Rice-Fish-Vegetable Integrated Farming: Towards a Sustainable Ecosystem

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India, like the rest of the developing countries, is plagued with overpopulation, malnutrition, poverty in general and a degraded environment. Yet it is favored with vast lands, 2.5 million ha of which are deepwater ricelands. These are flooded to depths from 0.5 to 2.0 m for 5 to 6 months per year. The practice of most Hindu farmers is to cultivate traditional varieties of deepwater rice with yields of 1-1.5 t/ha/year. The carrying capacity of these lands is not utilized to the fullest. Moreover, calamities such as floods and prolonged drought often cause farmers to suffer economic setbacks.

These areas, however, could be used not only for rice production, but also for raising fish, prawns and vegetables in integrated rice-fish-vegetable farming. This will help to compensate for the economic losses in rice production brought about by natural calamities, and will also optimize land use without degradation: a sustainable ecosystem. Further, it could generate employment, increase farmers' incomes and help alleviate malnutrition by providing additional sources of animal protein and vegetables. Following are suggested steps for adopting such an integrated farming system in India. The authors hope that these suggestions might be useful, if modified, in other rice-growing countries.

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Cultivation of Rice

Field preparation is generally done at the start of April. A small sump is dug in the lowest portion of the field. The soil from the sump can be used to strengthen and widen the dike. A lateral canal (1 m x 1 m wide) around the field can be dug instead of a sump. The area of the sump or canal should not exceed 10% of the total field area. The sump facilitates fish sampling when monitoring fish condition, feeding fish and harvesting.

After 3-4 days of plowing, rice cultivation starts. Rice cultivation can be done either by direct sowing or by transplanting.

Generally, direct sowing should be done earlier, before the onset of the monsoon, so that the rice plants can grow sufficiently tall and strong and thereafter resist the force of the monsoon rains. Rice seeds are sown either by broadcasting or in rows (dibbling) with 20 cm x 20 cm spacing at 75 kg rice seed/ha. If there is a good drainage facility in the field, rice can be transplanted (20 cm x 20 cm spacing) by July. Rice varieties which can grow tall with increasing water depth and can withstand forceful rains, water movement and prolonged submergence are usually selected for cultivation under such conditions.

Vegetable Cultivation in the Dikes

If weather is favorable following pre-monsoon sowing, vegetable seeds like ridge gourd (*Luffa acutangula* L. Roxb.) and cowpeas (*Vigna unquiculata* L. Walp.) can be sown in rows on the dikes of rice-fish culture plots during the third week of May, leaving 20-22 cm space from row to row, with two consecutive rows of ridge gourd, followed by one row of cowpea. A bamboo trellis (Fig. 1) is useful to support these creepers. About a fortnight after the germination of ridge gourd and cowpea seeds, French bean (*Phaseolus vulgaris* L.) seeds can be sown in rows 12-15 cm inside the ridge gourd and cowpea line, leaving

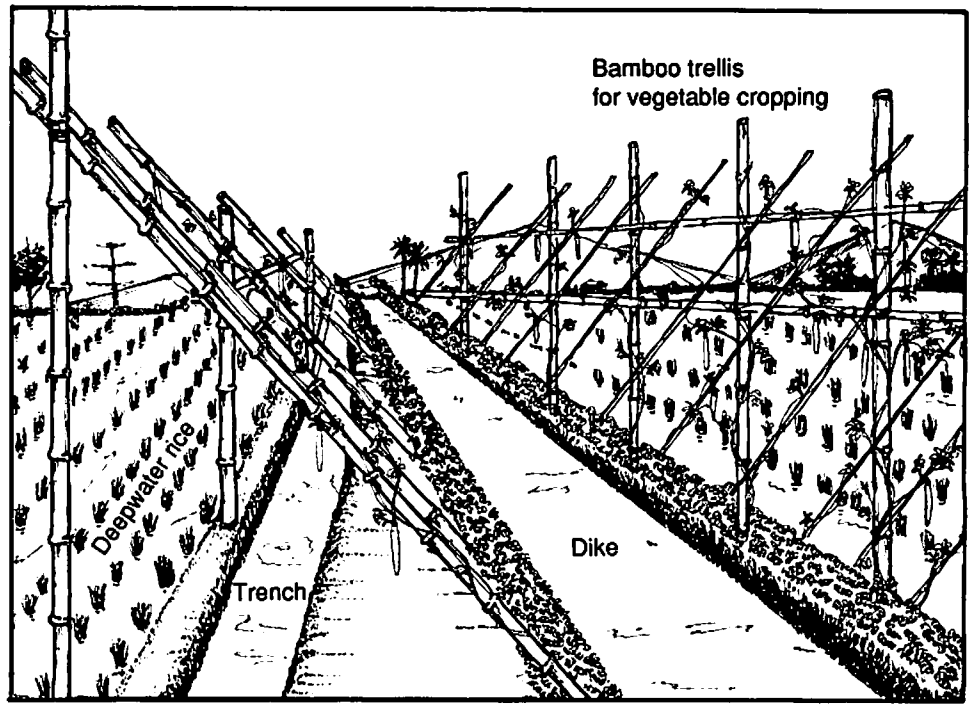

Fig. 1. Diagrammatic presentation of three-tier cropping (deepwater rice-fish-vegetable system).

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Fig. 2. Harvesting vegetables from the dikes of a deepwater rice-fish-vegetable farming plot.

Fig. 3. A farm family with the haul of fish and prawns from experimental deepwater rice-fish culture.

90-100 cm space between two French bean rows. The vegetable plants should be irrigated twice a week in prolonged dry periods.

Raising Fish and Prawns

When the water depth of the field rises to 30-40 cm, fish fingerlings and prawn juveniles can be stocked. Stocking is usually done at one fish or prawn/m² between the last week of July and the middle of August, more or less 10-12 days after transplanting rice. In India, the species may comprise 50% freshwater prawn (*Macrobrachium rosenbergii*), 20% Java barb (*Puntius javanicus*), 20% common carp (*Cyprinus carpio*) and 10% rohu (*Labeo rohita*). If sufficient prawn juveniles are available, monoculture of prawn can be done instead of mixed culture. Stocking advanced stages of fish fingerlings and prawn juveniles reduces mortality and losses to predators such as birds, snakes and otters. Frequent visits to the area also help to deter predators.

Eight to 10 days after stocking, supplementary feed is given at 2-5% of the total fish/prawn biomass in the field, adjusted monthly after sampling. Polished rice bran and mustard or ground nut oil cake mixed in a ratio of 2:1 is used. All supplementary feeds are mixed with water to form a dough and are given to fish/prawns at certain portions of the sump or canal in the morning or afternoon. Farm yard waste like cowdung compost at 10,000 kg/ha/season or poultry manure at 3,300 kg/ha/season can also be used in several applications to obtain higher rice and fish production.

Harvesting Vegetables

The ridge gourds start producing fruits from early July and continue to the end of August. By middle to late August, the cowpea has become fully grown and starts flowering. During this period, and after harvesting the fruits (Fig. 2), dried and ripened ridge gourd plants should be removed from the trellis to allow cowpea to flourish and to produce fruit from early September until late October. During the last week of October, all the dry ridge gourd and cowpea plants should be removed and the trellis cleared for the French beans, for which the fruiting spell continues from early to middle November to January. Green vegetables are harvested for household use and the excess is marketed. Seeds are also collected by drying plants. Vegetable seeds can bring more economic returns than green vegetables.

Harvesting Rice and Fish

In the Indian situation, water starts receding from the middle or end of November. Rice is generally harvested by the middle of December. After the rice harvest, water from the field is usually pumped out to concentrate fish and prawns in the sump or the canal for harvest by a small hand net (Fig. 3).

In traditional deepwater rice cultivation, yields of rice range from 1.0 to 1.5 t/ha and fish production may be 50 to 200 kg/ha/season. Introduction of integrated deepwater rice-fish vegetable farming as described here has given a production of 4.8 t/ha of rice and 1.2-1.9 t/ha of fish and prawns with supplementary feeding. If cowdung is applied, production of 3.1 t/ha of rice and 0.67 t/ha of fish and prawn is possible, whereas 2.8 t/ha rice and 0.6 t/ha of fish and prawn can be obtained with poultry manure as the input. Moreover, a production of 2.3 t/ha of ridge gourd, 0.3 t/ha of cowpea and 0.6 t/ha of French beans as green vegetables can be achieved from the dikes, assuring better returns from the same area of land.

Suggested Advantages of Integrated Deepwater Rice-Fish-Vegetable Farming

- Synergistic effect of fish on rice.
- Control of weeds and insect pests by fish.
- Increased efficiency of resource utilization, reduced investment risk through crop diversification and additional sources of food and income.
- More frequent visits by farmers which result in better management of the rice crop.
- Low risk for poor deepwater rice farmers and modest capital requirements.
- Year-round employment opportunities for the farm family.
- Improved farm family income and nutrition.