From 1984 to 1995, most of my life was involved in rice-fish culture research and development in north-eastern Thailand and Bangladesh. Some of the lessons and data from these assignments may be useful.

Historically, the popularity of rice-fish culture has waxed and waned. Farmers then will need to come to understand with their landlords, and success in communal management will depend on the level of communication and attitudes of those in the group.

Problems with Rice-Fish Culture

1- Rice-fish culture requires land. Farmers who cannot manage their plots with sufficient autonomy may face challenges here. Tenant farmers, then, will need to come to an understanding with their landlords, and success in communal management will depend on the level of communication and attitudes of those in the group.

2- Initial plot preparation normally requires a considerable investment of either money or labour. The farmer who does not have to modify his plot in the interest of flood control and water conservation is rare.

3- Profits tend to be low compared to many other activities. Very rarely do people get rich from rice-fish culture.

4- Fish production is unpredictable since the rice field environment is subject to many uncontrollable factors. Rainfall, especially quantity and timing, is foremost among these. Pollution, theft, disease and predators could also lead to losses.

5- Seed supply can be a problem. Farmers commonly need the fish during rice-transplanting time, when they are short on both time and money to get the seed fish. In the absence of telecommunications, they may find that after a long trip they cannot get the seed fish they need. The development of local nursery facilities helps re-solve this problem, once the demand for fish is sufficient.

6- Rice yields are very occasionally reduced as a result of rice-fish culture. The most serious problems can be avoided by stocking the fish well after rice has been planted or transplanted. Matching appropriate rice varieties to anticipated water depth would also help avoid this.

7- There have been occasional reports of reduced yields of wild fish from stocked fields. The behaviour of some stocked species may have adverse effects on wild species, under hitherto undefined circumstances. Modifications normally required for rice-fish culture (notably raised dikes) may interfere with the movements of some wild species.
Advantages of Rice-Fish Culture

1- Compared to many "new" on-farm activities, rice-fish culture is low-risk. Costs are modest and so are potential losses, should failure occur. The technology is not particularly revolutionary for most rice farmers, and therefore familiar. Finally, there are minimal conflicts with other farming activities.

2- Many farmers find that rice-fish culture provides a more convenient, predictable, continuous source of fish than wild sources, particularly if they are in decline.

3- Since costs are modest, most farmers need not borrow money to start the practice. Therefore, farmers have various options regarding the use of production: They can sell, eat, keep for further culture, or give the fish away, as they wish.

4- The technology is very adaptable to farmers' circumstances. There is no single way to culture fish in rice fields: The "right" way is time- and space-specific. Hence, farmers in many different situations can succeed.

5- Rice yields usually increase as an apparent result of rice-fish culture. Our studies indicate higher yields from stocked fields in about 60% of the cases. Overall, yields from fields stocked with fish were about 10% higher than yields from comparable unstocked fields. Yield enhancement appears most marked in poor soils where fish are cultured intensively.

6- Competition among practitioners is minimal. As indicated, one important "market" for rice field fisheries is the family of the practitioner and the commonest practice is to sell the fish that are surplus to family protein needs.

7- Rice-fish culture is highly compatible with integrated pest management schemes. As fish farmers realise that pesticides are dangerous when culturing fish in rice fields, they will be reluctant to apply them. Under some circumstances, fish reduce the incidence of certain pest species.

8- Development workers should therefore find rice-fish culture attractive because many rice farmers can benefit from the technology.

The Technology

Rice-fish culture can be either concurrent or rotational. Under concurrent culture systems, fish are grown simultaneously with rice. In rotational systems, fish are cultured in rice fields—during periods when rice is not planted in the field. One farmer can carry out both types of culture in different plots or at different seasons.

While some farmers can produce seed fish successfully from concurrent culture, rotational culture is commonly advisable if the farmer wants to attempt breeding or nursing in the field. There will be less shading by rice plants, and therefore higher and more diverse production of natural feed organisms. The farmer is in the best position to decide which practice is most appropriate for the circumstances. Rotational culture may also be appropriate in cases where rice can be grown for only part of the year due to excessive water depths in the off-season, where the rice variety in question requires pesticide treatment, or where the rice variety does not thrive in depths greater than 5 cm.

A further point: The newcomer should remember that initial attempts at any technology amount to an experiment, the results of which will be uncertain. This should determine the amount of investment.

In what follows, the steps required to carry out concurrent rice-fish culture will be considered. These are summarized in Figure 1.
The following steps are presented as guidelines that cover the most common concerns, although the considerations given are not exhaustive.

**Step 1: Culture or not?**

The farmer first has to decide whether or not it is worthwhile to try culturing fish. A few considerations to keep in mind:

Can the farmer conveniently get all the fish his family needs? All year around? If the answer to both questions is yes, fish culture may not be of interest.

Can the farmer keep at least 5 cm. of water in his rice field for at least three months? If not, the viability of rice-fish culture is doubtful.

Does the farmer have access to seed fish?

Does the farmer have control over the plot of land? Does he have the time, money and labour needed to prepare the plot and purchase seed fish? Is the farmer interested?

**Step 2: Site Selection**

A number of factors can affect the farmer's decision about where to culture fish:

There should be neither too much water nor too little. Sites subject to uncontrollable flooding are not appropriate, nor are those vulnerable to drying. The farmer must be able to build dikes higher than maximum flood levels, and balance this against the need to assure catchment to hold sufficient water. The holding capacity of the soil is a further consideration here. The farmer will know best. Plots located near the farmer's residence tend to be easier to manage, especially if more intensive management is desired.

Plots with existing ponds or high boundaries will save labour at plot preparation time.

Plots vulnerable to toxic runoff or other sorts of pollution are best avoided.

Plots that are transplanted early and harvested late will tend to allow the fish a longer growing season.

Is there any prospect for conflict with neighbours? In which plot is this minimal?

**Step 3: Site Preparation**

Correct preparation is crucial to successful rice-fish culture. The only universal characteristic of successful rice-fish operations is that the farmer has been able (a) to hold enough water over a large area for sufficient time to allow for fish production, and (b) to control flooding.

(a) **Plot size:**

What size plot can the farmer afford to prepare? With what size plot does he wish to experiment?

How large an area can the farmer manage and under what level of intensity?

How big an area is suitable for rice-fish culture?

(b) **Dikes:**

Dikes must be higher than maximum expected flood levels. Otherwise, the fish will swim out over the flooded dikes. Farmers should add a little extra at the top to allow for erosion. A very important side-benefit from this is that such dikes conserve water for a longer period than would lower dikes. Dikes of sandy soil should slope more gently than those made from finer soils. Excavated sods and topsoil should be put on the outside of the dike to encourage dike stabilization.

(c) **Refuges:**

A refuge is a hole, trench, or low point in a rice field which can hold water and fish at times when there is little or no water in the field. Hence, it assures the survival of fish during droughts and after the rainy season.

Under some circumstances, a refuge can allow for the early release and nursing of seed fish prior to transplanting.

A refuge is normally located in the lowest part of the culture field. On sloping land, it will normally be on the low side of the field. When the land is very flat, the refuge may be a trench running around the perimeter of the field, particularly if the field is large and equilateral. If the topography of the field is dish-shaped, the refuge may be in the middle of the field.

A refuge is commonly and conveniently excavated when a dike is raised. The slope of the banks, as with dikes, should be gentler in sandy soils. From the point of view of the fish, it is preferable if the plot takes up 2-3% of the field. Minimum depth should be half a metre, but a depth of one to 1.5 metres is preferable in most cases. Advisable depth may be limited by various factors. Of particular note are the following: If the farmer plans to use the refuge as a nursery, it should dry shortly before the rains start; otherwise, control of predators is difficult. A nursery with predators is worse than no nursery, since it is very difficult for seed fish to escape predators in a small pond. The farmer should also use his knowledge of the underlying soil: the refuge should not penetrate a dry, porous layer that underlies a more impermeable layer of soil. Otherwise, seepage will be a serious problem.

Seepage should diminish as the refuge ages and pores get blocked with organic matter. Application of manure can accelerate the process.

Finally, the farmer who plans to use the refuge as a nursery should build a very low dike around the refuge. This will help keep fish confined to the refuge during transplanting time, should water levels rise unexpectedly. This can be breached once it is time for fish to enter the field.
(d) Drains:
Every stocked field should have a drain set in the dike in the lower part of the field. The level of the drain should conform to the maximum depth suitable for the rice variety grown in the field. The width should be great enough to accommodate flooding and prevent overflow. The farmer will know best here. The drain should be screened so that fish do not escape. On flat land and in irrigated areas, all inlets to the stocked field should also be screened, so that fish cannot escape by swimming up-stream.

Step 4: Stocking

(a) Nursing:
This is optional. The farmer who decides to nurse does so because he can buy smaller, cheaper fish before the season of peak demand and before he transplants rice. In many cases, he can produce fingerlings surplus to his needs, which can be sold to neighbours.

The pond used as a nursery should be dried, preferably until the mud cracks. If a pond cannot be dried, the farmer must be sure he can eliminate predators prior to stocking.

Lime (calcium hydroxide) should be applied evenly over the pond bottom. In rain-fed ponds, this can accompany the first rains. In irrigated ponds, it can be applied one to two weeks before stocking. In new ponds with acid soil, a rate of 2.5 kg per hundred square metres can be applied. Half this level is more appropriate in older ponds in alkaline soil.

Three days to one week before stocking, manure should be applied. Cattle or buffalo dung is usually the most easily available. New, infertile ponds can get 40 kg. per hundred square metres and older, fertile ponds half this level. If the dung is fresh, these levels can be reduced by half. If pig or poultry dung is used, another halving of rates is advisable.

New ponds with high seepage rates may need higher rates of application. Caution is advisable, particularly after stocking.

Fish should be stocked when the water turns greenish to greenish-brown and the hand disappears at 20-40 cm. depth. Manure can be added at half the initial rate any time the water becomes clearer than this.

If the water is turbid, fertilisers will have less effect on food production. Feeding becomes more important. Rice bran is commonly used, but other non-injurious feeds are also advisable, especially if the water is turbid. Animal protein (insects, fishmeal, etc.) will help accelerate growth.

In the long run, turbidity can be reduced by applying manure, straw or rice husks over the water surface. Results are not immediate.

If the fish are gasping at the surface early in the morning, fertilisation should be reduced. If water can be added, this is desirable, particularly if it splashes into the pond, since this will add oxygen to the water.

(b) Stocking:
Seed fish are best transported early in the morning, before sunlight becomes intense. The second choice is during late afternoon or early evening, when temperatures are dropping. Fish should be moved promptly, with minimum shaking. Care should be taken that plastic bags are not punctured during transport.

On arrival at the pond or rice field, the bags should be placed in the water and left for a few minutes until temperatures in the bag and the water become similar. This can be checked by hand. When the bags are opened, water from the pond should be splashed into the bag to get the fish accustomed to the new water. The bag can then be tipped over, and the fish should be allowed to swim out on their own.

What follows applies to stocking fish in rice fields:

What size? Over 5 cm. length is commonly recommended. Smaller sizes can be stocked, but mortality rates tend to increase as fish get smaller. Small common carp seem especially vulnerable to predators.

When? After the rice is well-established, provided there is 5 cm. or more water in the field. A farmer should wait for two to three weeks after transplanting fish longer than 5 cm. In most cases fish of 3 to 5 cm. can be stocked a week after transplanting.

Stocking fish in a field before transplanting is hazardous to the fish.

How many? Each farmer will have his own optimum. For newcomers, we suggest 3000/ha. At densities higher than this, feeding becomes advisable.

**What species?** The "big three" in Asia are common carp (*Cyprinus carpio*), nile tilapia (*Oreochromis niloticus*) and silver barb (*Puntius gonionotus*). Brood fish of snakeskin gourami (*Trichigaster pectoralis*) also reproduce successfully in well-watered rice fields. Naturally-occurring rice field species can coexist with these species. Some, notably walking catfish (*Clarias spp.*) and snakehead (*Channa spp.*) enjoy higher prices than stocked species. Chinese carp and Indian major carp will grow in rice fields, but in most cases, harvested size is less than desired.

If fish were initially stocked in a nursery refuge, they may be "lazy" to enter the field once it is ready. Application of manure and a little feed near the refuge should attract the fish into the field.
Alternative: Transplanting

Fish can be cultured in both transplanted and direct-seeded fields, but do better in transplanted plots, where the spacing among rice plants tends to be wider. I have not encountered a rice variety that is incompatible with rice-fish culture. Varieties with a long growing period and which are tolerant of greater water depths are often preferable. Pest-resistant strains are also desirable, since pesticides are not compatible with successful rice-fish culture. With this in mind, areas in which only one rice variety are cultured more often need pesticide application, since pests spread more rapidly under such circumstances.

Step 5: Maintenance

(a) Rice:

In most cases, rice in stocked fields can be grown in the usual way. Farmers should pay attention to water conservation. From the point of view of the fish, the deeper the water, the better. Inorganic fertiliser should present no problem, if applied at recommended levels.

The one major precaution involves use of pesticides. They should be used only as a last resort. At best, they will kill food organisms on which the fish depend and may accumulate in the tissues of the fish. At worst, they will kill the fish. When pesticides must be applied, it is better to drain the field and concentrate the fish in the refuge prior to application, then release the fish back to the field one to two weeks later. Dust-type pesticides are best applied early in the morning, when there is dew on the rice canopy; spray-type pesticides should be applied in the afternoon when the leaves are dry.

The farmer with a serious pest problem who feels that pesticide application may be necessary must decide which crop to put at risk, the rice or the fish.

(b) Fish:

The field should be visited daily. The farmer needs to check water levels at this time. If water is rising or falling unusually quickly, he should ascertain the cause and deal with it. For this reason, he has to go to the field with a shovel or hoe.

Early morning visits are advisable. Pollution of the water due to overfeeding or over-fertilisation is rare in rice fields, but as in ponds, if fish gape at the surface early in the morning, rates of feeding and fertilising should be reduced.

If fish are stocked at densities below 3,000/ha., feeding is usually not necessary. It becomes increasingly advisable as densities increase above this level. Adding a little rice bran or other feed at a designated time and spot each day will allow the farmer to check the health and growth of the fish.

The major source of food for the fish is the rice field. Food therefore should be put near (not in) the refuge, so that fish will be encouraged to range around the field. Overfeeding is also not advisable. If the feed disappears one to two hours after application, it is probably sufficient.

What should be given? Whatever is cheap, convenient and non-injurious. Manure and rice bran are common additions. Non-poisonous plant material and household organic matter are also common. Fish are excellent converters of human excreta and dead animals in areas where this is culturally acceptable.

Step 6: Harvesting

Harvesting of fish from rice fields is usually a continuous process.

When should harvesting begin?

- If fish growth is slowing down, harvesting will reduce competition for feed.
- If water levels are dropping and not likely to rise, harvesting will reduce crowding.
- Fish can be harvested when the farmer needs fish to eat or when there is an opportunity to sell.
- Harvesting some fish is advisable if the farmer anticipates a problem, such as disease.

Many farmers like to keep fish through the dry season, as a source of food and income. When possible, it is worthwhile to hold some fish for seasons when the price of fish is high.

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