IFF) refers to a practice of IFS where fish becomes the major component of the farming system. Thus, the practice of integrating fish with agriculture or livestock helps in utilization of farm space, recycling of resources, diversification of crops, minimising the use of farm feed and fertilisers, reducing the risks of crop loss, increasing productivity and income.

In order to achieve rapid progress and development in the rural and coastal areas of the country, the policies and research strategies must focus on conserving natural resources by enhancing the efficiency in the use of these resources for increasing productivity, income, and profitability. On the other hand, freshwater availability for human use is emerging as a national and international challenge, and its efficient management and recycling are of utmost importance. Recycling of farm and crop residue and agricultural by-products need to focus on minimizing the cost of production. Since animal waste makes good fertilizer for fish ponds, and 50 - 60% of the cost of fish farming

goes for feed, integrated farming is an ideal model for farmers and coastal communities. Integrated agri-aqua-poultry and goat farming system in brackishwater aquaculture ponds is one of the best examples of mixed farming. This farming practice involves a combination of fish polyculture integrated with crop or livestock production.

The Government of India has initiated several programmes over the years to improve the livelihood of coastal communities. As a part of these initiatives, the ICAR-Central Institute of Brackishwater Aquaculture (CIBA), Chennai, has developed various technologies and package of practices to provide alternative livelihood options for coastal fishermen/farmers/youth and women. One among these is an integrated aqua-agri-livestock - system developed and demonstrated by the Navsari-Gujarat Research Centre of CIBA (NGRC of CIBA), at the Matwad Farm for the benefit of the coastal community of Matwad Village, Navsari, Gujarat.

The model has different components as follows:

1. Nursery rearing of Asian seabass (*Lates calcarifer*), pearlspot (*Etroplus suratensis*), and milkfish (*Chanos chanos*) in hapas;

2. Farming of Asian seabass in low volume cages;

3. Farming of green mud crab, *Scylla serrata* and orange mud crab, *Scylla olivacea* in floating HDPE boxes;

4. Polyculture of milkfish and pearlspot in the pond;

5. Cobb broiler poultry birds, and surti goats as livestock components, and

6. Low salt-tolerant tomato, brinjal, chilly as horticulture components.

The brackishwater aquaculture pond area of around 2500 m^2 with a depth of around 1.5 - 2.0 m was used for the integrated farming system in with low-cost sheds of 6 m × 3.6 m and 12 m × 6 m for goat and poultry, respectively, on the rear end of pond dyke. Vegetable farming was carried out in a 250 m^2 area on two sides of the pond dykes.

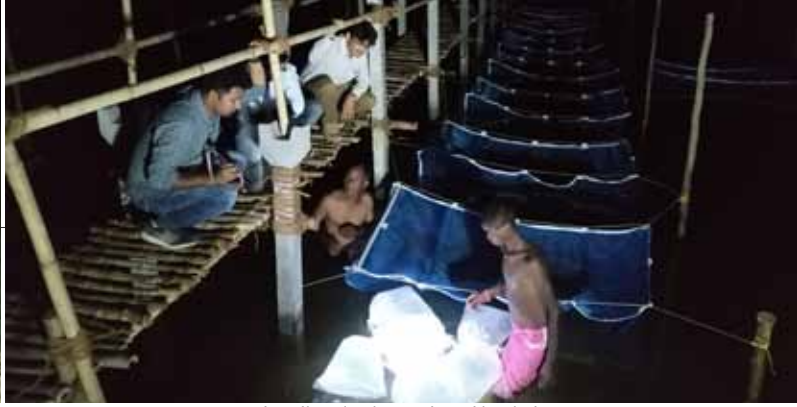
Components of integrated farming system in brackishwater aquaculture pond

a) Asian seabass nursery rearing in hapa in pond system

Asian seabass, also known as bhetki or barramundi, is a commercially important high valued finfish species caught from inshore areas, estuaries, backwaters and lagoons. They are fast-growing eurytopic fish, that can be grown in varying salinities including freshwater and is a suitable candidate for brackishwater fish farming. Seabass can grow to a mean size of 1.0 - 1.2 kg in 8 - 10 months and fetches a high domestic (Rs. 450 to 700) and international market price (USD 8 - 11/450 - 500g). The culture of seabass involves nursery rearing in hapas, pre-grow-out culture, and grow-out culture in ponds and cages.

Asian seabass, Lates calcarifer

Seed distribution to women SHG members

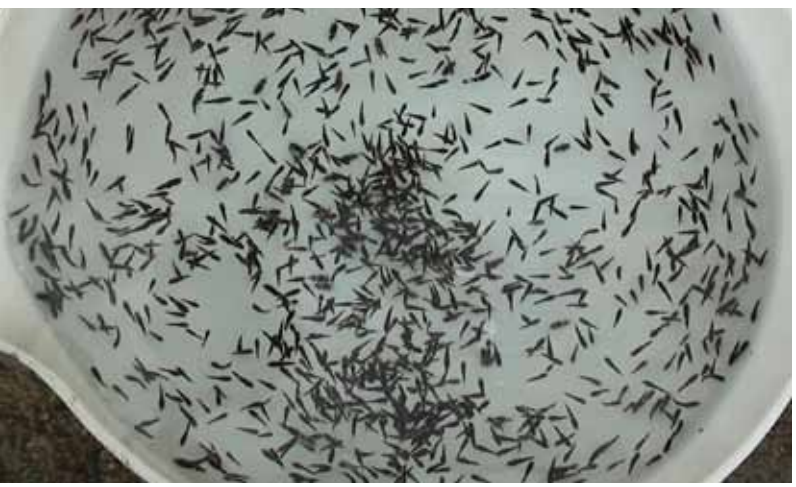


Seed acclimatization and stocking in hapa

Seabass seed grading, resizing and re-counting by women of a SHG

Feed ball preparation

Seabass feed balls



Stocked seabass seed

Harvested seabass fingerlings

Milkfish, Chanos chanos

HDPE knotless net hapa of 2 m ×1 m × 1 m with the mesh size of 2, 3, and 5 mm, respectively, were used for nursery rearing. Hapa were fixed in pond with the help of bamboos. Hatchery-produced seabass fry (1.5 - 2.0 cm) were transported from CIBA MES Hatchery, Chennai under optimal oxygen packing by air without any mortality. On the arrival, the fishes were acclimatized by sprinkling the rearing pond water to bring to the prevailing temperature/ salinity. Uniform size fry were stocked @ 500 - 750 nos./m^2. The seabass fry were fed with a slow sinking pellet feed of 0.4 - 1.2 mm @ 8 - 10% body weight daily in two rations (morning and evening). Feed balls were given for small seeds (1.5 - 4.0 cm) by keeping feed balls in a feeding tray tied inside the hapa. Since seabass is highly cannibalistic, size grading was done at 4 - 5 days intervals. Stocked fishes were graded as shooters, medium, and smaller-sized seed and restocked in different hapas separately. After 75 - 90 days of nursery rearing, seabass fry attained the fingerlings sizes (3 - 4 inches, 10 - 15 g) at a survival rate of around 55%. Harvested fingerlings were sold @ ₹40 - 50 per fish for grow-out culture in cages.

b) Milkfish and Pearlspot nursery rearing

Among brackishwater finfish varieties, milkfish is considered as one of the most potential candidate for pond and pen-based aquaculture systems due to its fast growth rate (attains 500 g in 6 months), salinity tolerance (0 to 50 psu) hardiness, and comparatelively lower production costs. They are euryhaline, and herbivorous fish, feeding mainly on benthic algae lab-lab, phytoplankton, and detritus. However, it also accepts low protein pelleted feed in culture systems. Milkfish farming requires less investment and forms a good livelihood option for coastal communities. Milkfish fetches ₹100 - 120/kg in the domestic market, whereas the cost of production is only ₹60 - 80/kg. Milkfish culture involves nursery rearing of fry in hapas and grow-out culture in ponds in either polyculture or monoculture systems.

Pearlspot is also known as green chromide and is popularly known as Karimeen (Malayalam) and *Kaalundri* (Marathi). It is the state fish of Kerala with great market potential, especially along the west coast of India with a market value ranging between ₹250 - 500/kg. Pearlspot is adaptable to different farming systems like ponds, pens, and cages. Being omnivorous, the culture of pearlspot is economical and highly suitable for supporting the livelihood of small-scale fish farmers and is ideal for polyculture, integrated farming, and cage culture.

Pearlspot, Etroplus suratensis

Nursery rearing of milkfish (6000 nos) and pearlspot (5000 nos) fry (2.0 - 3.0 cm, 0.3 - 0.5 g) to fingerlings were carried out in hapas of 2 m × 1 m × 1 m installed in ponds with a stocking density of 500 - 700 nos. in a hapa. Commercial nursery feed (30 - 35% protein) were fed two times a day @ 8 - 10% body weight. Hapas were cleaned regularly to facilitate proper water flow in the hapa. Periodic sampling was done to check the growth and survival of the seed at an interval of 15 days. After 60 days of nursery rearing, the stocked milkfish and pearlpsot fry reached the fingerling size (10 - 15 cm) with the survival rate of 96 and 98% , respectively. Fingerlings were harvested and sold for grow-out culture in ponds @ ₹15 - 25 per fish.

Stocked milkfish seed

Harvested milkfish fingerlings

Stocked pearlspot seed

Harvested pearlspot fingerlings

c) Green mud crab and orange mud crab rearing in floating HDPE boxes

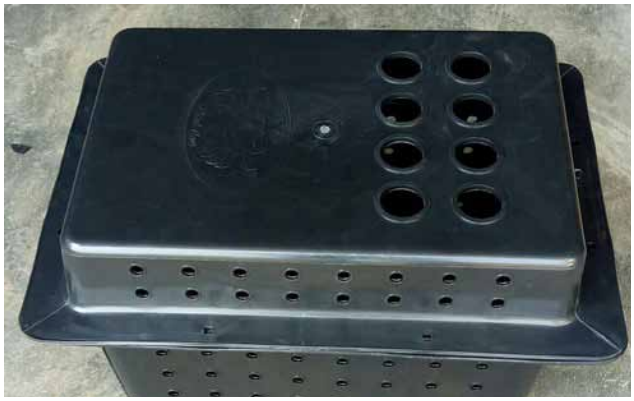
There are two species of mud crab available in the Indian coastal waters, under the genus Scylla i.e., green mud crab, *Scylla serrata*, and orange mud crab, *Scylla olivacea*, that can be farmed under controlled conditions. Green mud crab grows to a maximum size of 1.5 - 2.0 kg, whereas orange mud crab attains a maximum size of 0.5 to 0.7 kg. Among these two species, green mud crab is the species of choice for farming, owing to its faster growth rate, larger sizes achieved, higher market price, suitability to pond culture, lesser aggression, and ease of handling. Orange mud crab demonstrates aggressive behaviour and intense burrowing habit that damages the dyke structure, apart from being lower-priced and attaining a smaller individual harvest sizes.

Rearing of crabs directly in ponds under a polyculture system is not recommended due to its intense burrowing habit and aggressive behaviour, affecting dyke stability, harvesting, and handling. Therefore, the farming of crabs is recommended in a box culture system, wherein each crab juvenile is placed in individual HDPE box that are floated on a raft structure. The HDPE boxes come in various sizes; however, larger-sized boxes (approximate size range) have shown better results. These boxes have larger perforations on the top for feeding and smaller ones on the sides and bottom for water circulation and discharge of wastes and faecal matter. Boxes consist of two parts, viz., upper lid and lower body immersed in water. The boxes are rigged on a PVC floating raft and assembled in a battery structure such that about 3/4th volume of the box goes underwater, thus keeping the mud crab juveniles within the water in the pond environment.

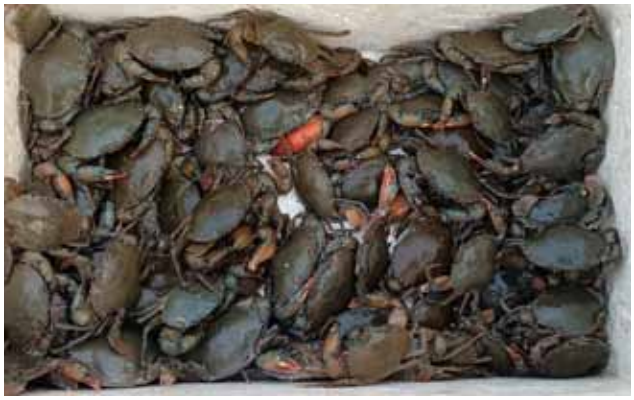
Around 300 boxes were installed in a 2500 m^2 pond. Crabs (100 - 150 g) were stocked individually in each box and fed once using trash fish at the rate of 1 - 5% of body weight for 180 days. Periodical cleaning of crab boxes done to avoid disease occurrence and mortality. After culture of 180 days, stocked crabs (300 - 500 g, 75% survival) were harvested and sold in the local market @ 500 - 800/kg.

Scylla serrata

Scylla olivacea

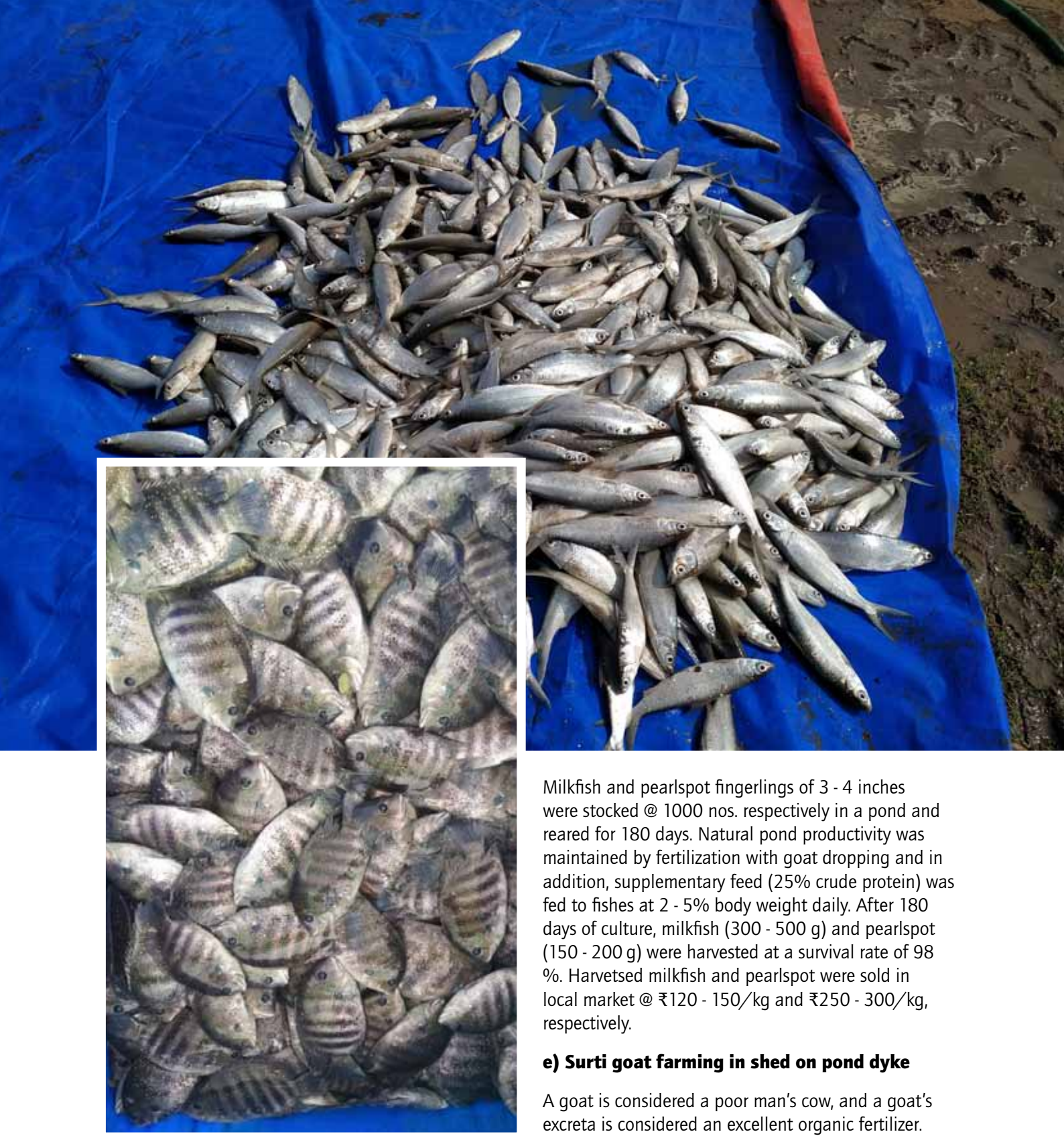


HDPE crab box



Stocked crab juveniles in crab boxes

Floating crab box culture unit of integrated farming system of brackishwater aquaculture pond



Harvested milkfish and pearlspot from polyculture unit of integrated farming system of brackishwater aquaculture pond

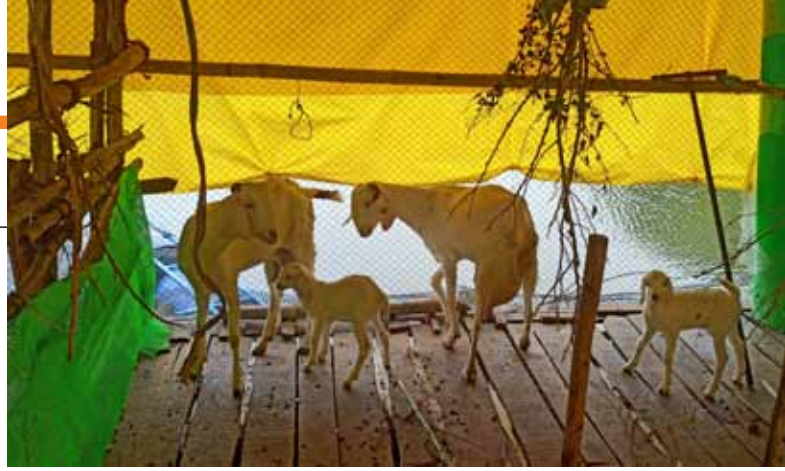
d) Polyculture of pearlspot and milkfish

Polyculture is the farming of a combination of fish species with different feeding habits within the same pond. Milkfish and pearlspot are herbivorous fish species that exhibit good growth and survival rate, and are found compatible for polyculture in the integrated farming system of brackishwater aquaculture pond.

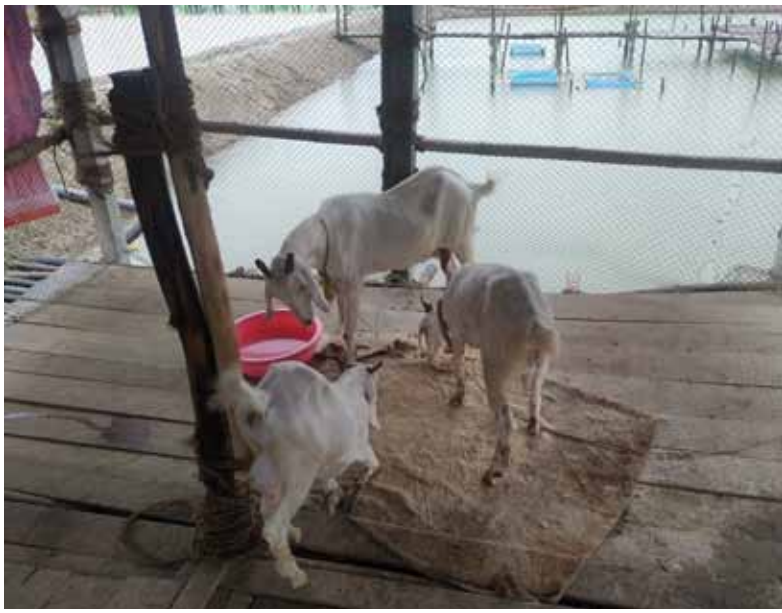
Milkfish and pearlspot fingerlings of 3 - 4 inches were stocked @ 1000 nos. respectively in a pond and reared for 180 days. Natural pond productivity was maintained by fertilization with goat dropping and in addition, supplementary feed (25% crude protein) was fed to fishes at 2 - 5% body weight daily. After 180 days of culture, milkfish (300 - 500 g) and pearlspot (150 - 200 g) were harvested at a survival rate of 98 %. Harvetsed milkfish and pearlspot were sold in local market @ ₹120 - 150/kg and ₹250 - 300/kg, respectively.

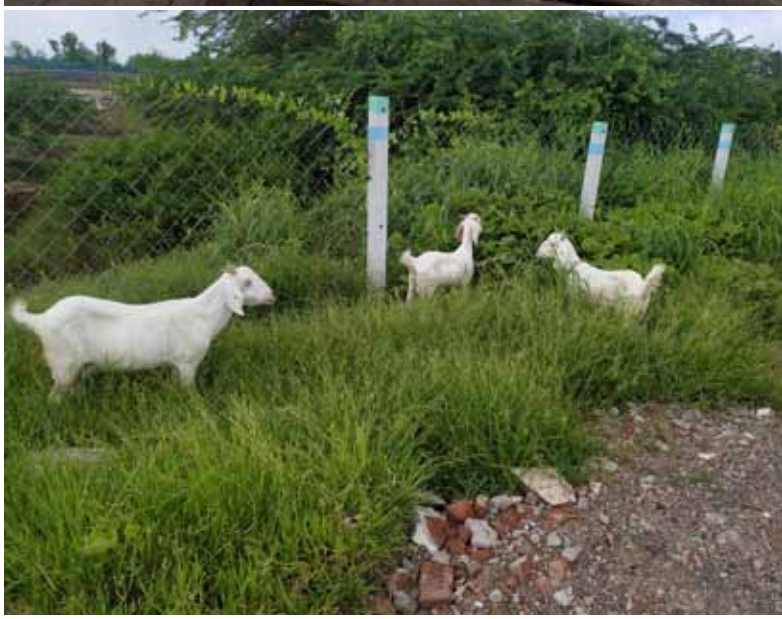
e) Surti goat farming in shed on pond dyke

A goat is considered a poor man's cow, and a goat's excreta is considered an excellent organic fertilizer. The Surti goat is one of India's best dairy goat breeds of domestic goats and is mainly reared for milk production. They are distributed in the areas around Surat and Baroda in Gujarat and Nasik of Maharashtra. They are raised and maintained in small flocks of 3 to 15 goats. The ideal male: female stocking ratio for breeding and kid production is 1: 4. Most of the flocks are raised on an extensive grazing system. Their coat is predominantly white with short and lustrous hairs and medium-sized dropping ears.



Surti goat flocks along with kids in low cost goat farming shed of the integrated farming system





Goat feeding: concentrate feed and green grass of pond dyke

For integrating goat farming along with the brackishwater pond, a low-cost goat farming shed of 20 ft x 10 ft was built on the rear end of the pond with the use of cement poles, bamboo, fencing net, plastic, and GI roof sheets. The base of the goat farming shed on the pond dyke fabricated using wooden planks. The shed floor was kept dry and perforated to have proper ventilation system. The goat waste (uneaten feed & faecal matter) through the perforated base of the shed fall into pond water and acts as a natural fertilizer, which helps to augment the natural productivity of the culture pond.

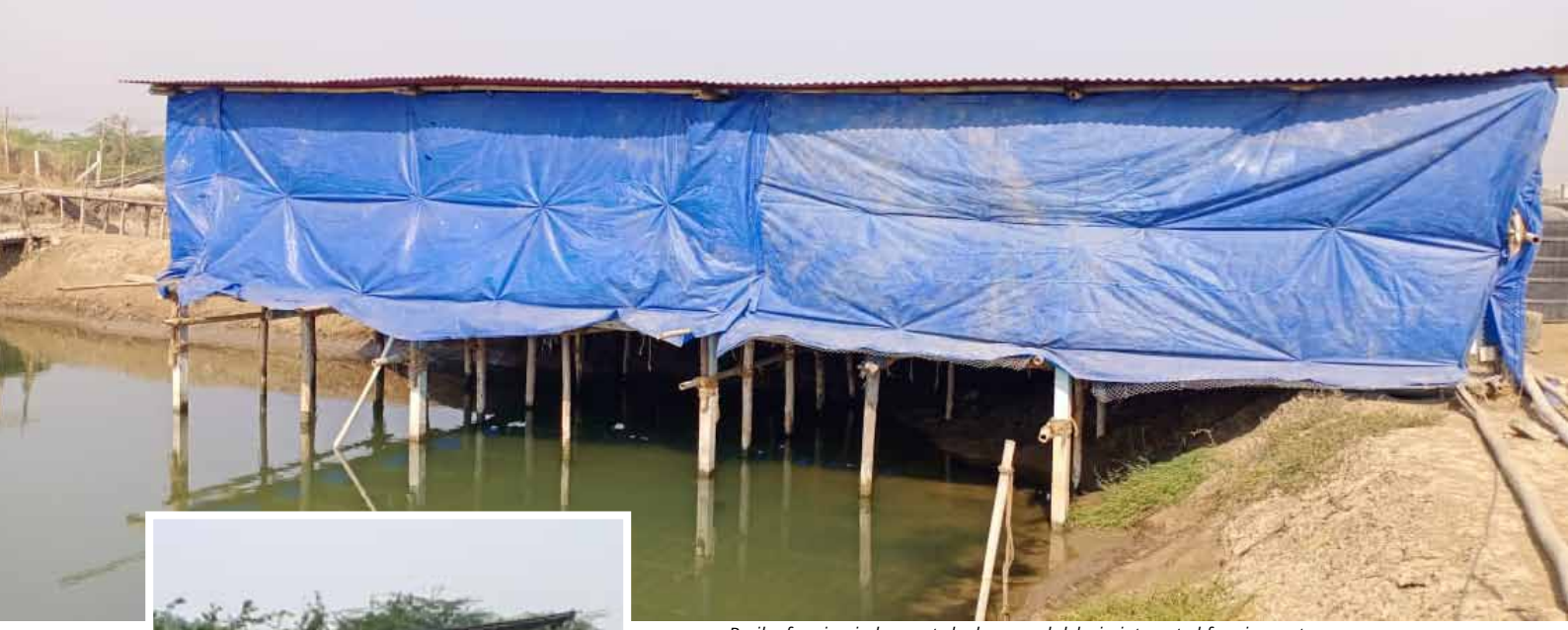
For this farming demonstration, nine surti goat kids in the size range of 6 - 8 kg were stocked in the shed and reared for a period of180 days. The goat kids were fed twice a day with green grass cut from the brackishwater pond dykes and nearby shrubs. In order to balance the diet of the goats, concentrate feed (mixture of maize, wheat, rice bran, wheat bran, barley, millet, soybean, by-products of oilseeds) consisting of 20 - 25% crude protein was also fed @ 300 - 500 g/day to each goat. After 180 days farming, 100 % survival was obtained in goat farming with production of goat adults (30 - 50 Kg) & three new goat kids (5 - 7 kg). Adult goats were sold in the local markets.

f) Cobb broiler poultry birds farming in shed on pond dyke

Poultry birds of Cobb variety are mostly preferred for farming as they require an area of only 0.3 - 0.4 m^2/ bird. Hence a small, low-cost poultry shed of 40 ft x 20 ft was built on the rear end of the pond using cement poles, bamboo, fencing net, plastic, and GI roof sheets. The poultry shed floor was constructed using cement sheets to prevent the bird droppings from falling directly into the pond. After the culture duration, the waste was used for the production of bio-fertilizer.

Around 500 nos. of one day old Cobb chicks were stocked in the poutry shed. Feed hoppers and drinkers were used in the shed to minimize feed and water wastage. The broiler chicks were vaccinated periodically to avoid disease and mortality. Maximum light (for temperature) was provided in the poultry shed to avoid the mortality of chicks during the winter period. The broiler birds were fed with pre-starter, starter, and grower feed (1500 kg feed) as per their age and body weight. After 35 - 40 days, the birds reached in the size of 1.8 - 2.0 kg with survival range of 90%. The birds fetched a price of ₹120 - 130/kg in the local market.

In brackishwater aquaculture farms, pond dykes occupy a substantial area. However, these pond dykes are most often underutilized in the aquaculture system. Inner and outer dykes of the pond and adjoining areas can



Broiler farming in low-cost shed on pond dyke in integrated farming system

Low-salt tolerant vegetable farming being carried out with drip irrigation on the dyke ofthe integrated farming system

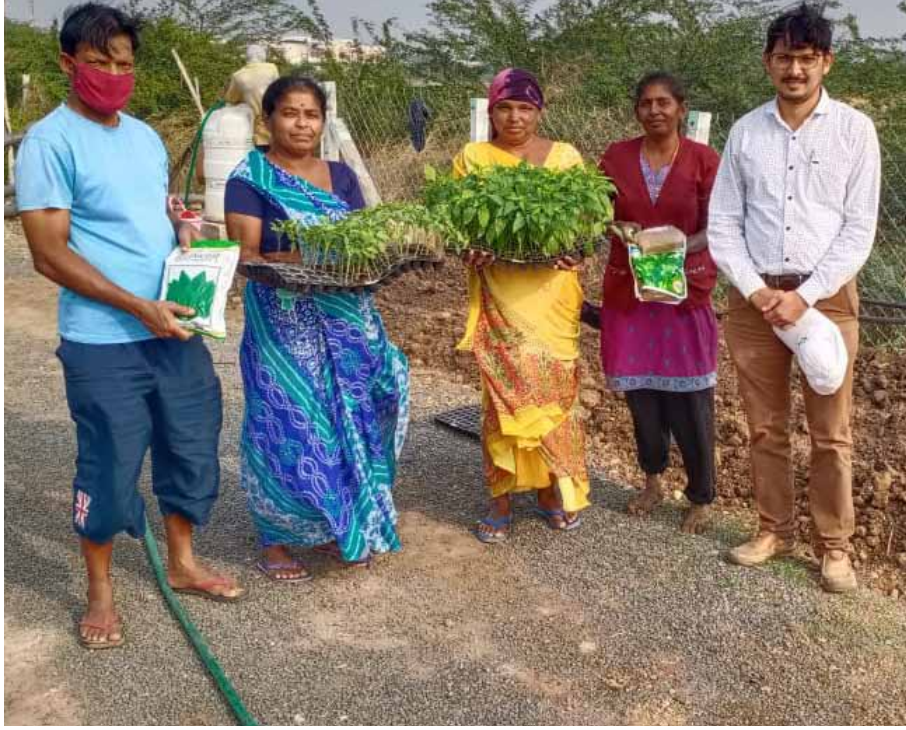
Stocked Cobb broiler chicks and harvested birds from poultry farming unit

actually be used for cultivating low salt-tolerant fruits, vegetables as well as flowering plants without affecting the aquaculture activities. The low salt-tolerant vegetables like brinjal, tomato, chilies, cucumber, etc can be grown according to their season throughout the year. The waste leaves of vegetable crops can also be used to prepare manure with a mixture of goat and bird wastes.

As a part of the low salt-tolerant vegetable farming on the dykes of brackishwater pond, about 200 saplings of tomato, brinjal, chillies and seeds of spinach were sowed on the pond dyke area (250 m^2) during winter for a crop duration of 120 days. A freshwater drip irrigation system was adopted for better productivity than the conventional method. About 203 kg of vegetables were harvested from one complete crop.

Advantages and inferences of integrated agri-aqua-poultry and goat farming system in brackishwater aquaculture pond

- An integrated farming system allows efficient waste utilization and recycling of wastes for overall culture production.
- It reduces the additional cost for supplementary feeding as well as fertilization.
- It increases the culture output with higher per unit area production and economic efficiency.
- It provides more employment generation and livelihood opportunities to coastal communities throughout the year.



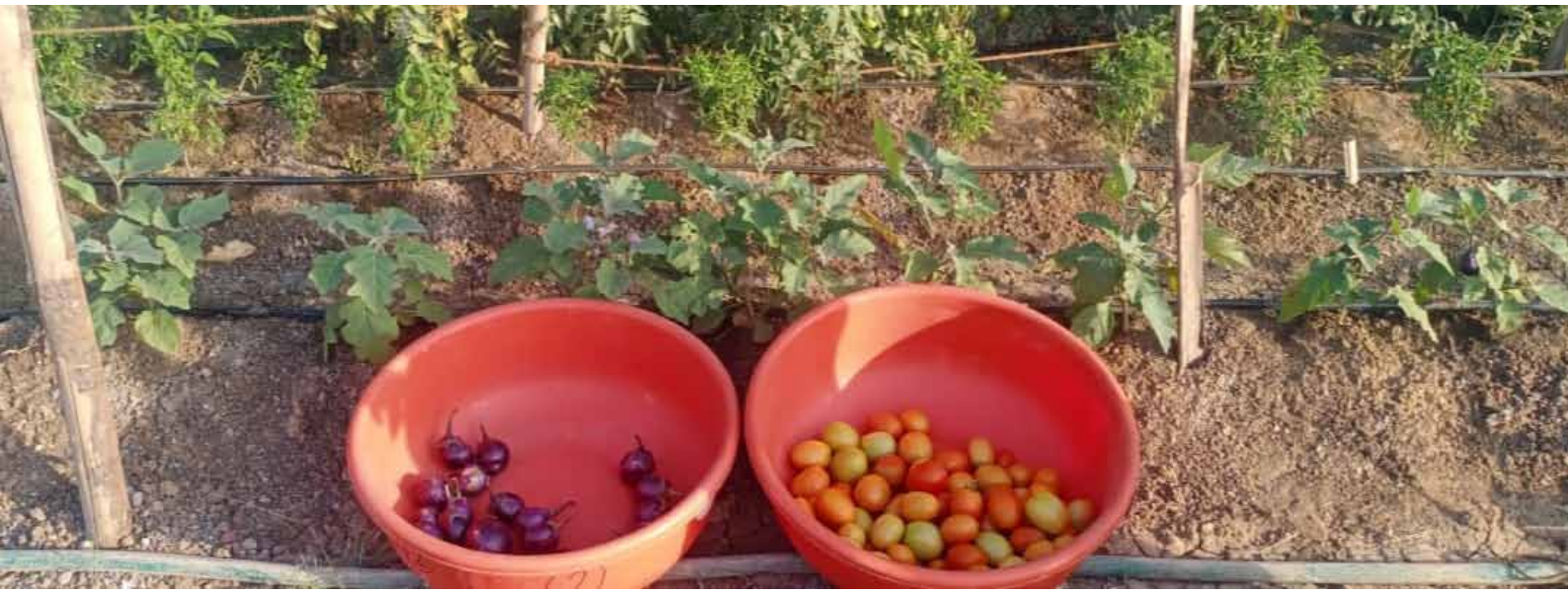
Vegetable farming area on the pond dykes and distribution of vegetables seed and saplings to the women members of the Self Help Group

- Improvement in skill and knowledge development in the integrated farming system.
- It provides monthly income through harvest and sale of different crops in a short period.
- Utilization of non-utilized untapped brackishwater and saline lands for horticultural and agricultural uses.
- It increases the socio-economic status and doubling of coastal farmers' income.
- It serves as a model of sustainable food production.

Crop of low salt tolerant tomato, chilly, brinjal and spinach on pond dyke

Economics

Integrated agri-aqua-poultry and goat farming system in brackishwater aquaculture pond is a sustainable business model. From a 2500 sq. m pond, a revenue of about ₹9.10 lakhs was obtained against total capital and operational cost of approximately ₹5.13 lakhs yielding a net benefit of ₹3.97 lakhs. The findings of



Partial harvest of brinjal and tomato from pond dyke of the integrated farming system

the study suggest that nursery of finfishes, poultry and vegetable farming can be undertaken 2 - 3 times in a year in an IFF unit which can benefit more (₹12.50 - 13.00 lakhs) to fish farmers with minimal risk as compared to conventional mono-culture or poly-culture fish farming systems. Therefore, integrated agri-aqua-poultry and goat farming system in brackishwater aquaculture pond is more economical and sustainable business model where farmer can get monthly income from regular sale rather than depending solely on income after sale of entire crop.

Component	Period	Density	Production
Pond area	2500 Sq.m		
Seabass nursery	75 - 90 days	10000 Nos (1.8 - 2.0 cm, 0.3 - 0.5 g)	55% survival (10 - 15 g)
Pearlspot nursery	60 days	5000 Nos (2.0 - 2.5 cm, 0.3 - 0.5 g)	98 % survival (8 - 10 g)
Milkfish nursery	60 days	6000 Nos (2.0 - 2.5 cm, 0.3 - 0.5 g)	96 % survival (10 - 15 g)
Floating crab box culture	180 days	300 Nos (100 - 150 g)	75% survival (300 - 500g)
Pearlspot & milkfish polyculture	180 days	2000 Nos (1000 each; 10 - 15 g)	95 % survival (pearlspot 100 - 120g; milkfish: 300 - 500g)
Goat farming on dyke	180 days	9 Goats (6 - 8 kg)	100 % survival with production of goat broodstock (30 - 50 Kg) & three new goat kids (5 - 7 kg)
Poultry farming on dyke	35 - 40 days	500 Chicks (1 day old)	90% Survival (1.8 - 2 kg poultry bird)
Low salt tolerant vegetable Farming on dyke	120 - 150 days	Tomato, brinjal, chilly (200 Nos each), Spinach seed	203 kg

Income cheque distribution to women SHG of Matwad, Navsari towards production and sale of milkfish fingerlings from integrated farming system of brackishwater aquaculture pond in COVID-19 pandemic period

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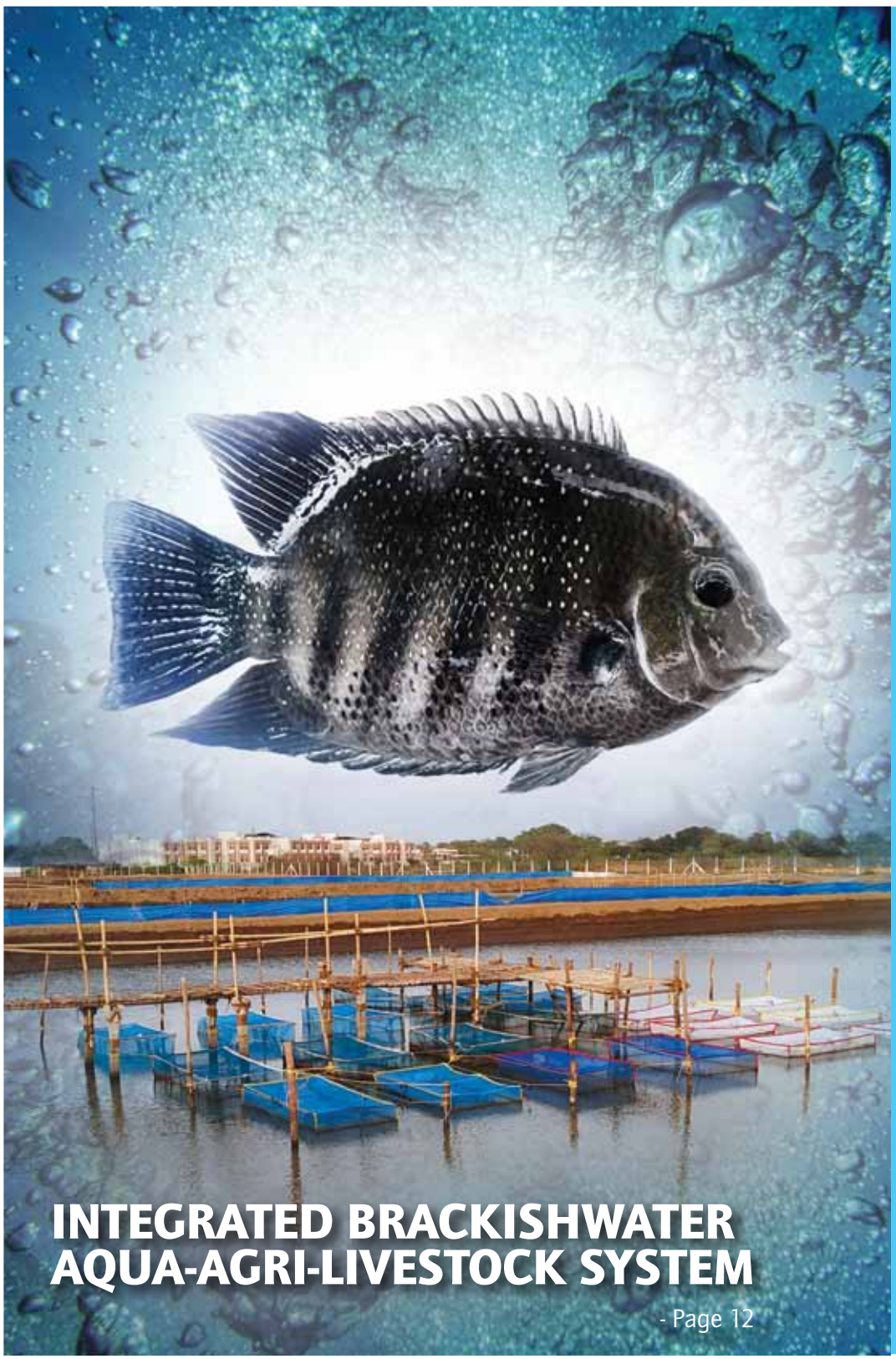
ISSN 2581-7892

Volume 5, Issue No.12 | December 2022

Aquaculture Spectrum™

The Indian Aquaculture Magazine



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