Successful cage culture (farming) initiatives by CMFRI during the 11th Five Year Plan

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Focal Points at a Glance

All the experimented work related to the introduction of cage culture (cage farming) in Indian coastal waters has been accomplished by CMFRI all along the Indian coast line to the stage of introducing commercially-oriented cage culture (cage farming) in Indian coastal waters. The author, who has been at the helm of the related developmental work as Director, CMFRI, presents in this write-up the results of successful cage culture (farming) experiments of CMFRI for the benefit of the entreprenuership. The nation is now very close to the commercial era of sea cages blooming up all along the India costline.

Central Marine Fisheries Research Institute (CMFRI) has initiated open sea cage farming as an R&D effort during 2006-07 with support from Ministry of Agriculture, Government of India. An indigenous cage of 15m diameter was launched at Visakhapatnam with primitive mooring techniques and stocked with 9000 nursery reared seabass seed of 50 g size. After 45 days the cage developed technical problems, drifted and hit the coast, and most of the fish escaped into the sea. However, the cage and nets were salvaged and analysed for several related issues. The juveniles retrieved had reached 150-350 g size which indicated good growth. With this valuable "setback" a new cage with modifications in design and mooring was launched in December 2007. Considering the previous experiences, importance was given to structural stability and safety of the cage. In this endeavour, the Indian Institute of Technology (IIT), Kharagpur, West Bengal was consulted, which collaborated in engineering aspects of the cage. As a consequence of this and for easy manoeuvring, 6 m diameter cages were designed recently, to cater to the needs of small farmers. The mooring and other aspects were also suitably modified. The volume of each cage is about 170 m^3 and production potential is about 4-5 t of fish. Further impetus was given by the participation of National Fisheries Development Board (NFDB) in the demonstration of open sea cage framing by sponsoring 14 cages of 6 m diameter. These cages were launched at different places, one at Sutrapada, Gujarat, 2 at Vasai, Maharastra, 2 at Mangalore, Karnataka, 2 at Cochin, Kerala, 2 cages at Pulicat, Tamil Nadu, one each at Nellore, Kakinada and Baruva in Andhra Pradesh and one cage near Balasore in Orissa. Apart from these, there are 12 cages including one with 15 m diameter, three each at Visakhapatnam in Andhra Pradesh, Mandapam in Tamil Nadu, Karwar in Karnataka and Vizhinjam in Kerala. In the mariculture farm at Karwar, at present there are 23 cages of different dimensions.

The demonstrations, covering almost all the maritime States, having different environmental and social conditions are in progress at the above places. For demonstration in some places, non-availability of seed hampered the work and stocking was delayed. In places where the cages were stocked, some teething engineering and social problems were encountered. So much so, the operation was restarted after the monsoon season. CMFRI has also done successful cage culture demonstrations in open backwaters in Kerala and brackishwater riverine systems in Andhra Pradesh using the 6 m diameter cages.

Potential for cage culture in India

The Indian fish production is contributed both by marine and inland sectors. The share of marine fish production in the total fish production declined gradually from 71% in 1950-51 to 38.16% in 2008-09, and that of the inland sector increased from 29% to 68.14% during the same period. On a global scale, the decline of fish stocks has been a motivating factor for expanding the role of aquaculture in the fishing industry (Baldwin *et al.*, 1999). The trend now a days demonstrates that while wild harvest volume remains stable (or is in decline in several fisheries) aquaculture production has increased. In this case, the system of cage farming has had an important role in meeting the global demand for fish products (Fredriksson *et al.* 1999).

Vast area available for aquaculture: The marine fishery resources of India include

waters along a coastline of 8129 km with numerous creeks and saline water areas, an Exclusive Economic Zone (EEZ) of 2.02 million km^2 and a continental shelf area of 5.3 lakh km^2 which contribute substantially to capture as well as culture fisheries. There are also about 3.15 million hectare reservoirs, 2.25 million ha of lakes and ponds, 0.82 million ha of *beels*, oxbow lakes, derelict water bodies and 1.19 million ha of brackishwater areas. These resources remain underutilised and can be considered for conversion into successful aquaculture ventures. Rational utilisation of these potential resources for cage culture can considerably improve fish production in India.

Abundant human resource: India has a huge human resource of about 14.66 million fishers population that includes adult fishers (8.7 million), full time (0.93 million), part time (1.07 million), and those who are involved in ancillary activities like net making, processing and fish vending (3.96 million). Development of mariculture through cage farming should be taken up with a focus on sustainability and production enhancement through empowering the fishers by achieving employment generation, social security and increased food security. These wild fish harvesters represent a highly trained workforce who has extensive knowledge of the ocean, boat handling, net mending and maintenance, fish harvesting and quality control that aquaculture companies can easily adapt to their own operations. To be engaged in mariculture through cage farming, they require only some basic training associated with standard farm operations and management.

Strong research and extension capabilities: There are 8 National Fisheries Research Institutes in India, with excellent infrastructure facilities and well experienced researchers in different areas of fisheries science. There are extension researchers as well as officers in different national and state level organisations which are also helpful when new and novel technologies like cage farming are introduced to aquaculture sector. Another group of available experts in the country includes technocrats, diploma holders and aquaculturists and entrepreneurs in aquaculture and allied sectors.

Central Marine Fisheries Research Institute (CMFRI) has pioneered in open sea cage farming and the institute has strong manpower with expertise in cage culture technology all over the country. This will be an added strength for entrepreneurs to have experienced consultants within the country rather than spending exorbitantly on foreign experts.

Strong domestic and export markets: The major advantage of Indian sub-continent is its ever demanding domestic market for fish. If the supply is assured during fishing ban seasons also, the returns to the farmers will be very lucrative. Similarly, if adequate post-harvest measures are adopted for live fish export to countries where such fish fetch good market price, export can also be enhanced. At present, shellfish are leading Indian export and the scenario will be changed if we can assure post production quality for harvested finfishes.

Capture Based Aquaculture (CBA): CBA was developed due to the market demand for certain high value species for which life cycles cannot be closed on a commercial scale. CBA is a world-wide aquaculture practice and has specific characteristics for culture, depending on the species and locality. Several studies and observations by CMFRI indicated that dol nets of Gujarat and Maharashtra, shore-seines of east coast, thalluvalai of southeast coast, Chinese dip nets of Kerala *etc* which are mostly operated between 2 to10 m depth, land juveniles/seed of high value species. The species include seer fish, pomfrets, mackerel, koth, ghol, shrimps *etc*. Also, there exists a good fishery for live juveniles of different species of lobsters with very little being used for fattening. It is estimated conservatively that about one million seer fish juveniles of 7-10 cm and two millions mackerel juveniles of 5-8 cm are landed by shore seines in the month of April alone along the stretch of Visakhapatanam- Kalingapatnam area. If only a small fraction of these juveniles are brought in live condition, they form a very good source of CBA without affecting the ecosystem and livelihood of fishermen. Similarly the juvenile yellow fin tuna available in plenty in and around Lakshadweep waters can be used for farming in cages. The only precaution to be taken in CBA is that it should not target any single species, which might lead to vulnerability to endangering/ extinction in future. CBA enhances marine fish production and reduces the wastage of resource as low value bycatch and also ensures regular supply of high quality seafood items.

By harnessing the potential resources by means of cage culture, the fish production of the country can be doubled or even multiplied in terms of efficiency and sustainability.

Cage culture by CMFRI (2007-12)

Cage structure and frame: CMFRI has developed and experimented with five versions of indigenously fabricated cages at different locations in India. With funding from the Union Ministry of Agriculture and National Fisheries Development Board, CMFRI had introduced open sea cage culture in almost all the maritime States. The first three versions were done with 15m diameter high density polyethylene (HDPE) cage. A successful demonstration was carried out with the third version, by involving modifications suggested by

Table 1: Cage culture sites along the Indian coast

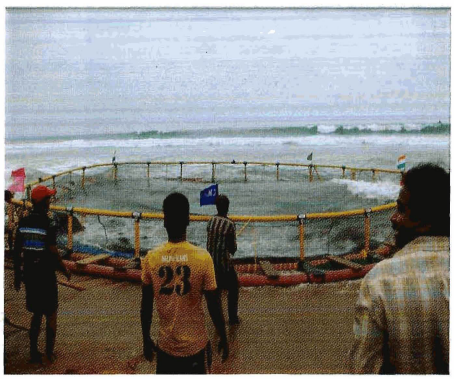
Sl. No.	Cage culture sites	Maritime state
1.	Sutrapada, Veraval	Gujarat
2.	Kalamb, Mumbai	Maharashtra
3.	Karwar	Karnataka
4.	Byndoor, Mangalore	Karnataka
5.	Cochin (open sea & backwater)	Kerala
6.	Vizhinjam	Kerala
7.	Balasore	Orissa
8.	Uppada, Kakinada	Andhra Pradesh
9.	Srikakulam	Andhra Pradesh
10.	Visakhapatnam	Andhra Pradesh
11.	Nellore	Andhra Pradesh
12.	Chemmanchery, Chennai	Tamil Nadu
13.	Kanyakumari	Tamil Nadu
14.	Mandapam	Tamil Nadu
15.	Antarvedi, Narsapur (Godavari estuary)	Andhra Pradesh
16.	Nagaya Lanka, (Krishna estuary)	Andhra Pradesh

Table 2: Species cultured in cages

Sl. No.	Location	Species
1.	Antarvedi	a)Asian sea bass b)Pompano
2.	Balasore	Asian sea bass
3.	Byndoor, Mangalore	a) Asian sea bass b) Red snapper
4.	Chennai	a) Asian sea bass b) Lobster *P. homarus*
5.	Kalamb, Mumbai	a) Lobster *P. polyphagus*
6.	Kanyakumari	a) Asian sea bass b) Lobster *P. homarus*
7.	Karwar	d) Cobia d) Red snapper e) Pompano f) sea bream
8.	Kochi	a) Pearl spot b) Red snapper c) Grey mullet
9.	Mandapam	a) Lobster *P. homarus* b) Asian sea bass
10.	Nagaya Lanka	Pearl spot
11.	Srikakulam	Asian sea bass
12.	Sutrapada, Veraval	Lobster *P. polyphagus*
13.	Uppada, Kakinada	Asian sea bass
14.	Visakhapatnam	Asian sea bass
15.	Vizhinjam	a) *L. calcarifer*

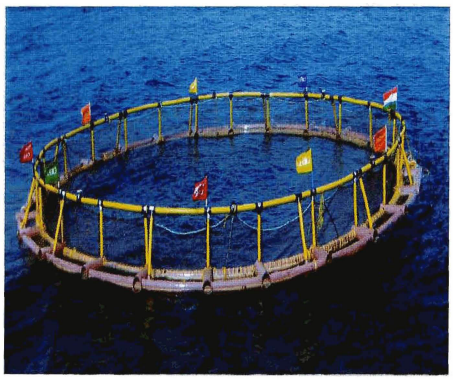
marine engineering and naval diving experts. The successful harvest of sea bass was done in April 2008. The fourth version had to be taken into consideration for easy manoeuvring and cost effectiveness of cages in terms of initial capital investment and reduced labour. Thus the size of the cage was optimised at 6 m diameter and the culture of finfishes and shellfish at different locations was demonstrated. The latest version is a cost effective epoxy coated galvanised iron (GI) cage designed at Karwar Research Centre of CMFRI for low investment farming operations. These types of cages are ideal for small entrepreneurs and farmers who have only limited extent of funds to invest in cage culture. Other innovation by CMFRI is the 2 m diameter seed cages for nursery rearing of fry in open waters or ponds and small scale farming of omnivores like pearlspot in Kerala. Based on this, artisanal cages of rectangular frame have been used widely in Byndoor, Karnataka for snappers, pearl spot and mullets.

Mooring: Two types of cages launched by CMFRI are the floating and the stationary. The floating cages are moored in open sea at single point using heavy weight (3-5 tonnes) gabion bag and allowed to rotate in accordance with the water movements. At many instances Gabion bags were found to be better than expensive anchors for mooring. For the stationary cages in



Version I

Version II



Version III

Version IV

Version V

Plate 1: Different Versions of Cage Frames

Plate 2: Mooring of Cages

Gabion box

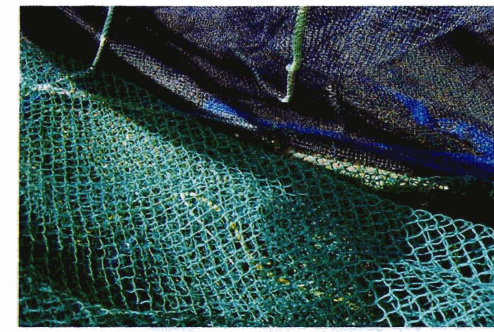
Gabion Box filled with stones

Single Point Mooring in Sea

Fixed mooring in backwater

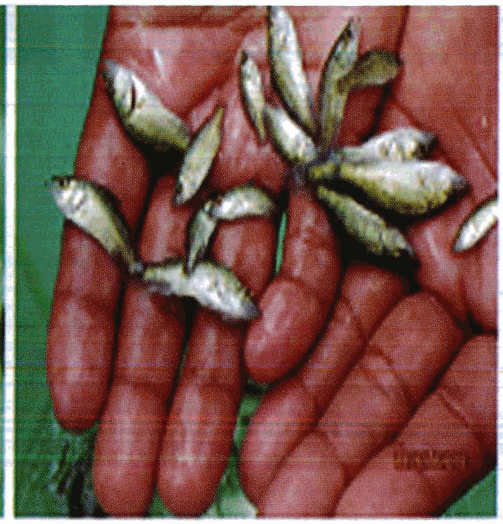
Plate 3: Nets used in Cage Culture

HDPE Inner Grow-out Net



Inner Sapphire & Outer HDPE nets

Plate 4: Different phases of cage culture at Antarvedi, East Godavari District, A.P



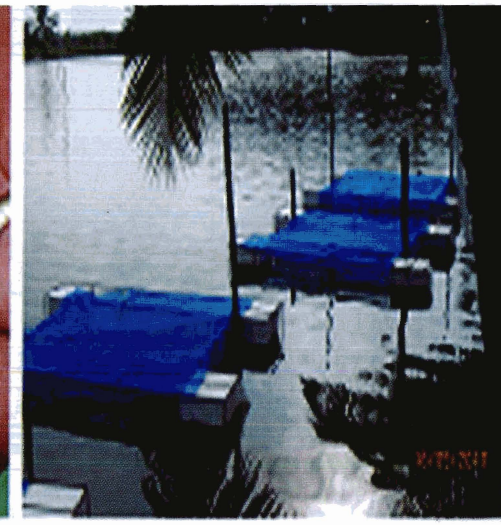
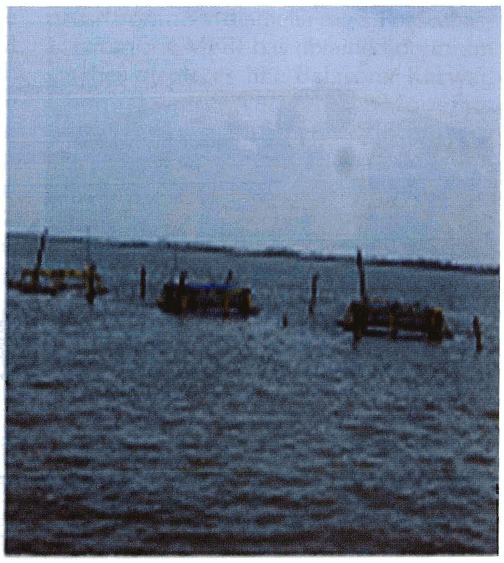
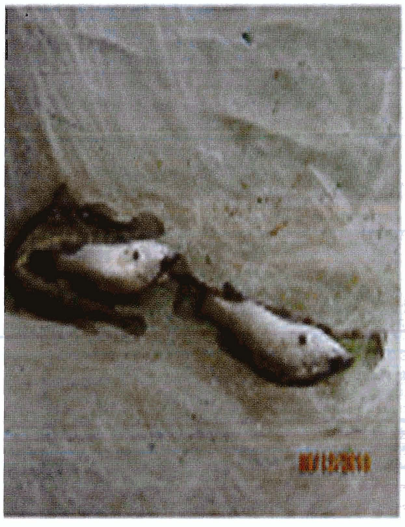
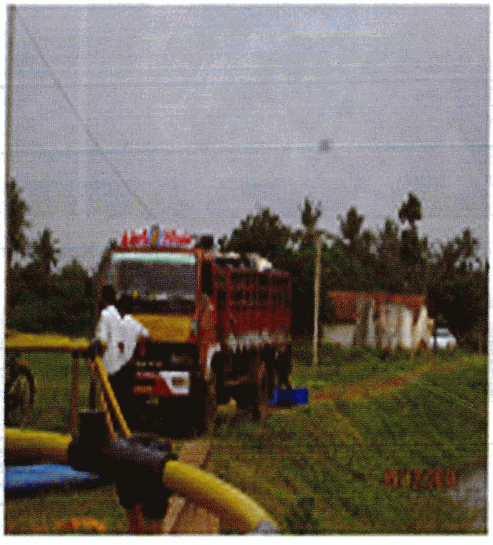


Plate 4 (continued): Different phases of cage culture at Antarvedi, East Godavari District, A.P



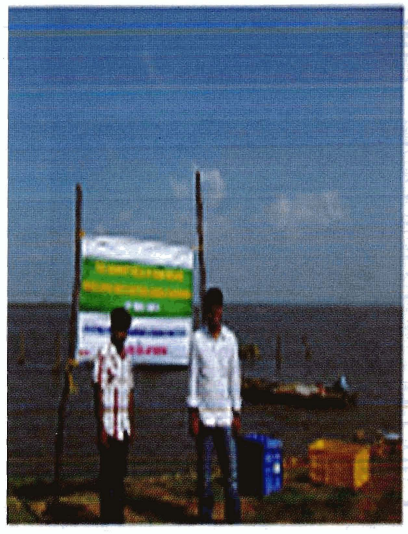
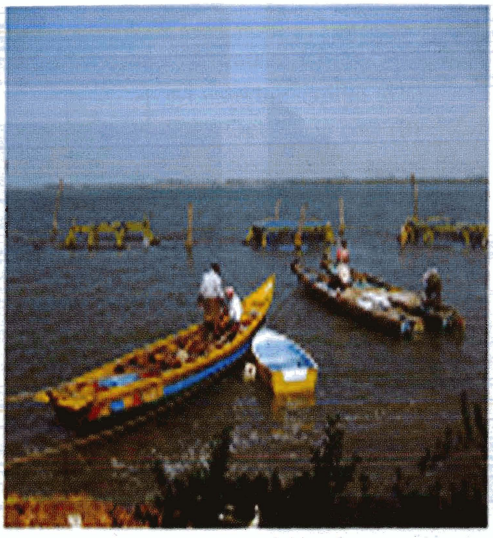




Plate 5: Cage culture at Nagaya Lanka, Krishna District, Andhra Pradesh

Plate 6: Seabass and Lobster Harvest (Chennai, Cochin, Kanyakumari)

estuarine areas and river systems, where space is restricted for free rotation of the cage, mooring was done by small anchors as well as by tying to fixed poles.

Nets: Three types of nets are used in each cage. Outer protection net made of braided HDPE (3 mm twine) prevents any attack by predators (mesh size 60 mm), grow-out net made of either HDPE or sapphire netting of varying mesh size (10 mm- 40 mm) depending on the fish size and a nylon or HDPE bird net (80 mm mesh) on top prevents bird attack. The net depth varies with the depth of the cage site (mostly 4.5-6.0 m for 6 m diameter cages).

Cage Sites: Site selection which is considered as top priority in cage culture has been done with utmost caution at all places because it affects fabrication costs, operating costs, growth and survival rate of the fish, and the longevity of the cages. CMFRI has selected sites along almost all the maritime States in India and demonstrated it to be operationally suitable at many places even with restraining situations prevailing. The different sites where CMFRI has demonstrated cage culture are given in Table 1. Other than open sea cage culture sites, open backwater at Cochin and riverine systems of Andhra Pradesh were also selected for cage culture.

A model cage farm with more than 20 units has been developed by CMFRI at Karwar for mariculture activities. After the initial demonstration by CMFRI, now the culture activities are being done in a PPP mode at Kerala and Andhra Pradesh. Self help groups, landless fishermen and aquaculturists are involved in such ventures. The entire technological support is given by the institute staff at its various centres all over the country. This has created vast awareness and confidence in cage culture among the group as well as the public in such localities.

Species: Species selection for cage culture was done mainly based on seed availability, growth rate and market value. CMFRI has done cage culture of different finfishes and shellfishes (Table2). Farming of Cobia, seabass, pearl spot and mullets were demonstrated successfully in cages. Though shrimps were farmed, due to WSSV attack the farming could not be sustained. However, lobster fattening was successfully carried out at Kanyakumari and Chennai in Tamilnadu in Gujarat, and in Mumbai. However, only the fishermen at Kanyakumari are carrying on with it due to the attractive incentives they receive on lobster fattening.

Feed: Trash fish was used for seabass in all the cages. The logic behind was the effective utilisation of by-catches and discards as feed for fish in cages. However, in certain instances, low value fish were purchased and fed to seabass. For mullet and pearl spot, scampi feed with wheat bran was used as feed initially. Lately, for omnivores and herbivores, and pompano, low protein (20-25%) floating pellets (Uno & Godrej) are being used in cages.

Disease management: Disease management has not been a major issue in cage farming as on date. However, scanty instances of vibriosis had been observed and managed with minor interventions.

Harvest: In all cases, harvest was decided based on the size of fish, season, market demand *etc.* CMFRI had harvested up to 3.5 of fish from a 6 m diameter cage. For seabass *L. calcarifer* CMFRI has obtained optimum catches at places like Balasore, Karwar, Chennai and Antarvedi. Moderate production was obtained at Cochin and Mangalore. Grey mullet *Mugil cephalus* and pearl spot recorded good catch at Cochin. Spiny lobster *P. homarus* fattening was successful at Vizhinjam, Mandapam and Kanyakumari.

Challenges for cage culture in India

Lack of clear regulations for use of open waters: The Indian seas and other open water resources are open to all Indians and the lack of any policy in utilisation of open waters is a

Economic performance of cage culture of Sea bass, Pompano and Cobia (for two cages)*

Sl.No	Details of cost and returns	Amount (in Rs.)
1	Initial investment for installing a 6m diameter cage (including cost of mooring, nets and other one time installation costs)	4,15,000
2	Fixed cost (For crop duration of six months)	
	a)Depreciation	48,417
	b)Insurance (2% on investment)	8,300
	c) Interest on Fixed capital (12%)	29,050
	d) Administrative expenses	8,300
3	Total Fixed cost (A)	94,067
4	Operating costs	
	a) Cost of seedlings	1,50,000
	b) Cost of feed & feeding	2,50,000
	c)Labour charges	52,500
	d) Boat hiring charges for feeding, watching, net changing etc.,	70,000
	e) Harvesting, marketing and other charges	1,50,000
	f) Maintenance and securityg) Interest on working capital (6%)	30,000 26,338
5	Total Operating cost (B)	9,28,838
6	Total cost of production (Seven months)	10,22,904
7	Yield of sea bass/pompano/cobia (in kg) (Two crops)	10,000
8	Gross revenue	18,00,000
9	Net income (5)-(6)	7,77,096
10	Net operating income (Income over operating cost)	8,71,163
11	Cost of production (Rs./kg) (6)/(7)	102
12	Price realized (Rs./kg) (8)/(7)	180
13	Capital Productivity (Operating ratio) (5)/(8)	0.52
14	Annual Rate of return	75.97%
15	Rate of return to investment	188.09%

*For Pearlspot, mullets ,lobsters the calculation will vary

major challenge in establishing cage culture. Allocation of suitable areas for cage farming, by means amicable to fishermen and other users of the sea (navigation, tourism *etc.*) has to be done in order to commercialise cage culture in Indian waters.

Technological challenges and concerns about competition from aquaculture: Since the industry is new, several stake holders many come with their offers, but without any proven technology. In such instances, the experiences of CMFRI are valuable, but have to be properly recognized by the concerned. Due to lack of awareness and insecure feeling, fishermen resist to take up any venture in the sea/ open waters. Only solution for this is to make them aware of the technology and get involved in cage culture operations.

Site selection: Site selection is a major challenge in determining commercial viability of cage culture. Identifying a location that has the optimum water quality (temperature, oxygen, light and nutrient levels), current movements and other infrastructure facilities is the most critical factor in cage culture. This has to be tackled by the expertise available with national institutes like CMFRI and other oceanographic data from organisations working in that line.

Cost of cages: The initial cost of the investment for 6 m diameter HDPE cage frame has come down and now it can be got for less than Rs.1,50, 000 which is quite affordable and economically viable with a life of at least 5 years. The cost of GI cage for calm areas will cost only Rs 50,000. The cost is further cheap for smaller dimensions to be installed backwaters and calm areas.

Species selection and seed availability: Though the availability of seed in adequate quantities is one of the present challenges in the expansion of cage culture, seed production technologies which have been developed for some marine finfish like Cobia, Pompano, Pearlspot and Seabass can be scaled up to commercial levels if demand arises. The hatchery seed production of many high value marine finfishes and shellfishes is complex and expensive due to the high costs involved in the establishment of broodstock and hatchery facilities. The complicated larviculture procedures for such species involving mass production of appropriate live feeds, their nutritional enrichment, feeding protocols, grading, water quality maintenance, nursery rearing and disease management needs expensive infrastructure and expertise. The establishment of a National Biosecure Brood bank under the control of CMFRI is suggested to maintain sustainable quality seed production in future. The concept is that the Institute will maintain the brood bank of major species which cannot be accomplished by private hatcheries due to technical and economic considerations and limitations. The Institute will supply required quantity of fertilised eggs/first day larvae which can reach any destination in India within 24 hours for further development. It can be supplied at a nominal cost to entrepreneurs and, by utilising the capacity of idle hatchery facilities massive marine fish seed production can be accomplished, which can be sustainably used for better utilisation of many abandoned high saline coastal ponds. Capture based aquaculture (CBA) is the alternative for those species for which hatchery technology is not developed. This is the only way to increase the marine fish production in India.

Cage management: Cage culture management must result in optimising production at minimum cost. The management should be so efficient that the cultured fish should grow at the expected rate with respect to feeding rate and stocking density, minimise losses due to disease and predators, maintain optimum environmental parameters and efficiency of the technical facilities. Physical maintenance of cage structures is also of vital importance. The frame and net-cages must be routinely inspected. Necessary repairs and adjustments to anchor ropes and net-cages should be carried out without delay. Exchange of nets should also be considered, as this ensures a good water exchange in the net, thereby washing away faeces, uneaten food and to a certain extent reduce the impact of fouling.

Fouling of cage net: Fouling of cage nets and other structures has been observed at many instances, as a challenge in cage farming. However, it has been taken care by net change and efficient management measures. The most easy and economic way is to have extra nets and change of nets at regular intervals and their reuse. The net costs are considerably lower now and are available for less than Rs 15,000/ 6m x 6m net.

Economic analysis: The success of the adoption of any innovation or new technology lies in its economic performance. The rate of return per rupee invested is the economic indicator that guides the investor to choose a particular enterprise or practice. Besides, the analysis of the economic performance serves as an indicator for the investor to allocate his resources in the enterprises. This becomes very much essential, since the resources are scarce and the investor is interested to invest his scarce capital resource in that enterprise that gives the maximum return for his investment.

The economic performance of the cage culture done by CMFRI had been worked out by calculating the annual fixed costs, variable costs and the annual total costs from the cost side. From the returns point of view, the harvest from the cage, the gross revenue from the sales of the product had been worked out. Using the cost and returns figures, the economic indicators were estimated to test the economic viability and financial feasibility of the operation.

Conclusion

In the existing challenges of filling the gap between growing demand and capture fisheries supply, mariculture production has to satisfy the need of the time in terms of nutritional security and optimum production. Significant progress is being made by CMFRI in this area through cage culture as evidenced also in scientific achievements and production trends. The economic analysis of the cage culture has also been worked out in certain cases with higher net operating income and net income in a crop period of seven to nine months. Cage culture has attained wide publicity through audio, video and print media, research publications, training and exhibitions organised by CMFRI. It has to be noted that once the practice is further expanded as a commercial venture, the cost will considerably reduce due to the economies of scale of operation. Cage farming is a viable alternative and economically and financially feasible aquaculture operation for the stake holders. However, with its development cage culture must be sustained in future by research and development in genetics, nutrition, health management, production economy, product handling *etc*. Future project assessments should involve not only technological and socio-economic considerations, but also its environmental efficiency, especially in terms of carrying capacity in a water body. The effective role of developmental agencies as partners is a prerequisite and it is very essential for transfer of technology through massive demonstrations and reaches every farmer/ fisher with the message *'Grow fish and reduce exploitation'*.