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COUNTRY REVIEWS

Techno-economic viability of rice-fish culture in Assam

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Abstract

The economic viability of rice-fish culture practiced by the farmers of Assam in North-Eastern part of India was evaluated using techno-economic approach. The farmers followed extensive level farming practice using low input technology. Cobb-Douglas production function was used to determine the input-output relationship of the system. The cost and return evaluation shows that rice-fish culture can be a more profitable option than monoculture of paddy.

Keywords: cost and earnings, rice-fish culture, production function

Introduction

Rice-fish farming systems have received a great deal of attention in the recent past because of government focus on sustainable rural development, food security, and poverty alleviation. Several reviews on historical, socio-economic, and ecological aspects of rice-fish farming have been published in the past decade with either a global or a national focus (Li 1988; Fernando 1993a; Halwart 1994; MacKay 1995; Choudhury 1995; Little et al. 1996).

De la Cruz et al. (1992) provided country overviews for Bangladesh, China, India, Indonesia, Korea, Malaysia, Philippines, Thailand and Vietnam while Symoens & Micha (1995) provided country reviews for Madagascar. Fernando (1993b) compiled an extensive bibliography on diverse aspects of fish culture in rice fields.

The prevalent practice of trapping fish and prawn in the tide-swept single crop areas (George et al. 1968; Pillay & Bose 1957) and freshwater paddy fields in riverine areas in several parts of India are fully dependent on the natural ingress of fish seed along with water courses in the impounded paddy fields (Natarajan & Ghosh 1985). To accelerate the fish yield in such habitats, judicious stocking of selected species of fast growing fish have been increasingly adopted by fish farmers in various countries (Eapen 1956; Ardiwinata 1957).

Rice- fish culture is a small-scale aquaculture in rice based farming systems. This system may be classified according to management intensity, growing period, field design, cultured species and stage in the production cycle. Rice-fish culture practice has had a long tradition in many of the South and South-East Asian countries for thousands of years (Ghosh et al. 1985).

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Rearing of fish along with paddy is an old practice in India (Alikunhi 1955). The practice of culturing fish in rice fields is a long tradition in many parts of Asia. It has largely been practised in a traditional way in the Indian coastal states of Kerala and West Bengal. However, it has not been popular, although considerable potential exists, in West Bengal, Assam, Bihar, Orissa and Andhra Pradesh (Ghosh et al. 1985). The reason for this is largely attributed to the change in cultivation practice of paddy from traditional methods to the more advanced methods involving high yielding varieties and progressive use of pesticides. Multiple cropping further improved the returns from agricultural land thus shifting the emphasis from such integrated farming. So rice-fish farming in India is considered particularly suitable for the less productive rain fed areas (Halwart 1994).

Rice is the main cultivated crop in Assam. Fish culture in the rice fields occupies about 27,000 ha area out of a potential 45,000 ha (Sugunan 1998). Fish is the most preferred food in Assam. Thus, rice-fish farming has a great potential to help improve the economy of the state. Very few studies on cost and returns as well as production function analysis have been reported for rice-fish culture farming system. This paper attempts to assess the techno-economic viability of rice-fish farming in two districts of Assam.

Materials and Methods

The study was conducted in two districts of lower Assam viz. Kamrup and Nagaon (Figure 1). A structured and pretested interview schedule was used to collect the data from 50 randomly selected sample farmers from each district. Based on data collected, costs and returns and maximum profitability of the farming system were worked out. Cobb-Douglas production function was used to describe the input-output relationship of the system.

Results and Discussion

Farming System

An emerging trend was observed among the farmers to adopt rice-cum-fish culture in a transition phase between traditional and scientific farming (Figure 2). In traditional rice-fish farming system, farmers use an existing or dug out pond adjoining to their rice field and make provisions to improve collection and capture of wild fish without any management practice. In the scientific method of rice-fish culture, proper fish pond preparation, selective stocking of different species of fish, addition of inputs like feed, fertilizer along with other post stocking managements and harvesting of marketable size of fish after gathering paddy crop are undertaken.

Farmers practised both simultaneous and rotational systems of culture depending on the prevailing conditions. In this paper, economic analysis is made only on simultaneous system in which fish and rice are cultured in the same field, with rice as the main crop. Preparation of the paddy fields starts in April-May and cropping of locally available variety of rice is completed within June-July. As the water level increases with the onset of monsoon, the farmers release fingerlings at a very high density of about 20,000-25,000 ha^{-1}. Fish stay in the paddy field up to December and start migrating to the actual fish pond as the water level goes down in the paddy field. Paddy is harvested during November-December followed by harvest of fish in January-February. Farmers use organic and inorganic fertilizers during paddy field preparation. They apply lime, to correct the acidity of water as the surface waters of Assam are a little bit acidic. Feed in the form of rice bran and Mahua oil cake in small quantity is given.

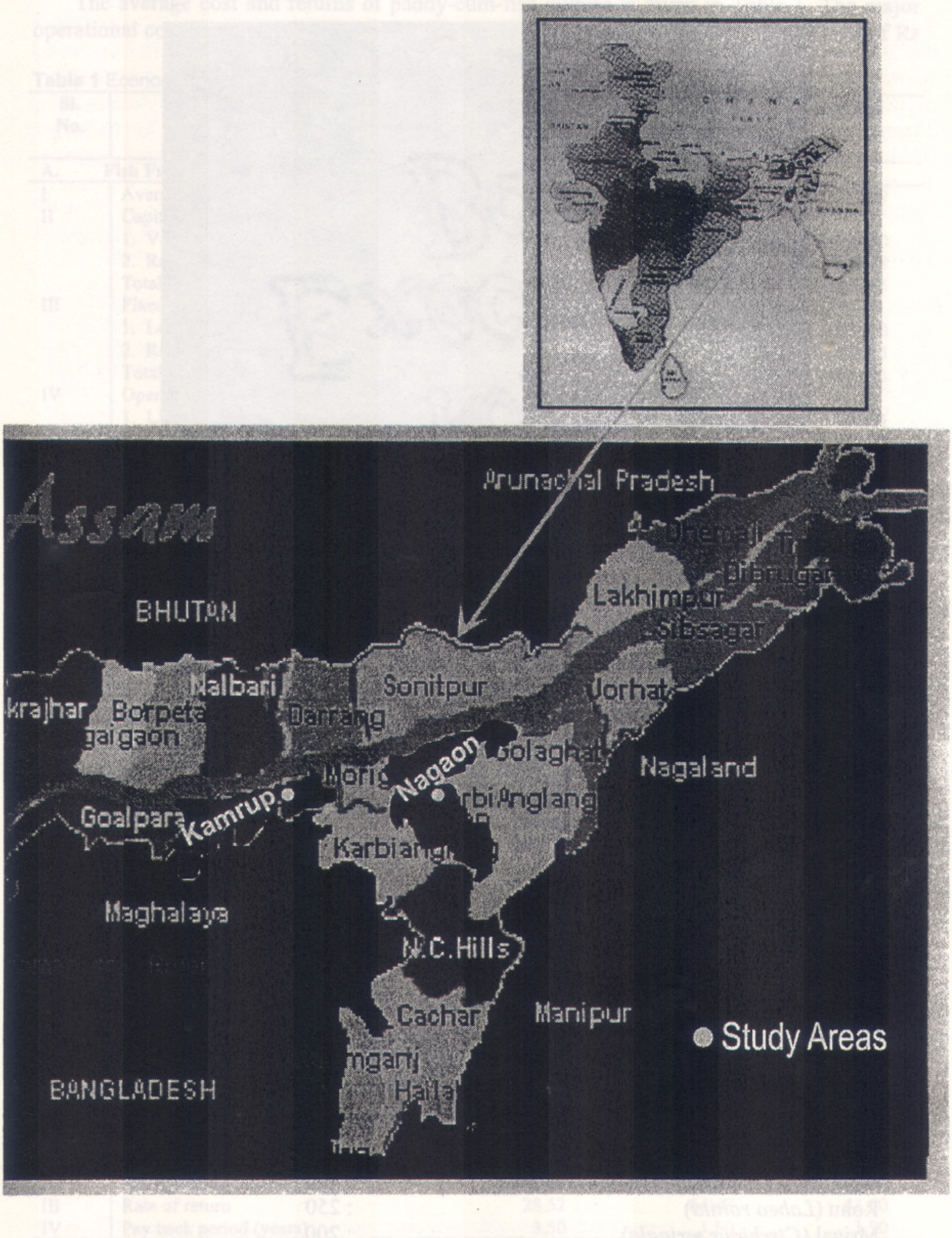

Figure 1 Location of Study Area

Figure 2 Rice-fish culture at a glance

A wide variety of fish species have been cultured including common carp (*Cyprinus carpio*), Indian Major Carp- rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*) and catla (*Catla catla*), Chinese carp - silver carp (*Hypophthalmichthys molitrix*) and occasionally grass carp (*Ctenopharyngodon idella*), tilapia (*Oreochromis niloticus*) and silver barb (*Puntius javanicus*) (Gupta et al. 1998). Depending upon the availability and suitability for culture under local conditions, fingerlings of *Labeo rohita, Catla catla, Cirrhinus mrigala, Hypophthalamichthys molitrix, Cyprinus carpio, Labeo gonius, L. calbasu, L. bata* and Puntius sp., were mainly stocked by the farmers in the paddy field. However, tilapia (*Oreochromis mossambicus*) and African magur (*Clarias gariepinus*) an illegal entry from neighbouring states were being stocked with the carps, often with disastrous results. Tilapia being a prolific breeder and African magur being a voracious feeder caused loss of biodiversity of indigenous fish.

Cost and Returns

A technology, to be accepted by, farmers should match the farmer's socio-economic circumstances including the farm environment. The present study aimed to work out the economic efficiency of the paddy-cum-fish culture system practised by farmers in two selected districts of the State of Assam.

On an average 16.67 per cent of total respondents adopted rice-fish culture. About 12.50 per cent of the respondents from Darrang adopted the technology in 0.14 ha pond size with an adjoining 0.12 ha paddy area whereas 20.83 per cent of those from Nagaon adopted it in 0.36 ha pond along with an adjoining 1.76 ha paddy area. The average weight of fish in gram (gm) at harvest for a period of 120-150 days was as follows:

Common carp (*Cyprinus carpio*)	: 450
Silver carp (*Hypophthalmichthys molitrix*)	: 500
Rohu (*Labeo rohita*)	: 250
Mrigal (*Cirrhinus mrigala*)	: 200
Catla (*Catla catla*)	: 200
Labeo bata	: 150
Labeo calbasu	: 200
Silver barb (*Puntius gonionatus*)	: 100

The average cost and returns of paddy-cum-fish culture is given in Table 1. The major operational cost items were labour, seed, feed and cow manure. A total operational cost of Rs

Table 1 Economics of paddy-cum-fish culture practices in Assam (n=50)

Sl. No.	Items	Darrang district average	Nagaon district average	Average
A.	**Fish Farming**			
I	Average pond size (ha)	0.14	0.36	0.29
II	Capital Investment (Rs.)			
	1. Value of land	25800.00	52272.73	44000.00
	2. Renovation	1860.00	3327.27	2868.75
	Total	27660.00	55600.00	46868.75
III	Fixed Cost (Rs.)			
	1. Lease value of land	1290.00	2613.64	2200.00
	2. Renovation cost	372.00	665.45	573.75
	Total (Rs.)	1662.00	3279.28	2773.75
IV	Operational cost 9Rs.)			
	1. Lime	277.00	515.45	440.94
	2. Cowdung	300.00	420.00	380.00
	3. Rice bran	1032.00	1127.27	1097.50
	4. Oil cake	320.00	1842.00	1490.77
	5. Fish seed	1635.00	2745.45	2500.00
	6. Labour cost			
	(i) Culture/maintenance	1000.00	3000.00	4000.00
	(ii) Harvesting	400.00	900.00	743.75
	7. Prophylactic measures	200.00	200.00	200.00
	Total (Rs.)	5164.00	15267.79	10852.96
V	Total Fish Production (kg)	250	500	425
VI	Total Revenue (Rs.)	12000.00	22500.00	18861.50
B.	**Paddy Cultivation**			
I	Average paddy field area (ha)	0.12	1.76	1.25
II	Recurring expenditure for paddy (Rs.)			
	1. Rice seed	36.00	507.00	359.94
	2. Cowdung	248.00	1088.18	825.63
	3. Urea	100.00	709.09	530.00
	4. SSP	100.00	1881.82	1359.38
	5. Labour cost			
	(i) Paddy plot preparation	250.00	3129.09	2678.67
	(ii) Seeding cost	305.00	4227.27	3186.67
	(iii) Paddy cleaning	224.00	3078.00	2334.00
	(iv) Paddy harvesting	222.00	800.00	2312.67
	Total (Rs.)	1285.00	17669.93	13586.96
III	Total paddy production	550.00	8139.00	5723.75
IV	Revenue from paddy	4000	49567.06	35658.96
C.	**Cost and earnings of paddy-cum-fish culture**			
I	Average paddy-cum-fish area (ha)	0.26	2.12	1.54
II	Total cost (fish and paddy) (Rs.)	8111.00	36217.00	28401.17
II	Total Revenue (fish and paddy) (Rs.)	16000.00	72067.00	54520.46
D.	**Income**			
I	Net profit (Rs.)	7889.00	35850.00	25123.00
II	Net operating income (Rs.)	9551.00	39129.38	27896.00
III	Rate of return	28.52	64.48	53.60
IV	Pay back period (years)	3.50	1.50	1.90

Note: In 2004, 1 US $ = Rs. 45.89

5,164 (in 2004, 1 US $ = Rs. 45.89) and Rs 1,285 was invested towards fish farming and paddy cultivation, respectively, in Darrang. In Nagaon, the amounts were Rs 15, 267 for fish farming and Rs.17, 669 for paddy cultivation. The farmers of Darrang registered a net profit of Rs.7889 and a rate of return of 28.52 per cent. The net profit achieved by the farmers of Nagaon was Rs 36, 217 at 64.48 per cent of rate of return. This clearly shows that the farmers of Nagaon benefited more from higher investments of input and more paddy area allocated for culture than those from Darrang.

Comparison with other studies

On average, a fishpond area of of 0.29 ha and rice field area of 1.25 ha yielded a net profit of Rs 25,123 and a 53.60 per cent rate of return. The study conducted on rice-fish farming in Mekong Delta in Vietnam revealed that total farm cash return from rice introduced fish, rice indigenous fish, rice-monoculture were Rs.3, 243.00, Rs. 3, 180.00 and Rs. 3, 914.00 ha^{-1} respectively (Nhan et al. 1997).

Experiments conducted on rice-fish farming at the Agricultural Research Station of West Godavari district in Andhrapradesh, India, revealed that paddy cultivation gave a net profit of Rs 6, 000 to Rs 8, 000 $ha^{-1}yr^{-1}$ only, whereas, under rice-fish and banana farming a net profit of about Rs 18, 000 to Rs.23, 000 per ha per yr was obtained (Raju and Reddy 1998). The cultured fish species were catla, rohu, mrigal, common carp and giant freshwater prawn Macrobrachium rosenbergii. In the present study Rs 16313.64 $ha^{-1}yr^{-1}$ was obtained as a net profit from rice-fish farming.

Shingare and Shirgur (2000) reported that rice-fish culture at a village of Raigad district of Maharashtra, India, in summer yielded an average of 140 kg of fish per ha over 80 to 90 days of culture. The yield of paddy was higher by 38 per cent in the plot with fish culture compared to the plot with rice alone. An appraisal of the economics of the trial operation indicated a net profit of around Rs.3103.00 largely from the sale of common carp.

A study by Ghosh and Pathak (1988) showed that the farmers should use some important inputs like lime 75 kg, raw cowdung 2 tons, fish fingerlings 5,000 nos., fish meal 500 kg ha^{-1} to get a profitable income of Rs.11,750.00. In Tamilnadu, India, Felix et al. (1992) calculated an annual turn over of Rs.34,550.00 ha^{-1} through production of 6 tons of paddy and 1 ton of fish by investing Rs.1,397.00 . The present study revealed that paddy contributed Rs 35, 658.96 from 1.25 ha area and fish contributed Rs 18, 861.00 from 0.29 ha area to the total revenue (Rs 54, 520.00) obtained under the system. Fish production from the cropping system in the present study was 1,465 kg/ha, whereas paddy production was 5 tonnes ha^{-1}. Thus in the present study fish production was higher while paddy production was lower as compared to the study of Felix et al. (1992).

Experimental paddy-cum-fish culture carried out in 1.02 ha in West Bengal showed a production of 1.2 tons of Kharif (starts by June-July and ends by September- October) paddy and 4.3 ton ha^{-1} of rabi (starts by October-December and ends by April-may) paddy, besides 700 kg ha^{-1} of fish over a 10-month culture period (Ghosh 1990).

Production Function Analysis

The Cobb- Douglas equation worked out to find out the input-output relationship is as follows:

$$Y = 4.4735\, X_1^{0.4452}\, X_2^{0.0783}\, X_3^{0.0103}\, X_4^{-0.1242}\, X_5^{0.0365}\, X_6^{-0.5061}$$

The coefficients of the variables area (X_1) lime (X_2), urea (X_3) and feed (X_5) had positive sign while fish seed (X_4) and labour (X_6) had negative sign (Table 2). The production elasticities of the variables X_1, X_2, X_3, X_4, X_5 and X_6 were 0.4452, 0.0783, 0.0103, -0.1242, 0.0365 and -0.5061, respectively. Among the six variables studied, the "t" value of area (X_1) and labour (X_6) were only significant (at 1%) indicating the decisive influence of these variables on production. Negative relationship of X_6 with the production indicated inefficiency of the labour inputs.

Table 2 Estimated production function (Cobb-Douglas), input means and estimated output for the paddy-cum-fish culture (n=50)

Items	Area (ha) X_1	Lime (kg) X_2	Urea (kg) X_3	Fish seed (Numbers) X_4	Feed (kg) X_5	Labour (mandays) X_6
Production coefficient	0.4452	0.0783	0.0103	-0.1242	0.0365	-0.5061
Standard error	0.0839	0.2098	0.0094	0.0658	0.1959	0.1662
t-value	5.30	0.37	1.09	1.88	0.1865	3.044
Input mean	0.27	30.0	25.0	9194.0	59.0	178.57
MPP	1444.0	1.02	0.1611	-0.0044	0.0097	-1.04
Price of input (Px)	2000.00	7.0	4.00	0.75	5.00	50.00
MVP	25723.00	40.72	6.4	-0.1760	0.3867	-41.75
Maximum profitable level	3.47	174.50	40	2980.00	114.00	157.00
Average Fish Production (Y) = 390 kg.			Price of fish (Py) = 40.00			

Note: R^2 = 0.69 ; Intercept = 4.4735

The farmers in the study districts have sufficient land area to expand their culture activities. As indicated in the present study, the area that gives the maximum level of profitability is 3.47 ha to increase fish production under the integrated system. At the same time it is also essential to decrease the excess use of inputs like labour from 178 man-days to the maximum profitability level of 157 man-days.

The study shows that there is a scope for increasing yield by incorporating the critical inputs at maximum profitable level (Table 2). The farmers practiced this farming system at extensive levels and earned marginal profit levels. If they follow the scientific farming system they could increase their returns.

Conclusion and Recommendations

Given the importance of rice and fish in the national economy, the decline in wild fish stocks and the growing need for fish protein, the feasibility of integrating fish culture with rice cultivation has been attracting increasing attention and could result in fish becoming available to a substantially greater number of rural households.

The present study has clearly indicated that rice-fish culture is a viable, environment-friendly, low-cost, low-risk additional economic activity with multiple benefits including increased incomes and greater availability of fish to rural farming community. Further work is needed in other regions of the country with different agro ecological conditions. Extension and development agencies should pay due attention to bring the benefits of the technology to marginal farmers.

The farmers who had capability to undertake rice-fish farming, however over used some of the items like fish seed and labor which was due to lack of proper extension service. On the other hand poor fish farmers don't have adequate funds to practice rice-fish farming with all the necessary inputs and dyke preparation.

Availability of fish seed and low lying deep water paddy field favours the growth of rice-fish culture in the study region. To harness this potential, the government should address the constraints by transferring knowledge to farmers by strengthening extension service and by provision of financial assistance to encourage the poor farmers to adopt rice-fish culture. Short-term, low-interest loans, primarily to support earth work (ditch excavation and dike strengthening) and subsidy to over come the loss due to flood should be made available to farmers. It is also necessary for the researchers as well as the fisheries and agriculture extension workers to work closely with farmers for technology transfer.

The farmers in the study areas have interest in expanding fish culture along with rice cultivation. A location specific program in this aspect will be more appropriate to motivate them to take up rice-fish culture in a scientific way. The occurrence of frequent flood in the region is a major obstacle to propagate rice-fish culture. Proper dike arrangement may help the farmers to overcome this problem to a great extent but it will increase the cost of operation.

The crest of dyke could be effectively utilized through plantation of papaya and banana saplings alternatively which will strengthen the dyke and compensate the cost of dyke preparation to some extent by the sale of banana and papaya. Vegetables can also be grown on the dyke during summer and winter. Further promising indigenous species deserve more attention. Paddy plots provide breeding ground for many air-breathing swamp fishes. Since air-breathing fish has a very good demand in the state, paddy plots can be best utilized for the cultivation of the fish along with rice.

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