Agro Economist - An International Journal
Citation: AE: 4(2): 99-107, December 2017
DOI: 10.5958/2394-8159.2017.00017.2

Aquaculture for Doubling the Farmer's income

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ABSTRACT

Farming community in India is highly diverse with respect to land holdings (large progressive farmers with big land holdings to small/marginal farmers with small holdings) and farming activity (crop cultivation, horticulture, floriculture, dairy, poultry, fisheries and many other allied activities). Operating small land holdings for sustainable economic benefits is becoming unviable due to many socio-economic factors and changing climate. For resource deficient small/marginal farmers, income flows are inadequate for supporting farm households. Productivity and farm income is declining and farmer community is sinking into poverty, indebtedness and distress due to uncertainties of input/output prices and markets, coupled with adverse impact of policy action and climate change. Doubling farmer's income was initiative taken by Prime Minister of India, Mr. Narendra Modi on 28 February, 2016 so that the income of farmers can be doubled by 2022. In order to enhance farmers' income, there is a need to increase farm productivity through technological interventions, improve market access, and also to develop the industrial and service sectors to support various farmer activities in terms of marketing and processing of their produce and other requirements in terms of self-employment/employment in farming sector.

Keywords: Farming, marginal farmers, productivity, Mr. Narendra Modi, farmers,

Aquaculture, as a weapon to fight poverty and reduce inequality has received renewed attention in recent years. All over the world, more than 30 million fishers and fish farmers and their families gain their livelihoods from fisheries. Global fish production has grown steadily in the last five decades with food fish supply increasing at an average annual rate of 3.2%, outpacing world population growth at 1.6%. Capture fisheries and aquaculture supplied the world with 167.2 million tonnes of fish in 2014 of which 93.4 million tonnes was from capture fishery and 73.8 million tonnes from aquaculture (FAO, 2016). In the same year, total production of India was 10.69 million tonnes which included 3.491 million tonnes from capture fishery and 6.577 million tonnes from aquaculture (State_of_Indian_Agriculture, 2015-16) and noticed increase at an annual rate of about 5.2% in compare to population growth rate at 1.3%. The domestic demand of fish is expected to cross the 16 million tonnes mark in 2025. Aquaculture sector is having tremendous potential but still the potential of this sector has not been harvested completely. The future potential of this sector towards food security depends on its sustainability in terms of its ecological, social and economic contexts. Fundamentally there are three ways in which income of farmers may be enhanced as shown in Fig. 1.

MATERIALS AND METHODS

The present paper was an attempt to find out the scope of aquaculture in doubling the farmers' income. Various studies and research findings were

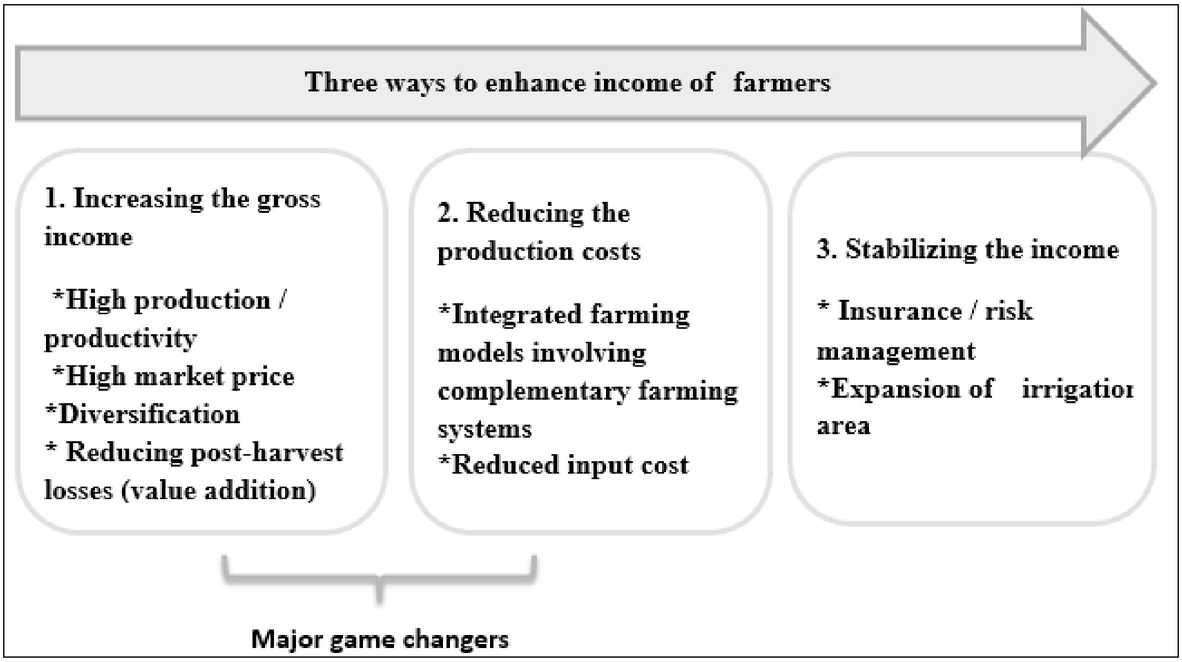

Fig. 1: Ways to enhance farmers' income

considered for determing the role of acquaculture and the ways in which the sector can contribute in oubling the farmers' income. The comparative economics of Integrated Farming Systems were also assessed to find out the best possible model for increasing the farm income.

RESULTS AND DISCUSSION

Aquaculture for enhancing farmer's income

The strategic plans for doubling farmers' income need to be addressed at State levels in harmony with the existing resources and climate as well as the traditional farming practices being practiced by the different farming communities of the states. As far as aquaculture is concerned, its role in doubling farmer's income can be addressed in three major ways:

1. Incorporating of aquaculture as a diversification component within the existing farming system
2. Utilizing degraded lands (salt affected and/or waterlogged) for aquaculture to help the farmers earn more from their poor or zero earning waste lands.
3. Enhancing productivity and profitability of farming communities already into aquaculture through:
   - ❑ Developing climate change resilience
   - ❑ Species and farming system diversification
   - ❑ Reduction in production cost
   - ❑ Reduction of post-harvest losses/through value addition

Aquaculture incorporation as a diversification component within the farming system

Integrated farming system is a resource management strategy which aims at increased productivity, profitability, sustainability, balanced food, clean environment, recycling of resources and income round the year. 'Aquaculture' can serve as a 'Synergistic Component' when integrated with any agricultural or livestock farming system as it is the only farming system where variety of agricultural and livestock wastes/byproducts can be utilized as a potential feed resource and (or) manure and converted into high value animal protein. Considerable potential lies in the integration of aquaculture and irrigation systems (Fernando and Halwart, 2000; Moehl *et al*. 2001) and aquaculture can make also use of land that is unsuitable for agriculture, such as swamps or saline marsh areas. In addition, there is a wide diversity of inland and coastal aquatic resources including rivers, floodplains, lakes, reservoirs, rice fields, estuaries, lagoons, coral reefs, mangroves, and mudflats that provide opportunity for the integration of well-controlled, sustainable aquaculture, enhancement or other form of aquatic animal management, into rural development (IIRR *et al*. 2001). Economics of a Sustainable Farming System model for Irrigated Agro-ecosystem as assessed by Jayanthi *et al*. 2003 is presented in Table 1.

Aquaculture integration with agriculture for irrigation

In view of depleting water resources, there is need to store water for irrigation and groundwater recharging. Aquaculture (fish farming) ponds, if incorporated as a component in an agricultural setup for rain water harvesting and storage, can serve as an 'Irrigation Tank' for agricultural fields for more efficient nutrient management in agriculture field (reduction in production cost) as well as resource for ground water recharging and producing fish.

Fruit, vegetables and forestry trees around the pond dyke

For efficient utilization of available land resources, it is proposed to grow vegetables, flowers, fruits and forest trees on and around the dykes of the aquaculture ponds. It will give extra income besides fulfilling needs of the farm household (diverse food production and additional regular income) and will also generate substantial green waste foliage for recycling in the fish pond as feed (input cost reduction).

Paddy cum fish farming

It is another successful system which can be adopted in regions where paddy is grown through traditional extensive culture practices without use of chemicals (organic farming), with special reference to pesticides. Paddy field is a rich source of organisms (plankton, algae, periphyton, molluscs, worms, insects, larvae of insects etc.), which serve as an excellent food for the growing fish and fish excreta serves as fertilizer for the crop (enhanced rice yield). Fish also increases release of nutrients from the soil by stirring/burrowing action and make them available for the rice crop. Fish also checks weed growth in the paddy field and serve as a biological agent for control of many significant crop pests breeding in water (reduced crop damage). In china, 47-51% less stem borers has been reported in paddy cum fish culture systems as compared to monoculture of paddy. An economic field survey conducted by Bangladesh Agricultural University (Bangladesh) revealed 1.92 and 2.84 times higher returns from rice cum fish culture system as compared to rice monoculture with and without hired labor, respectively. Another study conducted in India by CIBA to evaluate effect of pond area ratio on system performance and impact of harvesting in coastal zone of West Bengal revealed that paddy cum fish farming with 20% area as pond provided more profit of ₹ 19000/ha than 30% area utilized as fish pond.

Aquaculture integration with livestock

The main potential linkages between livestock and fish production concern use of nutrients, particularly reuse of livestock manures for fish production. The term nutrients mainly refer to nitrogen (N) and phosphorous (P), which function as fertilizers to stimulate natural food web in an aquaculture

Table 1: Economics of a Sustainable Farming System model for Irrigated Agro-ecosystem of Varanasi and Chandouli region of NEPZ of UP

Farming system	Production (kg/ha)	Cost of production (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)
Cropping alone	12,222	24,922	61,112	36,190
Crop + fish + poultry	31,858	44,627	159,292	114,665
Crop + fish + goat	39,610	51,483	178,047	126,564

Source: Experiment undertaken at Coimbatore, Tamil Nadu (low land) by Jayanthi et al. 2003

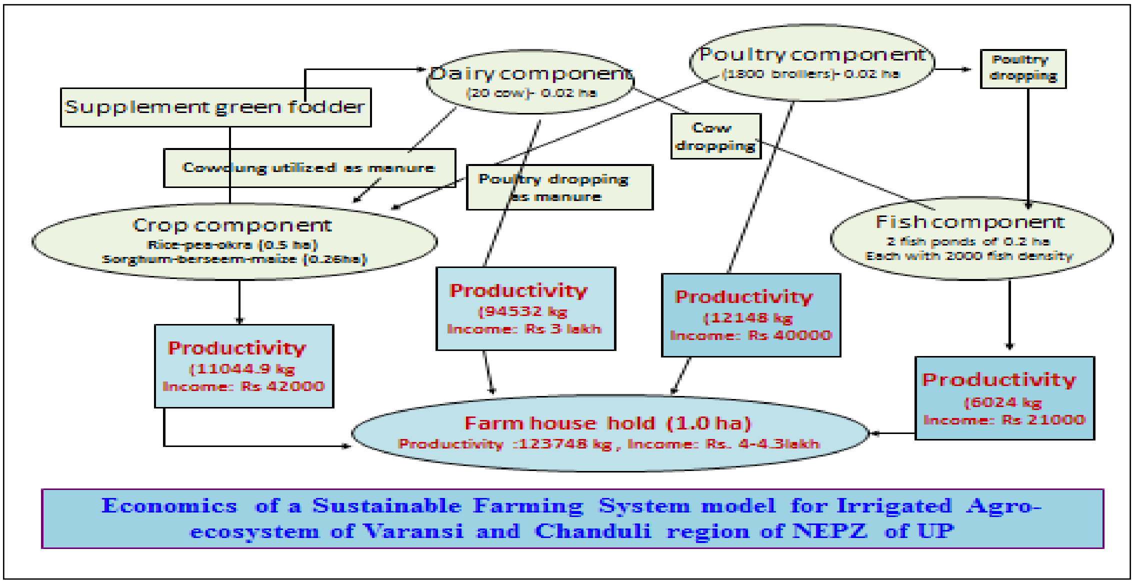

Fig. 2: Comparative economics of different integrated farming models

system. Production wastes include manure, urine and spilled feed which may be used as fresh inputs or processed in some way before use. Aquaculture can be integrated with variety of livestock farming systems including cattle-fish system, pig-fish system, poultry-fish system, duck-fish system and goat-fish system. In this practice, excreta of cattle, pigs, chicks, ducks or goats are recycled in the pond as manure/fertilizer or as direct feed for the fish. Hence, the expenditure towards chemical fertilizers and supplementary feeds for fish culture is not only reduce but also there is economy of space and the income has been found to be more than that of exclusive fish farming in ponds.

Promoting aquaculture for degraded lands

Degradation of land due to salinization and/or water logging has forced the farming community to work on daily wages. In the Indus-Ganga plains of North-Western India, salt affected soils are found in the states of Rajasthan, Gujarat, Punjab, Haryana, Bihar and Uttar Pradesh. Further, underground salinity and water logging has devastated agricultural productivity in over 24 lakh ha area in these states. Aquaculture development in the salt affected waterlogged waste lands will help in expansion of the sector without any undesirable effect.

Various aquaculture technologies involving freshwater carp culture in low saline areas (< 5 ppt salinity) and brackish water finfish fish (sea bass, mullets, peral spot, milk fish) and shell fish (tiger prawn and vannamei shrimp) culture in medium to high saline area (10-20 ppt salinity) have been developed and are available for adoption and replication in these areas (GADVASU, Ludhiana and CIFE sub-centre at Rohtak).

During last five years, freshwater carp culture has been adopted in over 250 ha of low inland saline water areas of south west districts of Punjab and brackish water shrimp (*Litopeneaus vannamei)* culture has been taken up in medium to high saline waters in Haryana.

Aquaculture has helped the debt ridden farmer to earn good returns of about 40,000-60,000/acre/year from their poor or zero earning waste lands (livelihood/income generation) and additional protein rich food production in the form of fish/shrimp (enhanced food and nutritional security) through horizontal expansion in conflict free resources unfit for any other farming practice. As compared to carp culture, vannamei shrimp is far more remunerative with a short culture period of 100-120 days. From a single crop, a net income of ₹ 3-4 lakh can be earned from 1 acre pond in a short period of 4 months, which is much higher than the income from any other agriculture or livestock (www.icar.org.in and www.ciba.res.in).

Enhancing productivity and profitability of farming communities already into aquaculture

Income and profitability of farming communities engaged in aquaculture also need to be enhanced through measures as discussed below:

Developing climate change resilience and species diversification

Make aquaculture more resilient /adaptive to climate Change by developing climate resilient technologies through modification of culture technologies by species and farming system diversification and by boosting adaptive capacity through community/ farmer level strategies and ecosystem level strategies. There is need to introduce some high value species of high demand and market price to increase profit margin of the farmer. Suitable species for diversification in freshwater aquaculture for higher productivity and income are pangas catfish, freshwater prawn and Amur carp.

Pangas catfish was first introduced into India in the year 1997 in the state of West Bengal from Bangladesh. It is most suitable species for diversification & productivity enhancement in India. In 2004, farmed area was about 40,000 ha with a production of 820,000 to 1500,000 tonnes. Now it is largely cultured in Andhra Pradesh with production of 50 lakh tonne/annum from 32000 ha of pond area having productivity of 12.5 to 50 tonnes/ha/yr and farmers are earning net Income- of 6-7 lakh/ha/yr. Although, pangas catfish is a cold sensitive species (does not survive below 20 ˚C temperature), has a limited culture period (April to October) and its seed has to be air lifted from far off states (West Bengal and Andhra Pradesh), but it has substantial scope in diversification along with additional benefits of productivity as well as farmer income enhancement (net profit 4-5 lakh/ ha/6 month) in northern states also.

Freshwater prawn had been successfully reared in nursery as well as in grow-out ponds with culture period of 45-60 days and 7-8 months respectively, produced 1.2t/ha in 8 months and earned net income of ₹ 2.50 lakh/ha in Haryana. Although, freshwater prawn is a cold sensitive species has a limited culture period (April to October), it has immense potential in diversification along with additional benefits of productivity as well as income enhancement.

Amur carp is superior carp breed released by Karnataka Veterinary, Animal & Fisheries Sciences University (KVAFSU), Bidar. Amur breeder seed has been supplied to both government and private hatcheries to use them as brood stock for the further multiplication and spread to different parts of the country and tested under different culture system (polyculture and monoculture). In Farmer's pond attained 268g against 99.5 g attained by local strain at stocking density of 5000/ha with 34.33% increase in Growth rate. Suitable species for diversification in brackish water aquaculture for higher productivity and income are shrimp, grey mullet, milk fish, sea bass and cobia.

Grey Mullets is fast growing euryhaline brackish water fish species which attains weight of 400 g in 8 months and grow faster during 2nd yr. it is good candidate species for monoculture and polyculture with shrimps. Its production yield is 2 to 2.5 t / ha in 8 months and fetch good market price of ₹ 100-120 kg.

A polyculture trial of mullet with *M. japonicus* conducted at West Bengal revealed that *M. cephalus* fingerlings (12 g) stocked at 1600 nos./ha along with Kuruma shrimp grew to 197 g in 90 days with 40% improved productivity and 30%more survival of Shrimp and Mullets from this culture system yield additional revenue of 73% as compared to monoculture.

A study conducted by CIBA for Grey mullet demonstration in farmer's backyard ponds with carps or tilapia resulted in higher mullet productivity as presented in Table 2.

Milk fish is fast growing fish (particularly 1st yr), hardy and euryhaline in nature which feed on lab-lab (algae) and suitable fish species for polyculture. A study conducted in Namkana, West Bengal revealed that by stocking milk fish fingerlings @ 7000/ha for 10 months, net income of ₹ 83000/ha can be earned.

Sea bass can be grown in fresh, brackish and marine waters, highly carnivorous feed on trash fish. A grow-out trial conducted at Madanganj, Namkana with hatchery produced seed at farmer's pond with stocking density@ 10000 nos/ha along with tilapia as forage fish for a period of 9 months had been produced 1.57 tonne of Sea bass from 1 hectare of pond area.

Table 2: Economics of Grey mullet demonstration

Pond area (ha)	0.07	0.135
Stock density / ha	3000 + 300 IMC	3000 + 300 tilapia
Size at stocking	10.2 g/9.4 cm	10.2 g/9.4 cm
Feeding	Rice bran + mustard cake @ 3% biomass 2/3 times per wk.	No feeding
Size at harvest	156.2 g / 24.2 cm	213 g / 27.5 cm
Total productivity (kg/ha)	351 (61% from Mullet)	417 (83% from Mullet)

Ornamental Fisheries for livelihood generation

Ornamental fisheries has more advantage over traditional farming system as it provide more income per unit area with less land requirement as it can be easily carried out Indoor under controlled conditions. It is manageable in smaller areas with lesser impacts of climate change and providing number of employment opportunities. People can easily earn ₹ 5000-6000/month from a low cost back yard ornamental unit of 500ft^2. Small home units can get additional monthly income ₹ 2,500-5,000 with involvement of women and children.

Input cost reduction

Production cost can be minimized by decreasing feed cost. As supplementary feeding cost more than 60% of total input cost. Feed cost can be decreased by replacing costly conventional feed ingredients with low cost locally available non-conventional resources/ingredients (NCFR) to improve sustainability of the farming system by formulating low cost feeds. Non-conventional feed resources (NCFR) having good nutritive value and locally available include press mud, molasses, brewery waste, poultry incubator waste and aquatic plants (Table 3).

Table 3: Efficacy of aquatic plants for formulating low cost feeds

Aquatic plant	Inclusion rate	Yield enhancement	Net profit enhancement
Lemna	10 %	30 %	45%
Spirodella	30 %	43%	64%
Azolla	20%	28%	45%

Adoption of new technologies

Some of the new technologies recommended for large scale adoption are discussed as below:

Aquaculture Intensification

The current trend of increased production can be maintained, either through intensification or expansion of areas under aquaculture production. Intensification of fish production can be done by increasing stocking densities with quality seeds (larger and stunted one), optimizing feeding rate to improve water quality with optimal pellet size and optimizing water quality parameters with water exchange facility and standard health management practice. The practice of stocking of stunted fingerlings in grow-out ponds is of recent origin. Stunted fingerlings exhibit better growth in the grow-out phase, with high survival rates. Aerators must be used to complete the demand of dissolved oxygen due to higher stocking density. For very high production, re-circulatory aquaculture systems (RAS) may be adopted which economize water use with very high stocking density (more fish per drop) and totally feed dependent with very high production per unit area. But weak rural extension systems and a lack of local examples of intensified aquaculture limit farmers' ability and willingness to risk intensification (Halwart *et al*. 2003).

Intensive cage fish culture

The development of intensive inland and coastal cage aquaculture of high value fishes has been encouraged and supported by different governments, as an opportunity for developing remote rural areas. In India, cage culture is still in its infant stage and developing fast to culture tilapia. In tilapia cage culture, fry from the reproduction ponds are passed through a 3.1 mm mesh grader to remove fry larger than 14 mm. The smaller fry are stocked in cages of mesh size 1.5 mm and stocked at stocking densities of approximately 2-3,000 per square metre.

Genetic and reproduction technologies for enhanced aquaculture

In recent decades there has been a revolution in application of genomics and gene-related biotechnology in agriculture and aquaculture. Biotechnology research aims to increase production and reduce costs, especially through the manipulation of the genes and chromosomes of cultivated species. Improved Jayanti Rohu is the first genetically improved fish variety in India. Jayanti Rohu has higher growth percentage (17%) over traditional rohu. The inbreeding factor also less in Jayanti as compare to conventional rohu. Another fish is Amur Carp, Superior common carp breed released by KVAFSU, Bidar.

Mono-sex Culture

Mono-sex culture is based on the culture of fish by producing all males or all females depending upon the sex which have better food conversion ratio and growth rate. Mono-sex tilapia has great demand and value in the local and international market. As a result monosex tilapia farming rate is growing day by day.

Biofloc technology

Biofloc technology is a technique of enhancing water quality in aquaculture through balancing carbon and nitrogen in the system. The environmental friendly aquaculture system called "Biofloc Technology (BFT)" is considered as an efficient alternative system since nutrients could be continuously recycled and reused (Emerenciano, 2013). The sustainable approach of such system is based on growth of microorganism in the culture medium, benefited by the minimum or zero water exchange. These microorganisms (biofloc) has two major roles: (i) maintenance of water quality, by the uptake of nitrogen compounds generating "*in-situ*" microbial protein; and (ii) nutrition, increasing culture feasibility by reducing feed conversion ratio and a decrease of feed costs.

Disease Management

Use of specific pathogen free (SPF) and specific pathogen resistant (SPR) stocks reduce the occurrence of disease in shrimp farming. The specific pathogens for these programs are those listed as 'notifiable' by the OIE, representing direct trade concerns, as well as, significant threats to optimal production (OIE, 2000, 2001). Taking this technology beyond specific pathogens, there is exciting potential for this approach to be adapted to selection of lines with high non-specific immunity or high tolerance of physiological stresses that facilitate opportunistic infections or other pathology (Bedier, 1998).

Reduction of post-harvest losses/through value addition

The development of value-added products has a significant role in raising socio-economic status of fish farmers. Post-harvest losses can be reduced by efficiently utilizing fish wastage include fish head, viscera, skin, fins and scales which comprise 57% of the total fish. From this wastage different products can be prepared like fish meal, fish oil and skin gletin. Further, value added products like fish ball, fish cutlet, fish nuggets and fish fingers can be prepared from minced meat of 43% of total fish which enhance its market value and consumer acceptability. With this post-harvest processing techniques farmer can earn 30% extra profit than traditional marketing practices.

Cluster farming

In a cluster model, some farmers may ultimately choose to specialize in one aspect of the fish custody chain, such as in hatchery production, fingerling nursery, or feed manufacture. Other farmers then can 'cluster' around these nodes of aquaculture services and are able to concentrate their own efforts purely on fish grow-out.

Proposed Action Plan

3-tier action plan is required to enhance farmer's income through aquaculture:

- Research and development (R & D) institutes must search for new technologies to increase production, reducing input cost and disease management. Region specific need based technologies are required to be generated to address regional issues with respect to utilization of available resources for maximum food production with minimum ecological impacts. It not only reduces water stress related ecological issues, but also help the farmer in recycling low value farm wastes

- Policy makers (national/ State government) should develop promotional schemes and incentives for farming communities.
- Stake holders (farmers) must adopt the recent technology

CONCLUSION

Aquaculture has the potential to double the farmer's income if proper training and technologies could be made available to the farmers. It may also help in creating new jobs and improve food security among poor households. Rural aquaculture is a good option for rural development, making an important contribution to farm income with a high adoption rate among poor farmers. Fish farmers have gained an increased level of satisfaction by means of fish culture production growth along with corresponding economic gain. Aquaculture in combination with other farm enterprise in the coastal regions of the country significantly contributes to the livelihood security of farm families. On commercial scale, *Recirculatory Aquaculture System* is a technique for raising water borne animals in a closed (usually indoor) system which minimizes water consumption, provides maximum control of the livestock's environment, and reduces the risk of exposure to parasites, disease, and predators. Therefore, it may be considered a most environmentally friendly way of producing fish at a commercially viable level.

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