Sewage Fish Cages of Kota Cianjur, Indonesia

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Aquaculture systems for common carp *(Cyprinus Carpio)* range across a continuum of stocking, feeding and management practices from extensive, traditional systems to modern intensive systems (see Table 1).

Fish culture in cages is normally considered an intensive system. For example, extrapolated annual yields of 1 million kg/ha have been reported for common carp *(Cyprinus carpio)* culture in running water systems (RWS) in Indonesia. Conventional cage culture requires high capital inputs for construction, seeds and feeds. We have begun to examine in detail a fascinating and unique exception: the sewage cage system of Kota Cianjur, West Java, Indonesia.

Within the cooperative Institute of Ecology (IOE), Padjadjaran University, ICLARM and the Indonesian Fisheries Agency program funded by the Indonesian State Electric Company (PLN) (see Naga, January 1987, p. 9-10), surveys were conducted in 1986-87 of the existing aquaculture systems available in West Java. In Kota Cianjur, we have documented and begun studies of the sewage cage system that requires little start-up capital and no supplemental feeds, yet still produces the high yields characteristic of intensive fish culture practices. The success and simplicity of this practice have been recognized by the fisheries agencies involved in the IOE/ICLARM project and the residents around Kota Cianjur.

In 1987, we witnessed its further implementation in the streams and canals that empty into the new reservoir at Cirata. In view of the abundance of small sewage-laden watercourses in many developing countries, this unique Indonesian cage culture system may have great potential for South-South technology transfer.

Table 1. The continuum of aquaculture systems for carp culture in Indonesia.

Characteristic	Extensive (Rice-Fish)	Semi-intensive (Ponds)	Intensive (RWS)
Stocking density (fish/ha)	Low (2-5,000)	Moderate (3-100,000)	High (200-500,000)
Feed types	Natural foods	Supplemental (rice bran, manure)	Complete (commercial feed, 20-25% protein)
Management	Stocking, harvesting	Stocking, feeding, harvesting	Stocking, feeding, water quality, quantity, stock manipulation, harvesting
Capital inputs (Rp/ha)	Low (20-50,000)	Low-moderate (100,000-5 mil)	High (500-700 mil)
Operating inputs (Rp/ha/crop)	Low (40-100,000)	Moderate (500,000-2 mil)	High, (150-200 mil)
Gross output (kg/ha/year)	Low (100-300)	Moderate (1,000-5,000)	High (100-250,000)
Net profit	Profitable, established, growing	Variable, according to seasons	Unproven, many bankrupt in 1987

History of Fish Cages in the Bandung-Bogor Region

According to our interviews, so-called "fish river cages" ("karumba sungai") first appeared in the Bandung regency of West Java during the years of World War II. The original practices and ideas evolved from traditional "fish keeping" practices. It is widely known that the first such cages were established in Bandung. They were made of bamboo, and rested or were fastened with bamboo stakes to the stream bed.

Some elderly, albeit lively, cage farmers explained that river cages originally grew out of the practical experience and observations of fish-mongers who brought live fish to centralized city markets from outlying districts on a weekly or occasional basis. Fish were kept alive in bamboo baskets at the market until sold. If unsold the fish were put in open-topped bamboo baskets in canals or rivers outside the market-place until the next market time, or until the fishmonger returned to the city from his home village, which could take a week or more. Upon return the fish-mongers noted that if the fish were kept in the sewage-laden surface waters that invariably flowed near the marketplace, they gained weight!

The practice of keeping fish in fully enclosed bamboo cages evolved from this simple holding of fish in open-topped bamboo "fish-transportation" baskets. River cages anchored to the bottom of canals were established in watercourses in Bogor and Bandung in the early and mid-1960s. During these years, it was noticed each rainy season that cages staked or weighed to maintain contact with the river bed filled with sediment and that fish survival was often poor. Off-bottom cages accumulated less sediment and fish growth and survival rates were higher; these floating cages spread so rapidly throughout West Java that they nearly filled all watercourses in Bogor and Bandung by the late 1960s.

A cage operator lifts the heavy wooden top of the cage to harvest common carp.

Soon, however, local irrigation officials noted that cages could impede the flow of water needed to irrigate paddy fields. In addition, rivers and canals became so crowded with cages that they caused major flooding problems during the rainy season. Heavy rains brought down weeds, garbage and tonnes of sediment from upstream water-sheds and these were blocked by the cages. Therefore, regulations were adopted to pro-hibit the construction of floating cages in public waters. This was a big blow to a new aquacul-ture practice that had successfully brought hundreds of tonnes of fish protein into the fish markets of West Java and had provided a new source of income where little previously existed. In the 1970s, however, a new and unique form of river cage was devel-oped in Kota Cianjur.

In-bottom river cages in a typical canal in Kota Cianjur, West Java. Each day the tops of the cages are cleaned.

Fish Cages of Kota Cianjur

Kota Cianjur is approximately 65 km west of Bandung. The surrounding rice ecosystem dominates the economic life of the city. Year-round rice cultivation is possible here due to extensive irrigation systems. These include 3-5 m wide canals that course through the city, diverting the flow of five major river systems to thousands of hectares of paddy fields.

With the burgeoning population of Kota Cianjur, dense settlements have grown up alongside many hundreds of kilometers of such canals. Raw sewage from these settlements pours directly into the canals. A new type of cage evolved in Kota Cianjur -- an *in*-bottom, dug out bamboo fish cage. Today over 5,000 units exist in Kota Cianjur alone, producing an estimated 750 tonnes of fish per year.

In our survey, we followed a 4-m wide canal that coursed through the city and noted more than 50 cage units over a three-month period. The mean cage size is 3 x 4 m. Cages are dug 60-80 cm into the canal bed, so that a mean water depth of 50 cm, the locally accepted depth for fishponds, is maintained. The cages are constructed of bamboo on all sides, with 1-2 cm wide spaces for water flow, and have soil bottoms. The surface of the cage is in line with or just below the water level. They present no barrier to water

flow and floating debris. Each day, the owner sweeps the top of the cage to remove accumulated waste. Each cage has a removable top door, which is usually constructed of bamboo with wood to give it extra weight as the wood becomes saturated with water. Cage tops are nailed shut after fish are stocked and only opened after 6 months to harvest the fish.

Three Functions

The cages have at least three functions: (1) they produce fish, exclusively common carp (*Cyprinus carpio*); (2) they capture sand; (3) they process sewage. Common carp are bought at the local fingerling markets and stocked in the cages at 1 kg/m^2 of cage, at a size of 8-10 fish/kg, and are harvested at a 0.8 kg/fish average size 6 months later. Cage farmers grow two crops of fish per year. A 3 x 4 m cage of 50 cm depth produces an average total fish weight of 150 kg a year with no supplemental feeding. Each cage can capture approximately 1.5 m^3 of sand per week during a 32-week rainy season. Sand is sold for rupiah (Rp) 2,000/m^3 (Rp 1,666 = US$1 as of April 1988).

A simple financial analysis (see Table 2) shows that a single cage produces a return over variable costs of Rp 244,450 per year, and a return over total costs of Rp 171,750. Families are allowed by the local fisheries agency to have up to four cages each. Many more city watercourses are open for cage culture development.

Table 2. Financial analysis of sewage cages at Cianjur.

Variable	Quantity per Year	Price/Cost per Unit (Rp)	Total Cost Value (Rp)
GROSS RECEIPTS			
a. Fish production	150 kg	1,600	240,000
b. Sand	48 m^3	2,000	96,000
TOTAL GROSS RECEIPTS			336,000
VARIABLE COSTS			
a. Fingerlings (100-125 g)	24 kg	1,800	43,200
b. Feed	0 kg	480	0
c. Labor	6 man-days	2,000	12,000
d. Repair and maintenance at 50% fixed costs			36,350
TOTAL VARIABLE COSTS			91,550
FIXED COSTS			
a. Bamboo	40 pieces	1,500	60,000
b. Nails	2 kg	1,500	3,000
c. Wood 12.7 cm x 17.8 cm x 5 m	1 board	1,700	1,700
d. Labor	4 man-days	2,000	8,000
TOTAL FIXED COSTS			72,700
TOTAL COSTS			164,250
RETURN ABOVE VARIABLE COSTS			244,450
RETURN ABOVE TOTAL COSTS			171,750

A large common carp harvested from an in-bottom cage in Kota Cianjur.

The natural food web of the Cianjur fish cages is being investigated. Prolific growth of bacteria-rich aggregates can be observed on all the cage material surfaces. The heavy sewage input supports a very productive heterotrophic food web. Microscopic examination of the aggregates from cage surfaces has revealed a microbial community heavily dominated by sulfur bacteria (*Beggiatoa* sp.) with a small contribution from attached diatoms and blue-green algae. Our team is now trying to isolate the organisms responsible for the high fish growth rates in the cage system and measure their growth rates. Further studies of the food webs of these systems could assist in the design of a new generation of aquaculture systems that produce the high yields characteristic of intensive aquaculture systems, but incorporate the social and economic advantages of extensive aquaculture. ●