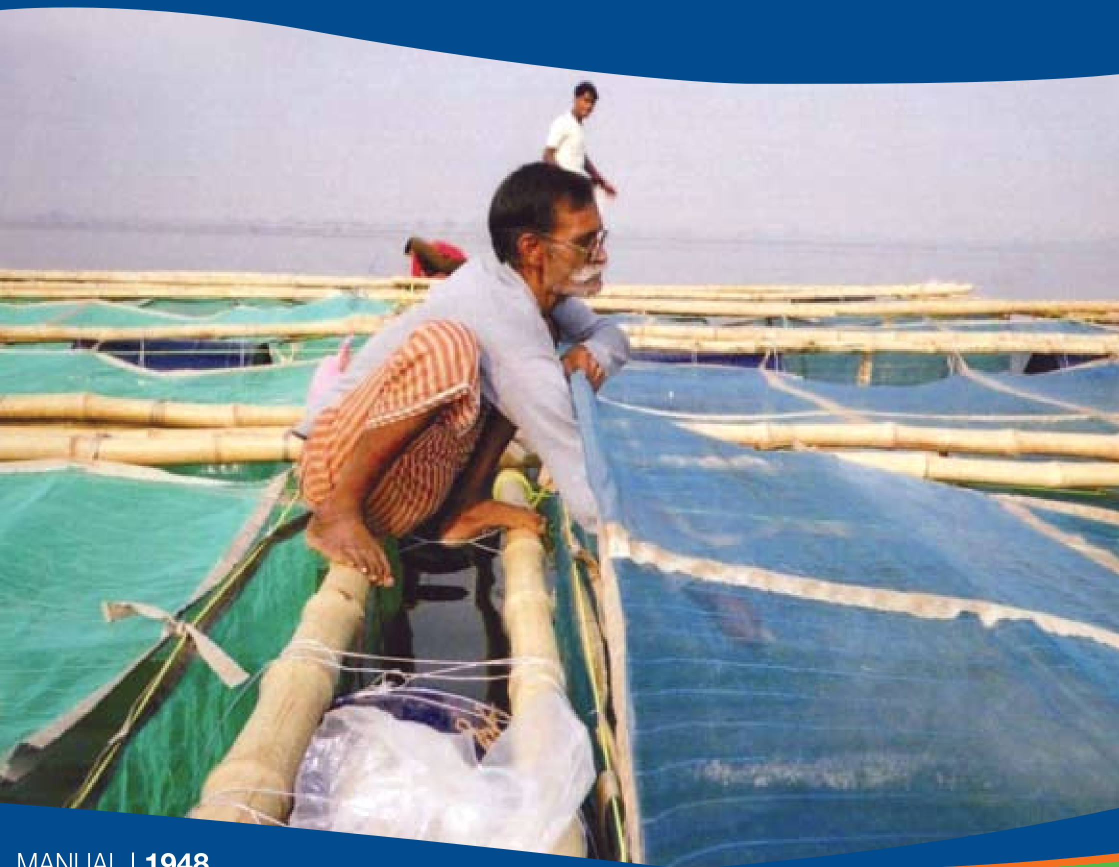

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Cage Culture in Reservoirs in India

Technical manual prepared for the Project: Improved fisheries productivity and management in tropical reservoirs, CP-PN34: Challenge Program on Water and Food

CGIAR Challenge Program on WATER & FOOD

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Cage Culture in Reservoirs in India
(A Handbook)

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CAGE CULTURE IN INDIAN RESERVOIRS

WHAT IS CAGE CULTURE?

Cage culture is when fish are reared from fry to fingerling, fingerling to table size, or table size to marketable size while captive in an enclosed space that maintains the free exchange of water with the surrounding water body. A cage is enclosed on all sides with mesh netting made from synthetic material that can resist decomposition in water for a long period of time and is sold under the brand name Netlon. Cages are generally small, ranging in freshwater reservoirs from 1 square meter (m^2) to 500 m^2. Several small cages combined in a battery, as described below, are suited for even intensive culture.

WHY CAGE CULTURE?

The reservoirs of India have a combined surface area of 3.25 million hectares (ha), mostly in the tropical zone, which makes them the country's most important inland water resource, with huge untapped potential. Fish yields of 50 kg/ha/year from small reservoirs, 20 kg/ha/year from medium-sized reservoirs and 8 kg/ha/year from large reservoirs have been realized while still leaving scope for enhancing fish yield through capture fisheries, including culture-based fisheries. The success rate of auto-stocking is very low in Indian reservoirs, especially in smaller ones. Many of the smaller reservoirs dry up during the summer, partly or completely, with no stock surviving. A policy of regular, sound and sustained stocking would greatly augment fisheries in such water bodies. The prime objective of cage culture discussed here is to rear fingerlings measuring >100 millimetres (mm) in length, especially carp, for stocking reservoirs.

Stocking with the right fish species, using seed of appropriate size and introducing it at the right time are essential to optimizing fish yield from reservoirs. Though 22 billion fish fry are produced every year in India, there is an acute shortage of fish fingerlings available for stocking reservoirs. Where fingerings are available, transporting them to reservoirs usually incurs high fingerling mortality. In this context, producing fingerlings *in situ* in cages offers opportunity for supplying stocking materials, which are vital inputs towards a programme of enhancing fish production from Indian reservoirs.

ADVANTAGES OF CAGE CULTURE

Cage culture is suitable to a wide range of open freshwater ecosystems, especially reservoirs. It efficiently exploits water bodies, tapping their natural productivity and thereby reducing pressure on other resources. It uses simple technology and locally available resources for cage construction and operation, making it economically, socially and environmentally sound. As carp feed at a low trophic level, rearing carp fingerlings has minimal impact on the environment. Polyculture of carp species with various feeding habits makes wise use of resources, as the different feeding habits of various species and their acceptance of a wide range of supplemental feeds maximizes fingerling uptake of feed while minimizing competition among species, feed waste and the resulting pollution.

Cage culture eliminates losses to predation and facilitates prophylactic measures to contain any outbreak of disease, allowing very high fingerling survival rates. It makes effective use of manpower, as daily maintenance routines and monitoring are relatively simple, and harvesting is rapid, easy, sure and complete. As cage culture can be practiced intensively, high yields can be achieved very cost effectively. Since most reservoirs in India are designated for multiple uses, including supplying drinking water, cage culture is appropriate because it is minimally polluting and maintains the ecological health of the reservoir.

CONSTRAINTS OF CAGE CULTURE

Unless managed carefully and correctly, cage culture can have certain drawbacks. Cages occupy space on the surface of water bodies and, if poorly positioned, may disrupt navigation or diminish the scenic value of the reservoir. Poorly placed cages may alter current flows and worsen sedimentation. Inappropriately intensive or poorly managed cage culture may pollute the environment with unconsumed feed and fish faecal waste, causing eutrophication.

During the summer months, cages may be damaged by strong winds or flooding, but this risk can be avoided by properly anchoring batteries of cages in protected inlets away from strong currents. Theft is rarely a problem in culturing fish to fingerling size.

As particular problems exist where intensive cage aquaculture is practised for producing marketable fish or prawns, the technology is used in Indian reservoirs only to rear fingerlings, with limited use of supplemental feed. As most of the reservoirs are in transition from an oligotrophic to a mesotrophic state, with very few in danger of eutrophication, the controlled discharge of waste products from cage culture can be immensely helpful in maintaining water nutrient levels.

STEPS OF CAGE CULTURE

- Types of cage
- Site selection
- Procurement of cage materials
- Frame fabrication
- Floating the frame
- Fitting the catwalk
- Installation of cages
- Selection of stocking materials
- Stocking
- Grow-out period
- Supplementary Feeding
- Cage and stock maintenance
- Removal and release
- Economics of cage culture
- Cost of production of each crop

TYPES OF CAGE

Four types of cage are used in cage aquaculture: fixed, floating, submersible and submerged. The fixed cage is the most basic and widely used in shallow water with a depth of 1-3 metres. It consists of net bag fitted to posts and is normally placed in the flow of streams, canals, rivers, rivulets, shallow lakes and reservoirs, not touching the bottom. Fixed cages are comparatively inexpensive and simple, but their use is restricted. Floating cages, on the other hand, are supported by a floating frame such that the net bags hang in water without touching the bottom. Floating cages are generally used in water bodies with a depth of more than 5 metres. Enormous diversity in size, shape and design has been developed for floating cages to suit the wide range of conditions of fish culture in open waters. The net bags of submersible cages are suspended from the surface, have adjustable buoyancy, and may be rigid or flexible. Submerged net bags are fitted in a solid and rugged frame and submerged under the water. Their use is very limited.

SITE SELECTION

The selection of site for cage culture is very important, as success often depends largely on proper site selection. Potential sites vary according to the size and shape of the reservoirs where cages are to be installed. The critical issues in selecting sites are the following:

- The depth of the water column should be at least 5 metres.

- Water quality and circulation should be good, free from local and industrial pollution.
- In large and medium-sized reservoirs, sites should be in sheltered bays for protection from strong winds. In small reservoirs, the cage should be anchored in the deeper lentic sector to avoid the current flow through sluice gates and irrigation channel.
- They should be safe from frequent disturbance from local people and grazing animals.
- There should be access to land and water transportation.
- They should be devoid of algal blooms to avoid fouling.
- They should be free of aquatic macrophytes and high populations of wild fish, which can cause oxygen stress.
- Cages should be placed where they will not hinder navigation.
- They should be at a distance from bathing and burning ghats.
- Sites should be secure.

PROCUREMENT OF CAGE MATERIALS

Making cage culture economically viable demands the preparation of a comprehensive list of materials available on local markets:

Bamboo. Bamboo poles should be straight, rigid and light, such as the *bhaluka* type from Assam, which is commonly available in local markets. Poles should be 7.5 metres long, with an internode circumference of about 26 centimetres (cm) at the base, 25 cm in the middle and 24 cm at the tip. This means a diameter of 8-9 cm and wall thickness of 2.5 cm at the base. Fifty-six bamboo poles are required to make one frame.

Floats. Empty 200-liter steel drums with tightened lids make suitable floats 88 cm long, 180 cm in circumference, 58 cm in diameter and weighing 22 kg. Twenty-four drums are required to float a frame 13.75 metres long and 11.05 metres wide, with drums sandwiched between upper and lower frames.

Figure 1. Cage materials

Figure 2. Cage materials

Floats are painted with acrylic paint and fastened with the frame with glazed iron (GI) wires.

Nuts and bolts. Steel bolts 18 cm long and 3 cm in diameter, with nuts, are used to fix bamboo poles at the corners and at the middle joints on the side. A total of 120 such nuts and bolts is required to ensure a sturdy bamboo frame able to withstand waves even during a cyclone.

Sinkers. Sinkers are locally available stones weighing 3-4 kg that are tethered to the bamboo frame with nylon ropes at the corners and along the sides to help cages maintain their rectangular shape. The bottom portion of Netlon cages is tied to the nylon ropes running down to the sinkers such that the Netlon does not bear the weight of the sinker but the ropes maintain the shape of the cage. Eight Netlon cages require 48 sinkers, with eight sinkers maintaining the underwater shape of each cage.

Anchors. Large, locally available stones weighing 40-50 kg or more are used as anchors that rest on the reservoir bottom to hold the cages in place. Two anchors are tied with Garware-brand thick nylon rope to every corner of the frame, and another anchor is tied to the centre of each long side, thus requiring 10 stones for each cage.

Figure 3. Cage anchor

Netlon. High-density propylene extract (HDPE) plasto nets with 1.5 mm mesh are used to prepare Netlon cages for rearing fingerlings to >100 mm from fry initially measuring 10-25 mm. A rectangular cage measuring 5x3x3 metres is convenient to operate. The cage is totally enclosed with Netlon on all four sides, the bottom and the top (to prevent predation by birds). Small flap openings at two top corners allow feeding and harvesting. The Netlon should be well stitched with doubly laced nylon ribbon 3.8 cm in width at the corners and joint, with loops at the corners and sides. The same nylon ribbon stitches together the upper and lower lids at regular intervals to make

Figure 4. Netlon cages

the cage more sturdy. Eight cages are hung from bamboo frame and tied with the sinkers at the bottom corners to keep them straight and hanging vertical. Thus in a battery of eight net cages has a good functional volume of 360 m^3, of which 320 m^3 (40 m^3 in each cage) is under water. The net cages are tied with silk rope to the frame to keep them straight.

FRAME FABRICATION

The frame of the cage can be made from locally available bamboo, which is a cheaper option than wood, steel or polyvinyl chloride (PVC) and will last for at least 3 years, with 5-10% of the poles replaced as needed. Two frames are required, one above water and the other below, to hold the floats firmly. The useful life of bamboo poles in the underwater frame is much longer than for those on top.

Figure 5. Cage framing

Fully grown, cured bamboo poles at least 7.5 metres long and 8-9 cm in diameter at the base are best suited to make the frame. To make a battery holding eight cages, each measuring 15 m^2, the battery should be 13.75 metres long and 11.05 metres wide. To make such a frame, 32 bamboo poles are required for the top frame and 24 for the lower frame.

Figure 6. Installation of frame

Four poles are used to make one long side of the rectangle. Two poles are placed on the ground with their tip portions overlapping to make their combined length at least 14.5 metres. Six such lengths are made for the two long sides and the central divider. Each long side and the central divider consists of two such 14.5-metre lengths placed parallel 35 cm apart.

The short sides of the frame are made using similarly paired poles with a combined length of 11.75 metres. Ten such lengths are required for the two short sides and three partitions, again with two lengths placed parallel 35 cm apart. (The difference between the frame above the surface and the underwater frame is that the latter has only two partitions, instead of three, which is why it requires eight fewer poles.) Where the lengths cross at 90 degrees they are fixed with a bolt and nut, creating the rectangular frame of the battery, with inner partitions from which to hang eight net cages.

FLOATING THE FRAME

The battery of eight cages is buoyed by 24 steel drums. The drums are sandwiched between the two frames, one above the surface and the other below, placed mostly in the corners and near joints to provide the frame with balanced buoyancy. The drums are attached to the frame with two types of GI wire. The thicker, 2 mm wire is used at the central portion, and the thinner, 1.5 mm wire is used for encircling the drum with the frame at the end portions to better tolerate wave turbulence, especially during summer and storms. The drums are painted with acrylic paint before being attached to the frame. Only 16 cm of the drums' 58 cm of diameter is under the surface of the water when bearing the frame.

FITTING THE CATWALK

Catwalks made of locally available bamboo cross-beamed with wood are wired to the top of the bamboo frame with GI wire for ease of access. Care should be taken while wiring on the catwalks so that the wire ends do not damage the net cages. With the floats and catwalks wired to the frame, the assembly is towed to the selected site and anchored.

Figure 7. Catwalk on frame

INSTALLATION OF CAGES

Once the frame is anchored at the culture site, the next step is to tie on the Netlon cages, eight to a battery. Along the top, silk ropes are used to tie the nets to the bamboo frame firmly to prevent sagging. Sinkers are tied to the bottom corners and the sides of the Netlon cages to hold them vertical. The hanging net cages should remain at least 1-2

Figure 8. Installing frame at site

metres above the lake bottom to avoid damage caused by crabs and other bottom dwellers. Local fishers should be instructed not to tie their gillnets to the frame, as this may damage it. The net cages should be left in the water for at least a week before stocking to allow algae on grow on the netting. Curing the net thus reduces injury to fry.

Figure 9. A total cage view

SELECTION OF STOCKING MATERIALS

Many species are suitable to grow in cages. The present objective is produce fingerlings primarily of Indian major carps, as well as to grow some common carp (*Cyprinus carpio*) and grass carp (*Ctenopharyngodon idella*) provided that the food niches are sufficient for their further growth after stocking in the reservoir. First, the locality should be surveyed to see what stocking species are available. If there is nothing satisfactory, fry must be transported from West Bengal, where carps are available and less expensive than in other parts of India. If transported packed with oxygen, the fry can withstand a journey of 40 hours. The fry should be healthy when purchased and come from a clean water body with low eutrophication.

Figure 10. Fish seeds (fries)

Figure 11. Oxygen packing of fish seeds

STOCKING

For raising fingerlings in cages in Indian reservoirs, healthy carp fry measuring 12-15 mm long, or even up to 25 mm, are best suited. Advanced fry longer than 35 mm should be avoided for cage culture to fingerling size, as they routinely are affected by fungal diseases such as *Seprolegniosis* if collected from nurseries that have eutrophied. Indian major carps are especially prone to fungal diseases. A stocking density of 250 carp fry measuring 12-18 mm per cubic metre is best for cages installed in Indian reservoirs. Fry should be shifted late in the day or early in the evening to allowing conditioning at the site of procurement and acclimatization at the site of release in cages. Conditioning is required to transport the fry with empty stomachs, as the ammonia and carbon dioxide generated by fish waste may prove lethal to fry during transport. Fry acclimatization is essential at the site of release in cages to ensure a balanced environment, especially in terms of temperature. The oxygen packets transported with the fry (1,000 fry in 4 litres of water in a polythene packet 2/3 filled with oxygen) are kept inside cages for at least an hour before the fry are released. Prior to release, fry are subjected to some prophylactic measures to protect them from diseases and ecoto-parasites. They are dipped in a 5-6% salt solution as well as potassium permanganate (5-8%) for 1 to 2 minutes and then released into the cage water.

Figure 12. Transporting of fish seeds

Figure 13. Fish seeds shifting to cages

Figure 14. Fish seeds stocking in cages

GROW-OUT PERIOD

Raising carp fingerlings in cages generally requires 60 to 120 days, depending on the water body's natural productivity and the quality of supplementary feed. A culture period of 60 days was observed for Indian major carp fry measuring 12-16 mm to grow beyond 100 mm in cages installed in Pahuj

Reservoir at Jhansi, Uttar Pradesh, from 16 August to 16 October 2008. The same growth took 120 days in Dahod Reservoir near Bhopal, Madhya Pradesh, from 10 August to 10 December 2008, with feed materials and amounts the same in both reservoirs (Table 1). The reason for the difference is that natural productivity in Pahuj surpassed Dahod to a great extent during that period.

SUPPLEMENTARY FEEDING

Feeding is essential for carp fry in captivity, as the natural food in many Indian reservoirs may not be sufficient for their growth even to fingerling size. Feeds should be available locally and inexpensive to contain production costs. Carp accept a wide variety of feed, providing a range of options for selecting locally available feed ingredients with an eye on cost. In general, rice bran and mustard oil cake blended 1:1 provides a mixture with vitamins, amino acids and minerals available at concentrations of 0.01%. As the cages are installed in reservoirs and subjected to waves, it is not advisable to provide supplementary feed in floating trays, as is the practice in cages installed in wetlands or calm lakes. In general, the fine, flaky powdered form of rice bran and mustard oil cake mixed together is spreading over the water surface inside each cage twice daily at 08:00 and 17:00 hours, at a rate of 3-5% of aggregate fry body weight. Initially, 3-4 kg of feed is applied per cage per day. This is reduced as time passes. Feed floats on the water surface for a time before sinking slowly, thus favouring in succession the feeding habits of surface feeders like *C. catla*, column feeders like *L. rohita* and bottom feeders like *C. mrigala*, as well as common carp. Excessive feeding should be avoided in cages, as it may pollute the environment and hamper the growth rate of stocked fish. Feed usually comes in bulk, requiring proper storage to protect it from excess humidity and heat, insects, rodents, fungi, and contaminants. The spoiled feed can become less palatable and nutritious to fish, or even toxic. So, due care has to be taken to keep feeds properly and maintain their quality.

Figure 15. Feeding of fish seeds

CAGE AND STOCK MAINTENANCE

Monitoring water quality. Water quality parameters that must be monitored in the cages are dissolved oxygen, acidity, free ammonia and phosphate. Indian reservoirs normally maintain water parameters suitable for rearing

Figure 16. Monitoring of cages

fingerlings in cages, though very rarely an algal bloom may push some parameters to the point of threatening fish survival.

Cleaning Netlon cages. Cages should be cleaned with soft brush fortnightly to remove algae, sponges and other organisms. Floating macrophytes that waves sometimes push against cages should also be removed. Any dead fish should be removed from cages immediately and disposed of in a pit. Covering dead fish with lime helps contain any disease. Deaths should be recorded to facilitate later analysis of disease outbreaks.

Routine checking. Loose twine, mesh torn by predators, anchors and sinkers must be checked routinely and immediately mended or replaced as needed. Repair torn mesh with patches to keep fry from escaping. With the onset of bad weather, anchors should be checked and fastened tightly.

Fish stock monitoring. Routine checks of fish health help prevent massive fry loss. Fish health can be easily checked by monitoring fry response when feed is applied. Signs of ill health include surfacing, lesions, rashes, spots, lumps, excessive mucus formation, woolly mat formation, bulging eyes, and fin and tail erosion. Appropriate prophylactic measures should be applied as necessary and at least fortnightly. Remove the fry from the cages and soak them for 2 minutes in a 5-6% salt solution followed by 5-8% potassium permanganate solution to eradicate ecoto-parasites. A 20-30% potassium permanganate solution may be spread on the water surface inside the cages. At times, a lime solution may be spread inside the cages to clear the water.

Monitoring of growth rate. Samples should be taken at a regular interval to assess fry length and weight to monitor growth. This information is important for maintaining fish health and optimal feeding, as well as for scheduling the harvest.

REMOVAL AND RELEASE

Fingerlings are removed and released in batches. As fry grow at different rates, they must be segregated by size to prevent the slower growers from falling further behind. Fingerlings that reach the length of 70-80 mm should be harvested, thinning the cage population to allow the smaller fry to grow more quickly. Harvesting generally occurs in three batches as fingerlings approach 80 mm in length. Records should be kept of the length and weight of harvested fingerling batches. Cage culture of fingerlings in the reservoir that is to be stocked saves transport costs and minimizes fingerling mortality. Using the procedure described above should yield a fingerling recovery rate of at least 70%.

Figure 17. Removal of fish fingerlings

Figure 18. Removal & release of fish fingerlings

Figure 19. Release of fish fingerlings

Table 1: Cage culture in Pahuj Reservoir, Jhansi, and Dahod Reservoir, Bhopal

Reservoir	Grow-out period	Fish species	Initial length (mm)	Initial weight (grams)	Final length (mm)	Final weight (grams)	Recovery (%)
Pahuj	16 Aug-16 Oct 08	*C. catla*	11.0-15.0	0.10-0.12	80-180	6.12-74.88	87.80
		L. rohita	10.0-14.0	0.05-0.07	79-108	4.95-13.39	82.00
Dahod	10 Aug-10 Dec 08	*C. catla*	11.0-16.0	0.10-0.12	72-108	6.06-23.50	72.28
		L. rohita	10.0-17.0	0.04-0.08	68-124	4.10-19.20	77.71
		C. mrigala	12.0-17.0	0.03-0.06	62-110	3.89-14.26	72.30

Figure 20. Result of stocking

ECONOMICS OF CAGE CULTURE

Rearing fingerlings from fry using cage culture in the reservoirs to be stocked is more cost-effective than using either pens or nurseries. One battery of eight cages as described above is sufficient to produce stocking materials for a water body of 200 ha. Three crops of fingerlings can easily be harvested per year.

The useful life of HDPE plasto nets is at least 1 year and, with minor repair, may extend to 2 years, depending on their management after each harvest. Nets should be cleaned immediately after the harvest, dried in the sun, and either stored properly or immediately reused. After a year of use, Netlon may be sold as scrap for 7-8% of the initial procurement price.

As steel drums used as floats have only 27% of their surface area under water, they can easily be rotated immediately after the harvest to allow repainting the previously submerged portion. To maximize the useful life of the drums, the whole drum should be repainted annually. Steel drums used as floats can be used for at least 5 years, during which time 15 fingerling crops can be harvested. After 5 years of use, they can be sold for 40% of their procurement price.

Bamboo poles used for frames normally last for 2 years, with 10% of poles needing to be changed every year. The poles used in the submerged frame will last for more than 3 years with proper care and management. Used bamboo poles may be sold for 5% of their initial price.

The thicker nylon ropes used for anchors serve for more than 5 years, especially the portions that remain under water. The silk ropes for tying Netlon cages with bamboo frame last for at least 2 years.

COST OF PRODUCTION OF EACH CROP

The capital investment for a battery of eight cages covering 120 m^2 with a working volume of 320 m^3 is Rs4,117 per crop. Recurring expenses come to Rs18,275 per crop. This yields a production cost per crop — allowing for depreciation, interest, additional expenditures, and inflation — of Rs28,013. The market price of 70,000 fingerlings is Rs75,000, including transport, for the first 2 years and Rs93,500 for the remaining 3 years. The income per crop, cultured over 3 months, is Rs61,642. This yields a highly favourable cost:benefit ratio of 2:20, with the production cost per fingerling estimated at Rs0.40. If the fingerling culture period is reduced to 2 months, the production cost drops to Rs0.37, enhancing the cost:benefit ratio to 2:25.

The detailed economics of cage culture for a grow-out period of 3 months per crop at the price prevailing during 2007/08 is given in tables 2-4.

Table 2: Economics of cage culture with a grow-out period of 3 months at the Indian rupee price in 2007/08

1. Capital cost

A. Cage frame	Size/weight	No/kg	Unit cost (Rs)	Life (years)	Depreciation (yrs)	Total cost (Rs)	Cost/crop (Rs)
Steel drums	200 litre	24	550	5	70	1,680	560
Bamboo poles	7.5 metre	56	110	3	30	1,680	560
Transport		1 truck	800	5	160	160	53
Measuring tape	Large	1	100	10	10	10	3
Nuts & bolts	18 cm	120, 9 kg	60	5	11	99	33
GI wire	2 mm	20 kg	70	1	70	1,400	466
GI wire	1.5 mm	25 kg	70	1	70	1,750	583
Pliers	Medium	2	70	2	35	70	23
Bucket, mug & strainer	Large	2 each	70 +10+10	5	14+2+2	36	12
Cutter	Medium	2	50	10	5	10	4
Paint	Primer	3 kg	50	2	25	75	25
Paint	Acrylic	4 kg	120	2	60	240	80
Labour	Painting	8	100	1	100	800	266
Labour	Framing	8	100	1	100	800	266
						Frame subtotal	**2,934**

B. Netting							
Net cage	45 m^3, l.5 mm	8	800	2	350	2,800	933
Silk rope	1.27 cm diam.	5 kg	200	5	40	200	66
Nylon rope	1.27 cm diam.	10 kg	70	3	23	230	77
Nylon rope	2.5 cm diam.	20 kg	80	5	16	320	107
						Netting subtotal	**1,183**
Total capital cost (A + B)							**4,117**
2. Recurring Costs							
Labour	Net tying	5	100	1/3	300	1,500	500
Fry	12-18 mm	10,000	0.12	1/3	0.36	36,000	12,000
Feed	dust, flaky	270 kg	12	1/3	36	9,720	3,240
Agrimin nutr. supplement	dust, flaky	3 kg	45	1/3	135	405	135
Labour	Daily feeding	1	1,000/ month	1/3	9,000	9,000	1,000
Labour	Cleaning, etc.	10	100	1/3	300	3,000	1,000
Labour	Harvest	4	100	1/3	300	1,200	400
					Total recurring cost per crop Rs18,275		**18,275**

Production cost per crop, including interest, additional expenditure and inflation, is Rs28,013.

Income: Market price of 70,000 fingerlings @ Re1.00/fingerling is Rs75,000, including transport, for the first 2 years and @ Rs1.25/ fingerling is Rs93,500, including transport, for the remaining 3 years. Thus income is Rs89,655.

Expenditure: Rs28,013; Benefit: Rs61,642 and benefit:cost = 2.20; Production cost of one fingerling: Rs0.40.

Table 3: The material requirements and economics of fish seed raising in cages in Indian reservoirs

Item/Particular	Dimension	Unit	Quantity	Rate (Rs)	Amount (Rs)	Life (year)	Depreciation (Rs)	Cost per crop, @ 2 crops/year (Rs)	Cost per crop @ 3 crops/year (Rs)
Nonrecurring Costs									
Capital costs									
Floats (PVC drums)	200 litre	Number	24	550	13,200	10	1,320	660.00	440.00
Bamboo	7.5 metre	Number	56	110	6,160	5	1232	616.00	410.67
Nuts and bolts	18 cm	No./kg	120/ 9	60	540	5	108	54.00	36.00
Iron wire	2 mm	kg	20	70	1,400	1	1,400	700.00	466.67
Iron wire	1.5mm	kg	25	70	1,750	1	1,750	875.00	583.33
Saw	Medium	Number	2	50	100	10	10	5.00	3.33
Measuring tape	Large	Number	1	100	100	10	10	5.00	3.33
Cutting pliers	Medium	Number	2	70	140	2	70	35.00	23.33
Net cage	45 m^3, 1.5 m	kg	8	800	6,400	2	3,200	1,600.00	1,066.67
Silk rope (diameter)	1.27cm	kg	5	200	1,000	5	200	100.00	66.67
Nylon rope (diameter)	1.27cm	kg	10	70	700	3	233	116.67	77.67
Nylon rope (diameter)	2.25 cm	kg	20	80	1,600	5	320	160.00	106.67
Bucket, mug & strainer		Number	2 each	45	90	5	18	9.00	6.00
Paint	Primer	kg	3	50	150	2	75	37.50	25.00
Paint	Acrylic	kg	4	120	480	2	240	120.00	80.00
Fixed capital cost		**Rs**					**10,186.33**	**5,093.17**	**3,395.44**

Labour for frame & repair	Day	Person-day	8	100			800	200.00	133.33
Labour for netting & repair	Day	Person-day	5	100			500	125.00	83.33
Labour for paint & repair	Day	Person-day	8	100			800	200.00	133.33
Interest on fixed capital		Rs					982.91	449.45	299.63
Total fixed cost		**Rs**						**6,067.62**	**4,045.07**
Recurring Costs									
Seed	12-18 mm	Number	100,000	0.12				12,000	12,000
Feed	Dusk, flaky	kg	270	12				3,240	3,240
Agrimin	Dusk, flaky	kg	3	45				135	135
Transportation	Number	Truck	1	800				800	800
Feeding	Month	Person-day	3	1,000				3,000	3,000
Cleaning	Day	Person-day	10	100				1,000	1,000
Harvesting	Day	Person-day	4	100				400	400
Miscellaneous		Rs						500	500
Total expenditure		Rs						21,075	21,075
Interest on variable cost		Rs						1,264.50	1,264.50
Total variable cost		**Rs**						**22,339.50**	**22,339.50**
Total cost		**Rs**						**28,407.12**	**26,384.57**
Fingerling production	**70-100 mm**	**Number**	**70,000**	**1**	**70,000**				
Cost of production	**Per fingerling**	**Rs**						**0.41**	**0.38**
Value of fingerlings		**Rs**		**1**	**70,000**			**70,000**	**70,000**
Benefit:cost ratio								**2.46**	**2.65**

Table 4: Economics of fish seed rearing in cages in Indian reservoirs		
Item	**Per crop @ 2 crops/year (Rs)**	**Per crop @ 3 crops/year (Rs)**
Total fixed cost	6,067.62	4,045.07
(percent of total cost)	(21.36)	(15.33)
Total variable cost	22,339.50	22,339.50
(percent of total cost)	(78.64)	(84.67)
Total cost	28,407.12	26,384.57
Number of fingerlings produced	70,000	70,000
Cost of production/fingerling	0.41	0.38
Value of fingerlings @ Re 1/fingerling	70,000	70,000
Benefit:cost ratio	2.46	2.65

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- Enhancing fishery productivity in small reservoir in India.
- Building fish enclosure in Lake Nasser.
- Engaging local communities in aquatic resources research.
- Producing Tilapia in small cage in West Africa.

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