Rice - Fish Culture in China (IDRC, 1995, 240 p.)
Part IV: Economic Effects
Economic Analysis of Rice-Fish Culture
Economic Research on Rice-Fish Farming
Ecology and Economics of Rice-Fish Culture

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Part IV: Economic Effects

Economic Analysis of Rice-Fish Culture

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Rice-fish culture has received much attention since the 1980s. Rice-fish farming methods have increased both rice yields and economic benefits. The area devoted to rice-fish culture has expanded rapidly from 345 000 ha in 1982 to 558 000 ha in 1984, an increased of 62%. The yield of fish products has also increased from 24 000 tonnes 56 300 tonnes, an increase of 135%. Fish culture in ricefields has become an important component of freshwater fish production.

To evaluate rice-fish culture, its economic benefits must be compared with single-crop rice production. Moreover, comparisons between rice yields in rice-fish culture and in single-crop ricefields are needed to estimate the effects of rice-fish coexistence on rice yields. Twelve farm households in Hong'an and Hanchuan Counties, Hubei Province, were interviewed in June 1988. Among these households, four planted only rice and were used as the control. The other households adopted various types of rice-fish culture. The study used cost-benefit analysis to assess the various economic criteria of rice-fish culture.

Comparison with Single-Crop Rice Production

Survey data were collected from four farm households in Hong'an County, Hubei Province. The households practiced two farming types: rice-fish and single-crop rice. Although the two groups of households had similar conditions (e.g., scale of production, soil fertility, and production technologies) both the production value and economic benefits of the rice-fish households were higher (Table 1).

Yield Increase

In addition to the 253.5 kg/ha of production of fresh fish, rice yields with rice-fish culture were 7.8% higher. Rice and fish together produced a total product value that was 41% higher than from rice alone. In terms of protein output, rice-fish culture was 26.8% higher. Of the increase in protein, more than 70% was accounted for by fish protein (Table 2).

Relative Economic Benefit

Whether rice-fish culture can substitute for single-crop rice production depends

on its relative economic benefit. Various resource productivity criteria (e.g., land productivity, labour productivity, and capital productivity) were used to measure the relative economic benefit of rice-fish culture. The analysis showed that net income per unit input, net return to labour, and benefit-cost ratio were significantly higher for rice-fish culture (Table 3).

When extending new agricultural technologies, changes in socioeconomic factors (e.g., market institutions and new farming practices) can affect efficiency. The risk and uncertainty associated with of agricultural production mean that the economic benefits of new technologies must reach a certain level. Many countries use two indicators (the increment in economic benefit and marginal benefit-cost ratio of new technology) and set their critical values at 30% and 2, respectively. In China, these two values are 18-22% and 1.2-1.5, respectively. The results of our analysis indicate that these two indicators for rice-fish culture are 45% and 2.5, respectively.

The economic benefits of rice-fish culture were related to:

- **The increase in rice yields and the saving in labour and material inputs. Compared with single-crop rice production, rice yields in rice-fish culture were 7.8% higher, labour input were 19.4% lower, and material costs were 7% lower because of savings in the control of plant diseases and pests.**

- **The increase in net benefits because of fish production (CNY 286.5/ha).**

Different Patterns of Rice-Fish Culture

After the system of rice-fish culture is adopted, further increases in economic

benefit can be realized by improving the combinations of rice and fish and by designing and choosing different kinds of component technologies.

In Hanchuan County, Hubei Province, three different patterns of fish culture are used: breeding fingerling in ricefields, breeding adult fish in ricefields, and breeding both fingerling and adult fish in ricefields.

To determine the best pattern of rice-fish culture, the economic benefits of the different patterns of rice-fish culture were compared using relative indicators of economic benefit (Table 4). The values of both indicators (increment in net benefit and marginal benefit-cost ratio) exceed the lowest limit (critical value) for spreading new technology. It is difficult to determine which method is the best just by studying these two indicators. There are trade-offs between them. Based on the net benefit, mixed culture was the best pattern. Based on marginal benefit-cost ratio, breeding fingerlings is the best pattern. Therefore, it is necessary to consider some other indicators. It is generally agreed that the criterion of economic assessment for new technologies should be the maximum value of economic results. To modify the criteria, three indicators (net profit/area, output value/input costs, and net profit/input costs) were used. These three indicators valued mixed culture the highest (CNY 259.43, CNY 3.76, and CNY 2.76, respectively). Net profit was 1.3 times that of single-crop rice production, 4.5% higher than adult fish culture, and 36.3% higher than fingerling culture.

Factors Affecting Economic Benefits

In rice-fish culture, there are differences in methods of using the ricefield, patterns of rice-fish culture, combinations of inputs, combinations of fish, and

ways of breeding. All these differences can affect the economic benefits of rice-fish culture.

Tables 5 and 6 present data from Hanchuan County, Hubei Province. The inputs and outputs of two types of rice-fish culture were studied. The net benefit of group A was CNY 825/ha higher than group B. The net benefits of rice increased by 41% and the net benefit from fish increased by 59%.

The benefit-cost ratio of group A was 3.9% higher than group B. The higher economic benefits of group A were mainly due to the effects of higher inputs and the combination of different kinds of fish species.

Conclusion

Rice-fish culture is one way to increase the economic benefits from ricefields and develop freshwater fisheries. Rice-fish culture increases rice output. The average value of products can be increased by 41%, the rice yield by 7.8%, and the protein output by 26.8%. The increase in protein output is mainly animal (fish) protein.

When deciding whether to extend new agriculture technology, the economic evaluation usually requires that the increment in economic benefits and the marginal benefit-cost ratio must be more than 18-22% and 1.2-1.5, respectively. These two indicators in rice-fish culture were over the critical value. Compared with single-crop rice production, net profits from rice-fish culture were 45% higher, the rate of return to labour was 12.6% higher, and the benefit-cost ratio was 4% higher. The main reasons for higher economic benefits from rice-fish culture were:

- **Increase in rice yields and saving on labour and material inputs.**

- **Increases in net profits from fish production.**

Once rice-fish culture has been adapted, further increases in economic benefits can be realized. The net benefits from rice production combined with adult fish and fingerling production was 4.5% higher than from the combination of rice and adult fish, and 36.3% higher than from the rice-fingerling combination. Research to improve the component technologies may further increase economic benefits.

The ecological benefits of rice-fish culture were related to weeding, elimination of insect pests and diseases, preserving and increasing the fertility of the soil, environmental stability, and improving environmental conditions.

These results indicate that rice-fish culture provides technical, economic, social, and ecological benefits. In addition to technical knowledge, several conditions must be met to implement rice-fish culture:

- **The field must have a good irrigation and drainage system to ensure that there is no water logging during the rainy season and that the field does not dry out during droughts.**

- **Field ridges and fish ditches must be created to meet the different water requirements of rice and fish.**

- **High efficiency, low toxicity pesticides must be selected to avoid toxic effects on fish.**

- **A resource plan must be implemented to use resources rationally, increase rice yields, and optimize economic benefits.**

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Economic Research on Rice-Fish Farming

Jiang Ci Mao and Dai Ge

Since 1978, rice-fish culture has developed very rapidly in China. The area under production has continued to expand, and aquatic production has increased each year. In some provinces, rice-fish production accounts for the largest percentage of freshwater fisheries production (Table 1).

The development of rice-fish farming differs from place to place. In China, rice-fish culture accounted for 2% of freshwater aquatic production in 1982. In 1983 and 1984, the proportion was 2.5% and 3.1% respectively. In Sichuan, rice-fish culture now accounts for 7.6% of freshwater aquatic production.

Rice-fish culture is important part of fisheries production in Sichuan, Guizhou, Hunan, and Jiangxi. In 1949, production from rice-fish culture accounted for 15.5% of the aquatic production of these four provinces. By 1984, this figure was 21.6%. In Guizhou, rice-fish culture represents 75% of total aquatic production. In these provinces, rice-fish farming is common in the hilly and mountainous areas. For example, in Sichuan and Guizhou, about 75% of the production comes from these areas; whereas, in Quin Dong Nan, Guizhou, 85% of aquatic production is supplied by rice-fish farming.

Ricefields are a suitable place for the culture of fry and fingerlings. In Hunan Province, 0.44 billion fish were breed in 38 430 ha of ricefields and ponds. These fry and fingerlings can be used to promote fish production in ponds, reservoirs, and lakes.

Economics of Rice-Fish Farming

A survey of 23.8 ha of rice-fish fields was conducted in Jiangxi Province in 1984. The average input cost was CNY 660/ha and the average net profit from breeding and selling fish was CNY 4590/ha. The cost-return ratio was 7.9. Similar surveys were undertaken in Hunan and Guizhou. In Hunan, a survey of 7.3 ha of ricefields in 1984 showed that the cost-return ratio was 16.0; whereas, in Guizhou, 222.4 ha were surveyed and the ratio was 7.8. For China as a whole, the maximum cost of the rice-fish farming is about 20% of the value of production (input:output ratio 1:5). From these calculations, it can be seen that rice-fish farming provides a good return on investment.

Techniques and Management

Common carp, crucian carp, grass carp, and nile tilapia are raised in ricefields. The integration of fish and rice provides several benefits (e.g., pest control, fertilizer, and reduced need for pesticide). In general, rice-fish culture is a simple technique that is easy to popularize because there is little risk.

Farmers in economically developed areas are not as interested in rice-fish culture because they have relatively high incomes from other means. But for farmers in remote areas, the situation is quite different. In these areas, farmers have few income sources other than crop production. Therefore, rice-fish culture is attractive because of its low cost and good return. It is one of the best ways for remote areas to improve their economic development.

Rice-fish culture can also be easily popularized in the areas adjacent to cities and towns. Areas adjacent to cities and towns have the advantages of access to information and speed of market feedback. The site of production and the market are close together and the selling price of the fish is relatively high. Therefore, the return on investment is higher than in remote areas.

Rice-Fish Farming and Agriculture

Rice and fish are mutually beneficial. Fish can accelerate the growth and increase the production of rice. A large-scale survey of rice-fish culture indicated that rice production was increased by 5-15%. Rice-fish culture, beyond doubt, can promote agricultural production and development.

Economics

Before rice-fish culture was introduced in Sichuan, the average rice yield was about 6000 kg/ha and the income was CNY 1755/ha. However, when fish were raised in ricefields, the increase in income was CNY 150/ha from rice and CNY 750/ha from fish. In some areas, the income from selling fish was even higher (Table 2). The production value of rice-fish farming is much higher than rice production alone. Especially in hilly areas, there are many winter ricefields that have deep water storage and hold water for a relatively long time. Under these conditions, the value of rice-fish culture is about three times rice production

alone.

Compared with the cost of rice production, which is about 30-50% or even 60% of the value of rice production, the cost of fish grown in ricefields is relatively low (about 20% of the value of production). The economic benefit of rice growing is not as high as fish culture. At present, the unit yield of rice is stable. It is difficult to raise the economic benefit of the ricefield by increasing rice yield. However, improved benefits and production values can be achieved by raising fish in ricefields. Generally, from rice-fish culture the net income will be about CNY 600/ha. A maximum net income of about CNY 1500/ha is possible and is the goal of many farmers (Table 3).

Fish bring changes to rice cultivation and help achieve remarkable economic benefit. These changes mainly decrease inputs into rice cultivation. The fish eat weeds that compete with rice for fertilizer. The fish also help control plant diseases and insect pests and, therefore, reduce the need for pesticides and the amount of labour needed for weeding. Studies in Sichuan, Hunan, Guizhou, and Jiangxi showed that raising fish in ricefields saved about 8-12 days of labour.

Rice-fish culture improves labour productivity. Labour productivity is a measure of the total products produced in a certain period. Labour productivity reflects the level of fish-raising in ricefields. Low-level rice-fish farming has lower labour productivity than rice farming. When the ricefield is used to cultivate fry and fingerling the labour input is increased a little. Much higher labour productivity can be achieved by adopting new technical improvements (Table 4).

Land and Water Resources

China is a large country with a large population and a scarcity of agriculture land. Agricultural production occupies an important place in the national economy; therefore, comprehensive use of land and improvements in grain production are important. Rice-fish culture has many advantages: increases in grain yield, production of freshwater fish, an increase in the production capacity of arable land, increased economic returns, and a higher land-utilization ratio (Table 5).

Rice alone cannot make full use of the materials and energy in the ricefield. Rice-fish culture can greatly increase the use of fertilizer and energy, and transform these materials into human food. Water is a precious natural resource. Rice-fish culture makes more comprehensive use of available aquatic resources. The efficiency of water use is increased because more than one use is made of the water.

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Ecology and Economics of Rice-Fish Culture

Quing Daozhu and Gao Jusheng

The hilly district in the south of Hunan Province is one of the birthplaces of fish-rearing in mountain ponds and in ricefields. The area devoted to rice-fish culture was 30 000 ha in 1987. In Qiyan County alone there were 10 000 ha. Rice yields range from 7500 to 13 500 kg/ha, yields of fresh fish from 450 to 750 kg/ha, and output values from CNY 6000 to CNY 10 500/ha. The economic and ecological effects of rice-fish culture are remarkable. Research on high-yield technology

systems and the ecological and economic effects of rice-fish culture has been conducted since 1985.

Materials and Methods

Grass carp, silver carp, common carp, variegated carp, and crucian carp were tested. Summer fingerlings (3-5 cm long) were reared in the rice nursery of late rice for 20-30 days. They were stocked in the ricefields at the end of May or the beginning of June. Different rice varieties were grown each year: early rice (Zhuxi 26) and late rice (V64) in 1985, early rice (Zhuxi 26) and late rice (79-16, a strain with disease resistance) in 1986, and early rice (V49) and late rice (V64) in 1987. The size of the transplanted rice varied according to rice cultivars. The other planting conditions were: hill spacing 13 cm x 20 cm, 7-8 seedlings per hill, and 375 000 hills/ha for common rice, and hill spacing 17 cm x 20 cm, 2-4 seedlings per hill (including tiller), and 300 000 hills/ha for hybrid rice.

The experiments were conducted in a gleyed ricefield in Guangshanping Village in Quiyang County and in a ricefield with a green manure crop on the farm of the Hangyan Red Loam Experimental Station. The experiment included four treatments (no replications): ridge culture with tillage (RCT) in the gleyed ricefield (control, 0.03 ha), ridge culture with no tillage (RCNT) in the gleyed ricefield (0.03 ha), fish-rearing and ridge culture with no tillage (FRCNT) in the gleyed ricefield (0.12 ha), winter crop or green manure crop plus fish and early rice with ridge culture and tillage plus fish and late rice with no tillage (W-FRT-FRNT) (0.11 ha).

About 7-10 days before the rice seedlings were transplanted, 1.2-m wide ridges were made. The furrows were 30 cm wide and 20 cm deep (main ridge furrow was

40 cm wide and 30 cm deep). The fish pit was 3 m x 3 m. Decomposed pig and cow manure (1500 kg) was applied to the surface of soil before ridging. Urea (150 kg/ha), calcium superphosphate (450 kg/ha), and potassium chloride (150 kg/ha) were applied on the surface of the ridge before the rice seedlings were transplanted. In addition, 112.5 kg/ha of urea were broadcast.

Analysis of Experimental Results

Effect on Rice Growth

Rice-fish culture is a high-yield technology that makes good use of available resources and provides ecological benefits. To compare the effects on rice growth of different methods of planting and rearing, observations were made on the dynamics of rice tillering. There were no great difference in the number of rice stems (including tillers) in the early stage among RCT, RCNT, and FRCNT. The differences increased in the middle-late stage. The numbers of rice stems (including tillers) in the peak tillering stage were: 8 million/ha in the field with RCT, 6 million/ha with RCNT, and 5 million/ha with FRCNT. However, the difference in effective panicles became smaller at maturity. In the ACT field, the rice grew quickly and there were more tillers, but there were also more ineffective tillers and the percentage of ear-bearing tillers was low. In this field, there were 5.5 million ear-bearing tillers per hectare and the rate of ear bearing was 69.2%, with RCNT there were 4.7 million ear-bearing tillers per hectare and the rate of ear bearing was 78.1%, and with FRCNT there were 4.1 million ear-bearing tillers per hectare and the rate of ear bearing was 81.2%. The number of ineffective tillers was lower but the rate of ear bearing was higher in the rice-fish fields because the small tillers at the base of the rice plant were eaten by the fish.

Weeds, Diseases, and Pests

During the vegetative cycle of the rice, there were almost no weeds with rice-fish culture because the weeds became the natural food of the fish. There were 15 species of weeds in ricefields with RCT and RCNT. Monochoria vaginalis (21.8 and 22.0 plants/m²) and barnyard grass (Echinochlea crugalli) (4.0 and 3.5 plants/m²) were the most common weeds (Table 1).

RCNT, ridge culture with no tillage, FRCNT, fish-rearing and ridge culture with no tillage.

The results were different for insect pests and rice diseases. The incidence of rice sheath blight disease was 6.3% in the rice-fish fields compared with 3.9% and 2.1% in the field with RCNT and RCT, respectively. The number of rice leafrollers in the rice-fish fields was 4.1 heads per 100 hills compared with 5.7 and 4.3, respectively, in the fields with RCT and RCNT (Table 2).

Fish rearing reduced the amount of pesticides and the frequency of spraying. As a result, beneficial organisms were increased. For example, there were 380 000 red mites per hectare in the rice-fish fields compared with 65 500-86 000 in ricefields without fish. There were also nearly twice as many frogs.

Soil Fertility

Ridges help raise the soil temperature of the cultivated layer, which promotes the conversion of potential nutrients. Fish in the ricefields fertilize the soil with their excrement. Analysis of soil samples taken from the cultivated layer after rice and fish were harvested indicated that organic matter content was 4.11%, total

nitrogen 0.21%, total phosphorous 0.09%, alkali-hydrolyzable nitrogen 152.72 ppm, and content of available phosphorus 9.85 ppm. The same measures of soil samples from fields without fish were slightly less: 4.0%, 0.2%. 0.08%, 127 ppm, and 4.5 ppm, respectively. Soil nutrients were higher in rice-fish fields than in rice-only fields.

Rice Yield

Fish culture lowered rice yields. The number of effective panicles was highest in the field with RCT and lowest with FRCNT. Rice yields were 8195 kg/ha with RCT, 8058 kg/ha with RCNT, and 7454 kg/ha with FRCNT (Table 3).

An analysis of 13 samples taken between 1984 and 1986 showed that the difference in rice yield between RCT and RCNT was not significant. The rice yield from ridge culture was not significantly different between RCT and RCNT, but both were higher than the yield from the rice-fish field. However, in the gleyed field, zero tillage not only saved labour, but shifted the time of transplanting to earlier in the season. The adoption of no tillage also greatly reduces mechanical damage to fish and enhance their survival. This promotes higher yields of both rice and fish and increases the total value of the output.

Economic Benefits

When developing a plan for field engineering and cultivation technologies, the basic principle is that rice is the main crop and fish is the secondary one. The establishment of a good ecosystem makes full use of space, land, and water in the ricefield and to greatly raises the biomass and total value of the output of the

ricefield with little extra more input or cost.

From 1985 to 1987, the experiment on fish-farming and ridge culture of rice with no tillage produced 9774-13 124 kg/ha of rice (both early and late rice). The value of the rice was CNY 3909-5349/ha and the value of the fish was CNY 813-3610/ha. Total income increased by 17-41%, a significant economic benefit. Among different types of ricefields, rice yields and fish income differed greatly. In the fields of winter rice or winter green manure, water deficits during growth of late rice affected both rice and fish. As a result, rice yields were only 9774-11 282 kg/ha, which was 12-14% lower than from the winter-water fields. The income derived from fish in the winter-rice or green-manure field was CNY 813-2650/ha and the fish income in the gleyed ricefield was CNY 2258/ha (Table 4).

The best choices for rice-fish fields are winter-water gleyed fields that have plenty of water, but are easy to drain. Under these conditions, good growth of both fish and rice are ensured.

Polyculture

There are many types of rice-fish farming. Most farmers still use the traditional method of a level field to rear small-size common carp fry in natural water. As a result, fish output is low, commonly 150-300 kg/ha from one-season ricefields. Because the price of common carp is only CNY 2-3/kg, fish income is also low. Some farmers also maintain 3-4 cm of water in the field for a long time for the sake of fish. This affects the growth and development of the rice and leads to a reduction of rice yields and only slightly higher income from the fish.

A complete set of technological measures were applied in these experiments: the rice was planted on ridges, early rice (middle-late maturing variety) was selected, plant spacing was reduced, and tillage was increased in late ricefields. Problems of long-term submergence of the ricefield after the fish were reared were avoided. Moreover, polyculture of 3-5 varieties of fish raised the survival rate and increased the income generated from the fish (Table 5).

With polyculture, the value of grass carp contributed 65.5% of total fish income. The survival rates for the different species were: variegated carp 53.3%, common carp 38.7%, silver carp 21.2%, and other fish (e.g., crucian carp) 16.3%. From 1985 to 1987, the experimental area for fish farming in ricefields was 0.56 ha and the average income from fish was CNY 2194/ha.

The main ecological models for rice-fish culture in ricefields are rice-fish-duckweed and rice-fish. Rice-fish with ridge culture and no tillage was compared with RCT and RCNT. For the rice-fish system, two types of fields (winter ricefields and winter-water gleyed ricefields) were used (Table 6). The field with RCT had an output value of CNY 4876/ha, which was 4.8% higher than with no tillage. In the green-manure crop or winter-crop field with rice-fish, the output value was 31.9% higher than with RCT. In the gleyed field with FRCNT, there was an increase of 20-46% compared with RCT. There are clear the economic benefits to fish-rearing and ridge culture of rice with no tillage.

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