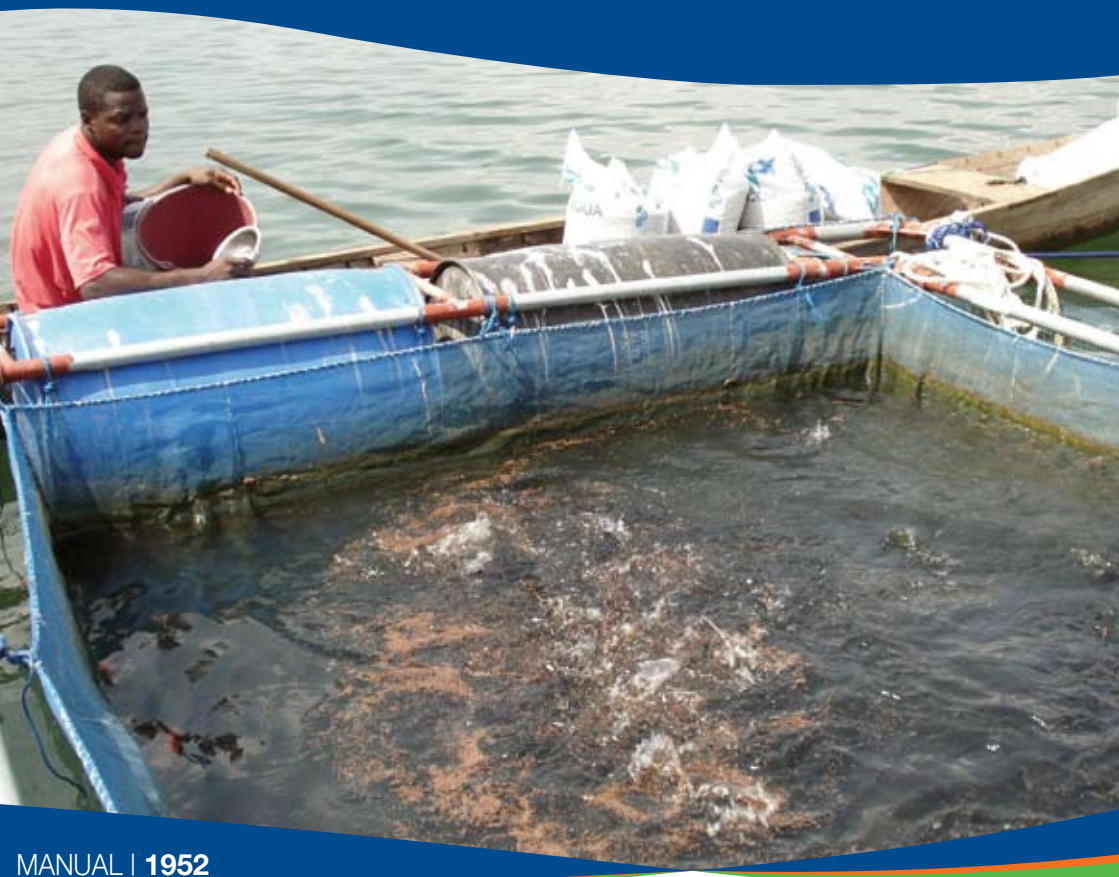

MANUAL | **1952**

Producing Tilapia in Small Cage in West Africa

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

WorldFish CENTER

Producing Tilapia in Small Cage in West Africa

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CONTENTS

PRODUCING TILAPIA IN SMALL CAGES IN WEST AFRICA[1]

WATER RESEARCH INSTITUTE[2]

Fish cages built from locally available materials and stocked with local fish that are fed local feeds are used for tilapia aquaculture in Africa, producing about 6,000 tonnes per year at bigger farms in Côte d'Ivoire, Ghana, Malawi, Uganda and Zimbabwe. Reported yield varies between 50 and 150 kilograms (kg) per cubic metre (m^3) per 9 months. In Ghana, positive cash flows have been reported for farms that achieve outputs averaging 20 tonnes per month throughout the year. The Water Research Institute (WRI) in Akosombo, Ghana, is working to bring cage aquaculture technology to smallholder farmers. The stocking, feeding and cage-construction technology piloted by WRI is now being widely adopted in the Lower Volta basin in Ghana. The results of WRI research over the period 2005-2009 are presented here as a guide to potential investors.

The Water Research Institute in Akosombo, Ghana, is working to bring cage aquaculture technology to smallholder farmers.

CAGE CONSTRUCTION AND PLACEMENT

Cages can sometimes be purchased locally. An alternative is to build one using the 15 millimetre (mm) multifilament stretched mesh netting typically used in beach seine fisheries. This material is cut to size and sewn together with heavy nylon thread to form a basket. The typical size used in Volta Lake is about 6×4 metres on the sides and 2 metres deep, for a volume of 48 m^3. Deeper cages have been tested but do not seem to increase production. The net basket is then attached with nylon twine to a pipe frame buoyed by oil drums, or plastic barrels originally sold containing paint or alcohol, both readily available on the market. A cover placed on top of the cage is essential to prevent bird predation.

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1 Consultative Group on International Agricultural Research (CGIAR) Challenge Program on Water and Food Project 34: Increasing Fish Production from the Volta Lake.

2 An agency of the Council on Scientific and Industrial Research, PO Box M32, Accra, Ghana.

Decking bolted onto the metal frame makes feeding and working around the cage easier.

Cages should be anchored in at least 8-10 metres of water. The best anchoring system comprises four 0.3 m^3 concrete blocks, into each of which is cemented a 6.4 mm (1/4") iron loop tied to ropes that are connected to each corner of the floating cage framework from which the cage was suspended. The cost of the cage is shown in Table 1.

Net cages buoyed by plastic barrels in at least 8-10 metres of water.

Table 1. Cage construction costs using locally available materials[a]

Item	Description	Quantity	Unit cost (¢)[b]	Item amount (¢)[b]
Galvanized pipe	1.5-2"	12	18	216
Floats	Plastic barrel (250 litre)	8	30	240
Nets	15 mm stretched mesh	40 metre	4.375	175
Shackles		16	3	48
Hapa nets	40 metre	0.5	100	50
Rope	10 mm diameter	2 coils	20	20
	6 mm diameter	1 coil	5	5
Anchors	0.3 m^3	6	5	30
Welding			50	50
Cage cover net	6×5 metre	1	12	12
Labour		1	30	30
Total				876

m^3 cubic metre, mm = millimetre.

[a] For a 48m^3 aquaculture cage manufactured from materials locally available in Ghana.

[b] Ghanaian cedi (¢1 = US$0.89).

Detail of cage construction showing welded brackets forming the frame.

Detail showing float and net cage attachment.

STOCKING

Fingerlings weighing 10-30 grams (g) are available from several hatcheries — among them Tropo Farm, Crystal Lake, Fish Reit, Anson-Greenfields — and from a selected line of *Oreochromis niloticus* produced at the Ghanaian Aquaculture Research and Development Centre in Akosombo. These grow some 10-15% faster than the local wild stock. Prices range from ¢0.10 to ¢0.15 for mixed males and females and up to ¢0.12-0.20 for all males. The advantage of using all males is that they grow about 40% faster than mixed sexes when producing fish of over 250 g.

Fingerlings can be stocked at rates ranging from 3,000 to 9,000 fish per 48 m^3 of cage (63-188 fish/m^3). Extreme care must be taken in transporting, holding and handling fingerlings to avoid heavy mortality. Fingerlings need to be kept cool and in clean freshwater. The water temperature in the transport container and the cage should be the same. Fingerlings should not be touched more than is absolutely necessary.

Decking attached with U-bolts to the metal pipe frame facilitates working around the cage.

Once in the cage, dead fish found floating should be removed daily and recorded. The rule of thumb is that for every dead fish found floating, two dead fish sank. Thus, three times the number of fish found floating dead during the first week

Figure 1: Growth of mixed sex tilapia in 4 cages over 6 months

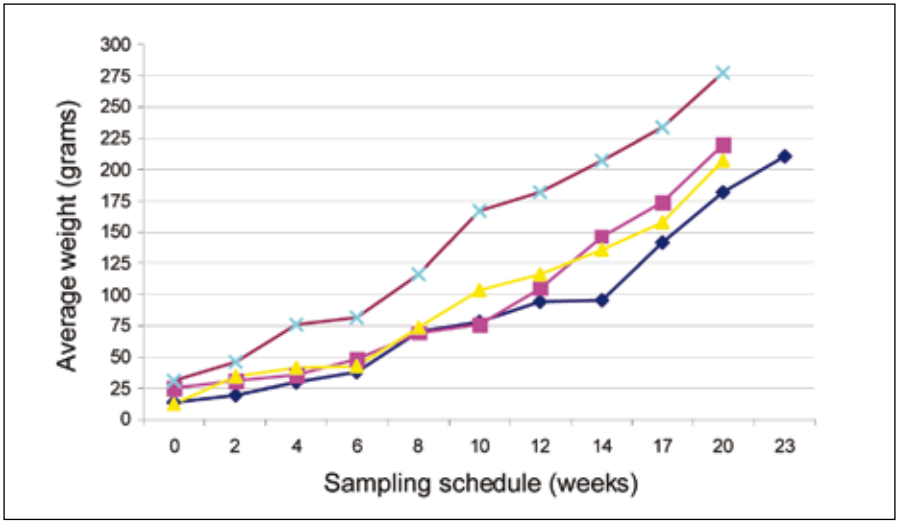
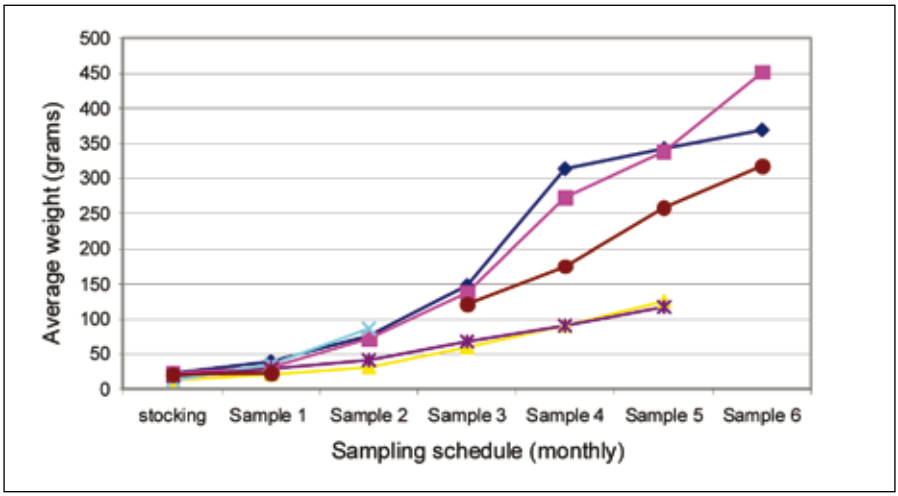


Figure 2. Growth of all-male tilapia in 6 cages over six months



are stocking mortalities and should be replaced with new fingerlings. Mortalities occurring later should be noted for the purposes of calculating the feeding rate (see below) but not replaced, as replacement would mostly increase variability in the harvested population.

Feeding a fish cage with imported floating pelleted feeds. Note the vigorous feeding response indicating healthy fish.

FEEDING & GROWTH

Fish in cages should be fed with pelleted fish feed containing approximately 28-32% crude protein. Optimal feeding requires that smaller fish receive somewhat higher protein levels, but these feeds are not generally available in the region at this time. Fish were fed at a declining rate of 10% down to 1% of estimated average bodyweight based on the monthly average weight of a sample of at least 50 fish from each cage (Table 2).

Table 2: Feeding regime using pelleted fish feed for tilapia cultured in cages

Fish average weight (grams)	Feed applied daily (% of body weight)
5-20	10.0-7.0
21-50	7.0-4.0
51-100	4.0-3.5
101-250	3.5-1.5
251-450	1.5-1.0

The advantage of using all males is that they grow about 40% faster than mixed sexes when producing fish of over 250 grams.

The total daily ration should be divided over 2-3 feedings administered by hand, using either floating or sinking feed. Floating feed is usually more expensive than sinking but facilitates monitoring the feeding response.

The feed conversion ratio (FCR) is the amount of feed required to produce 1 kg of fish; the lower the FCR, the better. The FCR in tilapia cage aquaculture systems in Africa is typically between 1.4 and 2.5. An FCR higher than normal can be the result of a high percentage of "fines" (feed dust) in the feed, variability in the reported nutrient content of the feed and/or a miscalculation of the number of fish remaining in the cage because of unrecorded mortality.

HARVESTING & MARKETING

The target size for fish in most of West Africa is between 300 and 500 g. With good management, this size can normally be reached in 5-7 months (Figure 3). Wholesale prices in Ghana vary according to size class. Fish weighing >300 g sold for 3.50 Ghana cedis (¢) (US$3.12) per kg, fish weighing 250-300 g sold for ¢2.80 ($2.49) per kg, and fish weighing <200 g sold for ¢1.50 ($1.34) per kg.[3]

Production and growth data from WRI trials in 2006 and 2007 in Dzemeni (Lake Volta, Ghana) are shown in Tables 3 and 4. Two cages were sabotaged by local fishers unhappy to see these cages in water that used to be available for fishing, reflecting the issue of enclosure of the commons often associated

[3] As these prices change frequently, estimates of profitability should be redone prior to each production cycle based on a careful analysis of current prices for both inputs and outputs.

with cage culture. Another cage was damaged when it became fouled with a submerged tree when the water level was low and then ripped open when the water level rose again, releasing the fish. Survival was low in all cages, averaging 30% among those that were not damaged or robbed. This was mostly the result of poor fish conditioning, handling and transport during stocking (see Stocking section above).

Figure 3: Tilapia harvested from cages after 6 months by size, and size categories' % in the harvest

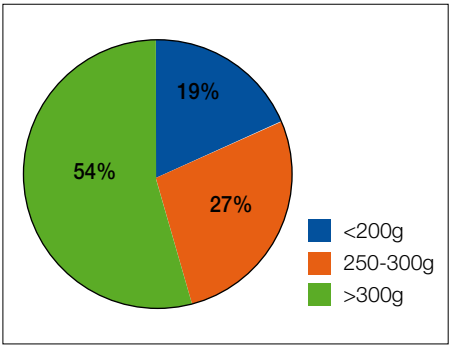


Table 3: Fish stocking, growth and harvest data (first pilot trial)[a]

	Cage 1	Cage 2	Cage 3	Cage 4
Date stocked 2006	27 October	08 December	31 October	31 October
No. stocked	4,000	6,000	7,000	2,780
Average weight at stocking (g)	13.4 ± 10.3	25.0 ± 4.1	12.9 ± 8.0	31.7 ± 15.0
Average weight at harvest (g)	207.5 ± 60.0	277.5 ± 42.4	219.7 ± 88.3	307.5 ± 134.2
Grow-out (days)	153	147	133	152
Biomass GR (kg/day)	2.69	9.05	7.1	4.14
No. fish at harvest	1,946	4,639	1,079	1,647
Survival (%)	48.7	77.3	15.4	59.2
Specific GR[b]	1.79	1.64	2.13	1.49
FCR	2.64	2.50	3.51	2.97
Gross yield (kg/cage)	324.7	1,175.7	247.1	402.5
Net yield (kg/cage)	270.9	1,025.7	221.3	314.3

FCR = feed conversion rate, g = gram, GR = growth rate, kg = kilogram, m^3 = cubic metre, No. = number.

[a] Nile tilapia grown in 48 m^3 cages and fed with sinking feed for 6 months in Volta Lake, Ghana.

[b] Specific growth rate (%/day) is the average final weight of individual fish minus the average initial weight, the difference divided by the number of days in the growth period.

The survival rate in smallholder tilapia cage culture is typically in the range of 70-80%, though survival rates as low as 60% have been associated with stocking densities in excess of 70 fish per m^3. WRI and other hatcheries have, since these trials, developed improved conditioning and transport methods that have reduced stocking mortality to less than 20%.

Table 4: Fish stocking, growth and harvest data (second pilot trial)[a]

	Cage 5	Cage 6	Cage 7	Cage 8	Cage 9	Cage 10
Date stocked 2007	31 Jan.	6 July	7 March	31 August	18 July	7 July
No. stocked	7,500	8,200	7,500	9,000	6,000	6,000
Average weight at stocking (g)	22.9 ± 9.8	22.9 ± 8.8	12.45 ± 4.9	12.5 ± 4.9	20.1 ± 9.3	20.1 ± 9.3
Average weight at harvest (g)	369.7 ± 155.5	452.2 ± 230.3	Net torn open on bottom; last sample on 10 Jan 2008, average weight 318 g	Net slashed by fishers; last sample on 25 Oct 2007, average weight 86.2 g	Poisoned by fishers; last sample on 23 Dec 2007, average weight 284 g	308.1 ±141.2
Grow-out (days)	169	147				130
No. fish at harvest	1480	523				1542
Survival (%)	20	6.4				25.7
Specific GR[b]	1.7	2.03				2.1
FCR	2.6	2.5				8.1
Gross yield (kg/cage)	324.7	232				503.4
Net yield (kg/cage)	270.9	44.4				389.7

FCR = feed conversion rate, g = gram, GR = growth rate, kg = kilogram, m^3 = cubic metre, No. = number.

[a] Nile tilapia in 48 m^3 cage aquaculture at Dzemeni in Stratum II of the Volta Lake, Ghana.

[b] Specific growth rate (%/day) is the average final weight of individual fish minus the average initial weight, and the difference divided by the number of days in the growth period.

PROFITABILITY

Feed costs averaged 52% of total production costs.

Only cage 2, from which more than 1 tonne of fish was harvested (>96 fish with a combined weight of 24.5 kg per 1 m^3), made a significant profit (Table 5). FCRs were between 2.5 and 8.1, averaging 3.54 (Table 3). Feed was the major component of cost, averaging over 50% of the total (Table 6). Fingerling purchase was another major cost, accounting for an average of 27% of the total.

Table 5. Economic analysis of tilapia aquaculture cages[a]

	Cage 1	Cage 2	Cage 3	Cage 4	Cage 5	Cage 6	Cage 10
Fixed cost[b]	109.5	109.5	109.5	109.5	109.5	109.5	109.5
Variable cost	1,760.7	2,700	2,458.7	1,468.1	1,598.0	1,867.0	1,687.0
Total cost	1,870.3	2,809.5	2,568.2	1,577.6	1,707.5	1,978.5	1,756.5
Revenue	812.8	3,527.0	741.3	1,207.5	1,136.4	812.0	1,760.1
Net income	-1,057.4	717.5	-1,826.9	-370.1	-574.1	-895.5	4.5

[a] Operated for approximately 6 months in Stratum II of the Volta Lake, in Ghana ¢ (¢1 = US$0.89).
[b] For the cage, amortized over 4 years.

Table 6: Production costs, revenues and return on investment

	Quantity	Unit value (¢)[b]	Item amount (¢)[b]
Item			
Cage (amortized over 4 years)	1/2	219.00	109.50
Fingerlings	6,000	0.12	720.00
Feed (kg)	3,000	0.49	1,470.00
Labour (person-months)	6	60.00	360.00
Marketing			50.00
Transportation			100.00
Total cost			**2,809.50**
Revenues			
Total harvest (kg)	1,176	3.00	3,528.04
Net income			**718.54**
Return on investment			**25.6%**

[a] Tilapia aquaculture using a 48 m^3 aquaculture cage in Stratum II of the Volta Lake, stocked at a density of 125 fish/m^3, cultured for 147 days and achieving a survival rate of 77.32%.
[b] Ghanaian cedi (¢1 = US$0.89).

According to the data collected at Dzemeni, a minimally profitable 48 m^3 smallholder cage aquaculture system in Ghana would have to produce at least 1 tonne of fish at an FCR of less than 2.5.

To break even, the harvested biomass of fish needed to exceed 15 kg/m3.

TECHNICAL SUMMARY

In Ghana, cages can be built or purchased at a cost of approximately $1,000 per 48 m^3. Nile tilapia (*Oreochromis niloticus*) are stocked at an average rate of 103 fish/m^3 and fed locally with available pelleted feeds for approximately 6 months. Total costs averaged $2,038 per 6-month production cycle. Gross yield ranged from 232 to 1,176 kg/cage, averaging 460 kg/cage (9.6 kg/m^3). Mortality, resulting primarily from poor handling during transport and stocking, averaged 70% and was a major constraint on production and profitability. To break even, the harvested biomass of fish needed to exceed 15 kg/m^3. At 25 kg/m^3, smallholder cage aquaculture generated a net income of $717 per cage per 6 months, for a return on investment of 30.2% on revenues of $3,500. Water

quality in the area surrounding the cages was not compromised by aquaculture at the scale tested, in which 5 tonnes of feed was applied over 6 months.

In conclusion, aquaculture is always challenging, and an investment in fish farming should never be considered a "sure deal". Many fish farmers, large and small, have lost money on aquaculture. The results reported here show how the problems encountered can make an enormous difference to the bottom line. It is normal for small businesses to take 3-5 years to turn a profit, and aquaculture is no different.

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The other Technical Manuals are:

- Cage Culture in Reservoirs in India.
- Enhancing fishery productivity in small reservoir in India.
- Building fish enclosure in Lake Nasser.
- Engaging local communities in aquatic resources research.

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