ICAR-CIBA Extension Series No. 72

Brackishwater Polyculture Farming Model with Shellfish and Finfish: A GUJARAT PERSPECTIVE

(Under Tribal Sub Plan)

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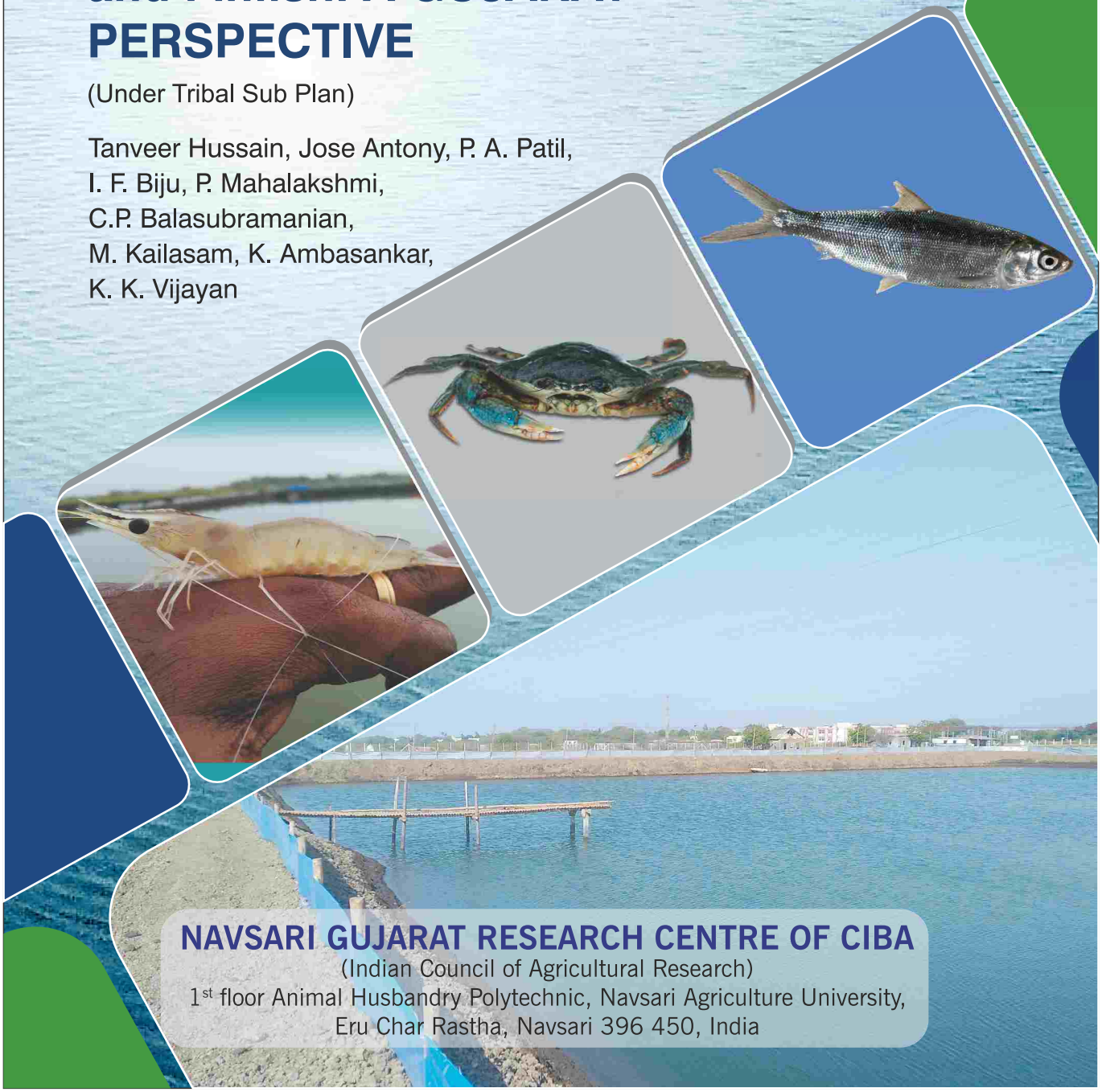

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Polyculture is the farming of two or more species of finfish or shellfish within the same farming system and the combination of the species are made on the basis their feeding behaviour, ecological niche, compatibility and increased revenue to the farmer. Polyculture is widely acclaimed as a sustainable model for any form of aquaculture. Polyculture of fish, shrimp and mud crabs have been widely accepted as a sustainable farming model in brackishwater aquaculture. Polyculture of shrimp with milkfish is a common polyculture practice in most of south and southeast Asia wherein both species are mutually benefited and farmer is able to obtain increased production and profitability. In milkfish shrimp polyculture farming system, milkfish takes cares of the water quality by promoting a green water system which has lower pathogenic bacterial load, eats the excess or left over feed to prevent organic matter loading in the system,thereby providing ideal environment for the high value shrimp to grow. Similarly, polyculture of mud crabs with milkfish or other herbivores/omnivore brackishwater finfish is also an acceptable model. Crabs being bottom dwelling animals would utilise the pond bottom and the water column can be used to rear fish. In most polyculture models, some of the species are either not fed or are only partially fed and full complement of feed is broadcasted to the other species. Polyculture models in brackishwater aquaculture are also considered as cost effective farming systems wherein even a low cost feed that can be equally utilised by the two species can be applied to the farming system. Polyculture farming systems in brackishwater aquaculture are an excellent opportunity for livelihood enhancement of coastal tribal communities.

Milkfish, *Chanos chanos*

Among brackishwater finfishes, Milkfish *Chanos Chanos* is considered as one of the most potential candidate species for pond and pen based aquaculture, due to its fast growth rate (attains 500 g in 6 months), hardy nature, and low cost of production. Being a euryhaline and herbivore fish, it feeds on benthic algae lab-lab, phytoplankton and detritus and it accepts low protein pelleted feed in culture systems and tolerates salinities ranging from 0 to 50 ppt. Milkfish farming requires less investment and it forms a livelihood options for tribal communities in coastal regions. Milkfish fetches Rs. 150-180/kg in the local market whereas the cost of production is only Rs. 50-60/kg.

Milkfish

Polyculture of Milkfish

Milkfish can be cultured along with shrimps, mud crabs and other fish species. However, the most popular and profitable combination is culture of milkfish with shrimps or with mud crabs. It is reported that milkfish can consume organic matter deposits at bottom sediment of the shrimp pond and thereby clean the waste accumulation and maintain the green water system, which helps the shrimp growth. This practice is very popular in the South-East Asian countries and in India this practice is emerging among the shrimp farmers. The production of milkfish ranges from 1200 to 1800 kg/ha as a primary crop when grown together with shrimp while shrimp production is from 100 – 200 kg/ha/crop. About 550 kg/ha of milkfish and 150 kg/ha of crabs per crop can be achieved using the polyculture method.

Polyculture of Indian White Shrimp and Milkfish

Polyculture of Indian white shrimp with milkfish considered as sustainable and economically viable type of farming system. Milkfish can be used as secondary crop along with shrimp to reduce cost of production. And, moreover milkfish being a illophagic feeding habit, it consumes excessive organic matter, reduces dissolved nutrients, improving water quality and increasing disease resistance against pathogens. Demonstration of polyculture of Indian white shrimp along with milkfish was carried out in 2000 m^2 pond at NGRC-CIBA farm, Matwad village, Navsari Gujarat.

Site selection

Site selection is the important process for success of any aquaculture operation. The selected site should have proximity to roads, hatcheries and good accessibility to electricity and communication. Site must be free from pollution by domestic drainage and industrial effluents. The selected site should have clayey loamy soil. The suitable soil characteristic for construction of shrimp farms are as follows.

Soil quality parameters	
pH	7-8
Organic carbon	1.5-2.5%
Calcium carbonate	>5%
Available nitrogen	50-75 mg
Available phosphoreus	4-6 mg / 100 g soil
Electrical conductivity	>4 mmhos/cm

Pond Preparation

Pond preparation to be started with drying of pond bottom till it cracks. Sun drying should be done at least 3 weeks for microbial decomposition and mineralization of organic matter. Ploughing or tilling of bottom soil improves soil quality by exposing to the atmosphere results in oxidation and release of nutrients that are packed in soil. Soil management practices like application of lime to the soil must be followed. A basal dose of lime @ 300 – 500 kg/ha can be applied if the soil pH is not < 7.5 if the pH of the soil is acidic. The quantity of lime to be applied depends upon pH of soil and liming material.

Ploughing of pond bottom soil

Milkfish polyculture pond at NGRC, Navsari

Water Intake and Disinfection

The source of water could be from creeks, backwater, estuaries or sea. Water can be drawn using pumps or sluice gate with proper screens. The source water should be filtered using coarse screens to remove unwanted predatory organisms and debris. Water should not be taken directly into the pond. First, it has to be taken into settling tanks to allow suspended particles in the source water to settle down, after that pumped to reservoir via series of 150 -250 μm mesh screens. Disinfection of water can be done by applying calcium hypochlorite @ 10 ppm to eliminate the potential pathogens and carriers. Treated water is aged up to 5 -7 days in reservoir for removal of residual chlorine. Dechlorinated water is taken into culture ponds. The optimum water quality parameters for polyculture of shrimp and milkfish is shown in the table below.

Water quality parameters	
Temperature	28-33
Transparency (cm)	25-45
pH	7.5-8.5
Dissolved oxygen (ppm)	5-7
Salinity (ppt)	15-25
Total alkalinity (ppm)	200
Dissolved P. (ppm)	0.1-0.2
Nitrate - N (ppm)	<0.03
Nitrite - N (ppm)	<0.01
Ammonia - N (ppm)	<0.01

Disinfection of pond water (application of disinfectant agent)

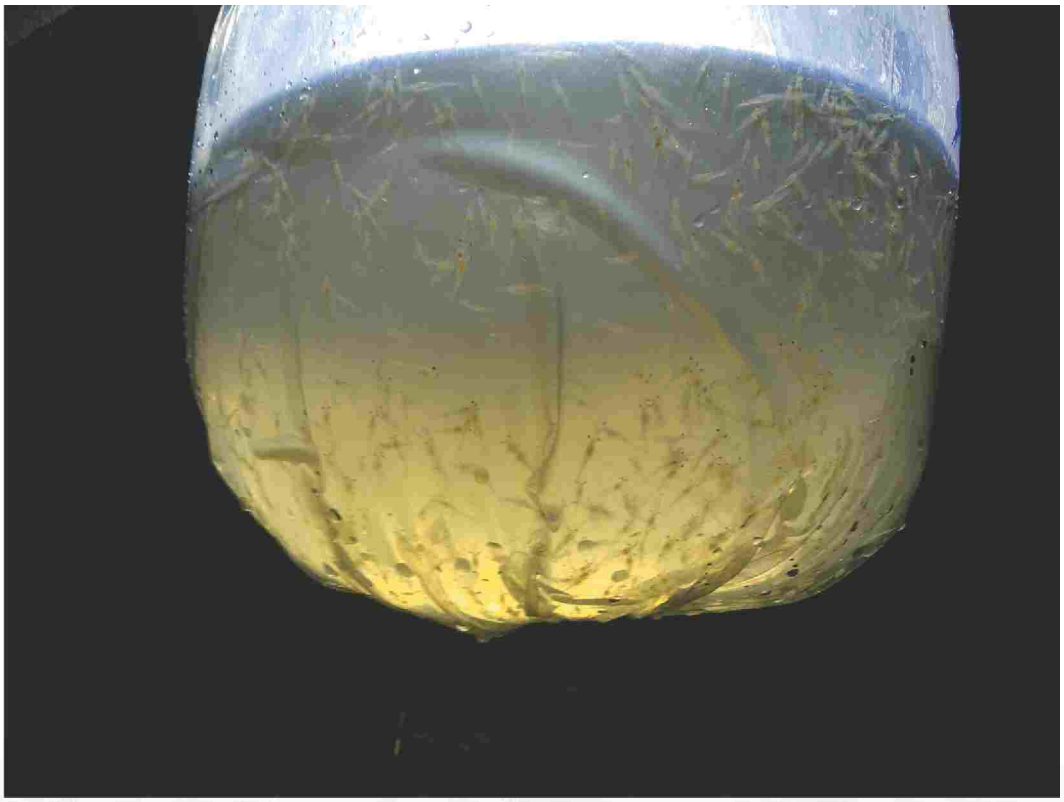
Pond Fertilization

Fertilizers must be applied to achieve healthy bloom of phytoplankton and zooplankton in pond. Both organic and inorganic fertilizers can be used in shrimp farming for early post larval stages. Fertilization helps to augment natural food organism available to the newly stocked post larvae. Molassess can be used as organic fertilizer that boosts growth of beneficial bacteria's and reduces ammonia and nitrite concentration in the pond. Molasses can be applied @ 50 -100kg/ha. Rice bran can also be used @250-500 kg/ha. Inorganic fertilizers such as urea and Di-ammonium phosphate/Single super phosphate in 1:1dose 20 kg/acre can be applied.

Stocking and Acclimatization of Indian White Shrimp and Milkfish

Quality and healthy Penaeus indicus seeds can be procured from any reputed CAA approved hatcheries. Quality seed stocked has direct relationship on survival and

better growth. Seeds should be booked well in advance so that entire larval rearing process can be observed and seed testing can be done at any stages. Acclimation of salinity can be done at hatchery itself. Post larvae (PL15) should be transported to the site with minimal stress. Transportation of seeds can be done in polythene bags placed in thermocol box or in large closed tanks with continuous oxygen supply. On arrival, post-larvae should be acclimated to the pond water condition such as temperature, pH, salinity to avoid stress and shock before stocking. Stocking should be done during cool hours early morning or evening. During stocking, acclimation of temperature can be done placing seed polythene bags by floating for about 30 minutes in the pond mixing equal amount of pond water into polythene bags for 30 minutes. Shrimp seed to be stocked @17 – 18 no's/m^2. Milkfish fingerlings of size 8 – 12 cm released after 45 – 50 day of culture of shrimps. Milkfish should be stocked @ 0.5 no's/m^2.



Post larvae of *P indicus*

Milkfish fingerlings 8 – 12 cm size stocked after 45 doc of P indicus

Aeration

Dissolved oxygen is considered as the most critical water quality parameter in shrimp ponds. Decomposition of organic matter, sudden plankton crash, warm weather and cloudy days' results in depletion of dissolved oxygen in ponds. Aeration is must in shrimp ponds during early morning hours when DO will be minimum. Paddle wheel aerators are common type of surface aerators widely used in shrimp ponds. Oxygen transfer efficiency of paddle wheel aerator is about 1.7 kg/kwh. Generally, paddle wheel aerators @ 4- 6 nos/ha is used in shrimp ponds according to the standing biomass and @ 1 hp aerator can be used for 500kg biomass of shrimp. Aeration must be given during early morning hours 3am – 7 am. Proper positioning of the aerators should be done to optimize the water flow within the pond.

Check tray Monitoring of feed utilization

Biosecurity

Biosecurity is the key element in success of shrimp farming. Biosecurity measures to be followed to prevent transmission of viral and other disease. Restriction has to be made for entry of outside vehicles or precautions like tyre dip should be followed. Proper filter of source water is to be done to avoid entry of carriers. Disinfection of water in reservoir is to be followed. Bird fencing and scares should be provided to restrict entry of birds, Disinfection of nets and other materials should be done in pottassium permanganate solution at required dose or bleaching powder before use in any pond to avoid horizontal transmission.

Paddle wheel aerator in polyculture pond

Feed and Feeding Management

Commercial formulated feeds can be supplied to *P indicus*. Feeds are available in three different grades such as starter 0.2 – 1 mm crumble, grower 1.8 – 2.3 mm pellet and finisher 2.3 -2.5 mm pellet. These feed suits to different size group of growing shrimp. ICAR-CIBA developed Vannamei Plus cost effective feed for *P vannamei* grow out culture. Vannamei plus feed can be also used for feeding *P indicus* for better production. Daily feed ration is calculated based on the biomass of culture pond. During, initial phase of culture, feed is offered @ 15 – 20 % body weight of shrimps. As the shrimp grows, it is gradually reduced and brought down to 2 – 3 % towards end of culture period. Daily ration of feed should be offered in 3–4 hours intervals. Management of feed must be done by monitoring consumption of feed in check trays. During moulting and stressful conditions, restricted feeding should be adopted. Milkfish may be fed using low cost feed polyplus at the rate 2 % of body weight.

Harvesting and Marketing

Harvesting can be done after complete draining the pond water by pumping and hand picking of the farm grow shrimps can be done later. Harvested shrimps should be washed in clean water and kill in chilled condition and icing is done immediately after harvest. Buyers collect the harvest from the farm site and transported in refrigerated vans. Milkfish can be harvested and marketed at the body weight of 300 – 500 g wherein total length ranges from 20–40 cm. Uniformly grown milkfish having body weight 300 g and above can be partially harvested from grow out facilities using dragnets or gillnets. Milkfish also can be harvested by different methods like complete draining of pond by gravity or by pumps, hauling of nets cage structure, use of seines or gill nets in pens. Milkfish fetches good price in national and international markets. In the domestic market of India, milkfish fetches 150 – 200 Rs/kg.

Harvesting of Milkfish

Production and Economics

Polyculture of Indian white shrimp and milkfish is a sustainable farming model. In 2000 m^2 pond stocked with 35000 *P indicus* and 900 nos milkfish fingerlings. A production of 450 – 500 kg *P indicus* and 200 kg of milkfish is easily achievable. This would generate into revenue to the tune of Rs. 1.8 – 2.0 lakhs rupees against operational cost of approximate Rs. 95,000 crop resulting in a net benefit of Rs 85000 to Rs. 1.05 lakh. The estimated productivity would be @ 3.5 tonnes/ha.

Harvested milkfish from polyculture pond

Harvested *Penaeus indicus* from polyculture pond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BRACKISHWATER AQUACULTURE

Polyculture of Mud Crab with Milkfish

Mud crabs of the genus *Scylla* are extensively farmed in the whole of south east and southern Asia. Commercial mud crab aquaculture in India is an emerging economic activity and is fuelled by the lower success rate and higher production costs encountered by the Indian shrimp industry. Although, productivity and profitability of mud crab culture would be lower than that of shrimp farming from the same unit area, systematic mud crab farming is bestowed with reduced levels of risk and operational ease. Mud crab culture is also an option for diversification in brackishwater aquaculture and commends greater environmental sustainability. The state of Gujarat has abundant resources of brackishwater and low lying salt affected land which is being mostly used for shrimp culture. Mud crab culture can be a supplementary farming practice to shrimp farming in Gujarat especially for regions with poor success rate in shrimp and farmers who are otherwise not capable of making larger investments and still wish to yield substantial revenue. Mud crab culture is also an excellent alternate livelihood option for coastal tribal communities owing to ease of farming practices and low investment requirements.
There are two species of mud crab available in the Indian coastal waters, underthe genus *Scylla*i.e. giant mud crab, *Scylla serrata* and Orange mud crab, *Scylla olivacea*that can be reared under controlled conditions.

Scylla serrata

Scylla olivacea

The estuarine and creek systems in coastal Gujarat is dominated by *S. olivacea*. *S. serrata* is abundantly available in the south east coast of India wherein it is subjected to excessive fishing pressure for export trade and seed stock for aquaculture industry. Excessive wild collection of mud crab juveniles (*S. serrata*) for farming has resulted in depletion of several stocks leading to reduced availability

and high price of seed. However, in West Bengal and parts of Orissa wherein wild stocks of mud crab are dominated by *S. olivacea*, the aquaculture industry thrives almost entirely on the farming of this species. Since, Gujarat also possesses abundant resources of *S. olivacea*, the future of mud crab culture in the state would be dominated by this species.

Seed

Hatchery technology for production of seed exist for *S. serrata* and hatcheries are able to supply crab instars (CW-0.5-1.0 cm) or crab juveniles (CW 4-5 Cm, BW-3-5 g). Small sized seed has to be subjected to nursery rearing and pre-growout rearing to obtain 50-100g crab juveniles that are suitable for stocking in growout ponds. Alternately, wild caught *S. serrata* juveniles (50-100g) obtained from mud crab fishery along the Indian coast line may be used as stocking material in mud crab growout ponds. Commercial hatcheries do not exist for *S. olivacea* and seed of the species has to be sourced entirely from mud crab fishery. Since, abundant resources of *S. olivacea* exist in Gujarat, seed can be sourced from the local fishery. Large markets dealing with trade and transport of mud crab seed around India exist in Tamil Nadu and Andhra Pradesh. The largest market for mud crab for both aquaculture and export trade exist at Chintadripet, in Chennai, Tamil Nadu.

Farming Systems

Mud crab aquaculture comprises of several farming systems such as fattening, monoculture, polyculture of mud crab with brackishwater finfish, box culture and recirculatory aquaculture systems for production of soft shelled crabs. Among the various farming systems, polyculture of *S. serrata* with brackishwater finfish and box culture of *S. olivacea*/ *S. serrata* are only relevant to Gujarat based on its location, culture conditions, markets and seed availability.

Polyculture of *S. serrata* with Brackishwater Finfish

Polyculture of *S. serrata* with Milkfish, *Chanos chanos* would be the best suitable model for mud crab aquaculture in coastal Gujarat wherein hyper saline conditions are widely encountered. Milkfish exhibits high tolerance to high saline conditions and demonstrate a fast growth rate even under such conditions. Polyculture of *S. olivacea* is not recommended as its intense burrowing habit would damage the dykes and further complicate harvest process.

Pond Design Considerations

Existing shrimp ponds or newly constructed ponds may be used for polyculture of *S. serrata*. Rectangular or square ponds may be used to rear mud crab, although rectangular ponds with their longest side aligned to local wind conditions would minimise aeration requirements. Pond of 0.5 to 1.0 acre (2000-4000 m^2) are suitable for polyculture of fish and mud crab. Fencing using 90-120 gsm plastic film (2-3 feet long) secured with short bamboo or casuarina poles may be provided on the dyke edges to prevent the escape of the crabs. Additionally, a portion of the pond may be separated from the rest of the pond using HDPE netting or PVC netting erected on to the pond bottom using casuarina poles creating a pen-like structure wherein mud crabs would be reared during the grow out. Ensure that both fencing materials continue in to the soil for at least a depth of 20-30 cm.

Water Depth and Culture Conditions

Depth of water in the pond shall be maintained at a level of not less than 80 cm and water depth shall not exceed 150 cm. Mud crab juveniles (GL size<350 g) may be stocked at densities of 0.5-1.0 ind./m^2 inside the pen and density calculations shall be made on the basis of the pen area and not the pond area. Old PVC pipes (110mm and above), earthen pipes, tiles may be provided in the pen as hideouts for crabs to minimise cannibalism. These structures may be provided at the rate of 50% of the total number of juveniles stocked. Water level in the ponds may be topped up using water from reservoir. Water exchange may be carried out once in 30-45 days based on water quality analysis at the rate of 20-30% of the total pond volume. Nursery reared milkfish fingerlings (TL 5 to 7 cm, BW~1-2 g) or bigger sized seed may be stocked in to the pond at the rate of 1000 nos to 1500 nos per 2000m^2 of pond area. Milkfish shall be stocked 15 days after stocking of crab seed or 30 days before stocking of mud crab juveniles.

Feeding

Commercial formulated feed is not available for *S. serrata*, although specially formulated crab feed is available with ICAR-CIBA which has been delivering optimal results. Commercial mud crab aquaculture depends on low cost thrash fish obtained from landing centres or other water bodies for feeding. Crabs may be fed using wet or dried thrash fish at the rate of 5-8% of the body weight on alternate days i.e. feeding is carried out only once in two days. However, in case of higher stocking density, feeding may be carried out daily. The entire feed ration may be broadcasted in a single feeding session preferably during late evening or early morning hours. Tilapia, marine eels, sardines and other low value marine fish are excellent feed for mud crab juveniles. Milk fish may be fed using CIBA low cost feed poly^{plus} or other commercial carp/catfish feed at the rate of 2-3% of BW starting from 30 days of stocking.

Harvest

When *S. serrata* juveniles of 50-100 g size are stocked, cull harvesting shall start from 4 months onwards wherein larger sized crab (>500 g) may be harvested using baited traps. This can be carried out once every 15 days until 6-8 months following which the entire stock can be harvested. In the case of milkfish, it is recommended to stock the fingerlings 30 days before stocking crab juveniles such that fish can be provided with a growing season of 7-9 months.

Production and Economics

Polyculture of *S. serrata* with milkfish is a sustainable business model. Survival rate at harvest observed for *S. serrata* and Milkfish is generally 55-60% and 90-100% respectively. For a 2000m^2 pond with a 1000m^2 pen stocked with 500 *S. serrata* juveniles and 1200 milkfish fingerlings, assuming an average survival and size (*S. serrata*-~500 g, Milkfish~400g) at harvest, a production of 100 kg of mud crabs and 480 Kg fish is easily achievable. Additionally, some shrimp (5000-7500 PL) and sea bass (10-15 nos, ~50 g size) seed can also be stocked in to the system which can result in a production of 50 Kg shrimp and 10 Kg Seabass. This would transform in to a revenue to the tune of rupees (Rs.) 2.5-2.8 lakhs per unit area (2000m^2) against an operational cost of approximately Rs. 1.9to 2.1 lakhs/crop resulting in a net benefit of Rs. 40,000 to 60,000per crop (Table 1).

Table 1: Economics of a 2000 m^2 mud crab polyculture pond stocked with 500 mud crab (*Scylla serrata*), 1200 milkfish, 7500 *Penaeus indicus*, and 15 Seabass juveniles.

Capital Investment	Amount (Rs.)
Pond construction	25,000
Pumps, engine, pipelines and motors	25,200
Aerator	27,000
Electrical lines and circuit	5,000
Farm tools and accessories	4,500
Total capital investment	86,700
Fixed cost	Amount (Rs.)
Lease value/rental	1,000
Depreciation on capital investment	8,670
Interest on capital investment	6,936
Repair and maintenance	5,000
Total fixed cost	**21,606**
Variable cost	Amount (Rs.)
Pond preparation	10,000
Cost of mud crab seed (500 nos~ 42 kg @ Rs. 700/Kg)	29,400
Cost of milkfish fingerlings (1200 nos@ Rs. 8/seed)	9,600
Cost of sea bass Juveniles (15 nos @ Rs. 70/seed)	1,050
Cost of Penaeus indicus PL (7500 nos @ Rs. 0.7/PL)	4,500
Thrash fish (525 Kg @ Rs.60/Kg)	31,500
Feed for milkfish (CIBA Poly plus @ Rs. 35/Kg for 864 Kg)	30,240
Fertilizer	2,000
Chemicals	12,500
Fuel and electricity charges	9,500
Fencing	30,000
Labour	17,500
Harvesting charges	3,000
Transportation	3,000
Miscellaneous cost	2,500

Total variable cost	**1,96,290**
Gross returnsTotal yield: Milk fish	480 Kg
Rate/Kg: Milk fish	Rs. 120/Kg
Total yield: Mud crab	120 Kg
Rate/Kg: Mud crab	Rs. 1500/Kg
Total yield: Seabass	14 Kg
Rate/Kg: Seabass	Rs. 400/Kg
Total yield: Shrimp	50 Kg
Rate/Kg: Shrimp	Rs. 300/Kg
Gross return	**Rs. 2,58,200**
Economic parameters	Amount (Rs)
Total gross return	**2,58,200**
Total fixed cost	**21,606**
Total variable cost	**1,96,290**
Total cost	**2,17,896**
Net return on TC	40,304
Net return on TVC	61,910
BCR on TC	1.18
BCR on TVC	1.31
Rate of return on capital investment TC basis	18.49%
Rate of return on capital investment TVC basis	20.53%
Total revenue (Rs/ha/crop)	**2,01,520**

BRACKISHWATER AQUACULTURE FOR FOOD, EMPLOYMENT AND PROSPERITY

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