Asian Fisheries Science 7(1994):249-258.
Asian Fisheries Society, Manila, Philippines

Economics of the Integrated Fish-Chicken Farming System (*Longyam*) in Tasikmalaya, Indonesia

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Abstract

One of the ways to increase income among fish farmers in Tasikmalaya District in the southern part of Java Island in Indonesia is the adoption of an integrated fish-chicken farming system known locally as *longyam*. The management of longyam is generally based on tradition, past experience and comparison with neighbors. The study examines the efficiency of the present management system and compares it with an optimal system generated by linear programming. The optimal solutions can substantially increase total net revenue. To achieve this, extension efforts should be intensified to introduce new technology, and managerial practices improved to increase productivity. Although increased income can also be achieved by expanding the land area, this alternative is not possible due to serious limitations of land availability.

Introduction

The annual per capita income for Tasikmalaya District in the southern part of Java Island, Indonesia, is Rp 425,000; this is lower than the per capita income of West Java Province which is Rp 585,000 (Bappeda Propinsi Daerah Tingkat 1 Jawa Barat 1989), and much lower than that of Indonesia as a whole which is Rp 950,000 (US$1.00=Rp 1,696 in 1989) (World Tables 1989). The lack of employment opportunities and inefficient use of labor are believed to be some of the causes for the low income, particularly in rural areas of Tasikmalaya.

Nearly three-fourths of the people in Tasikmalaya are involved in agriculture (Dinas Perikanan Kabupaten Daerah Tingkat II 1989). Hence efforts at augmenting income and employment opportunities have come mainly from the agricultural sector. One of the agricultural income-enhancing programs aimed at overcoming this problem is the integrated fish-chicken farming system known locally as *longyam*.

Introduced in 1981, longyam has become a feature of aquaculture in the Tasikmalaya District. It is popular among fish farmers because it generates higher production compared to fish-only culture. In longyam, fish farmers use the pond environment efficiently by rearing together different fish species targeted for different food niches in the ponds. The commonly cultured species are omnivorous mas (*Cyprinus carpio*), herbivorous tawes (*Puntius gonionotus*) and nilem (*Osteochilus hasselti*), and plankton-feeding tambakan (*Helostoma temmnicky*). In addition, omnivorous nila (*Oreochromis niloticus*) is also cultured.

In the chicken enterprise, fish farmers raise either egg layers, broilers or cockerels. In general, however, they prefer layers which generate a continuous flow of income from the sale of eggs.

Generally the longyam culture technique is based on tradition, past experiences and comparison with neighbors. No previous attempts have been made to examine the efficiency of the present management system. Hence the objective of the study is to compare existing practices with that of an optimal system generated by linear programming.

Methodology

Sources of Data

Primary data were collected through a farm survey conducted from August to September 1989. Longyam were found in 13 subdistricts of the northern and central parts of the Tasikmalaya District involving 304 households. However, only farmers with at least 4 years experience in longyam were considered for the study to ensure that those selected had already established themselves with the longyam culture.

Those chosen were categorized into three groups based on farm size, i.e., 27 small farms (<1,000 m^2), 25 medium farms (1,000-2,000 m^2) and 23 large farms (>2,000 m^2).

Model Specifications

Linear programming (LP) was used to determine the optimal enterprise mix and resource allocation among longyam farmers. The objective function of LP is the sum of the net revenues of each activity included in the model, and is computed as the difference between gross revenue and variable costs. The usual limitations inherent in the assumptions of the LP methodology apply.

The real activities in the LP model are enterprises practiced by at least some of the fish farmers in the survey area. The enterprises included in the model are: 1) the culture of five fish species, i.e., mas, nilem, tawes, tambakan and nila; and 2) the raising of broilers, layers and cockerels. The model also includes resource-hiring activities (as in the case of labor and capital) and transfer of cash activities which enable surpluses to be transferred to the subsequent month. These three activities namely, labor hiring, capital borrowing and cash transfer, make up the disposal activities of the LP model.

The only activities considered in the LP model are those which can be completed within the planning period. Since layers have the longest production cycle (21 months), this was considered as the planning period of the LP model. An enterprise which was stocked at different tiimes in the planning period was treated as a different activity.

REAL ACTIVITIES

The production cycle of each fish species is 3 months, including the time taken for pond preparation (about 2 weeks). Hence within the planning period, longyam farmers are expected to have seven production cycles or seven activities for each species of fish. The fingerling purchase price and the selling price of each of the cultured species in the system are given in Table 1.

Table 1. The purchase price of fingerlings and the selling price of the fish at harvest (in Rp per kg).

Species of fish	Purchase price of fingerlings	Selling price of fish at harvest
Mas (*Cyprinus carpio*)	2,500 (3-5 cm)	2,000 (50-80 g)
Nilem (*Osteochilus hasselti*)	1,500	1,200
Tawes (*Puntius gonionotus*)	2,000	1,500
Tambakan (*Helostoma temmnicky*)	1,500	1,200
Nila (*Oreochromis niloticus*)	1,200	1,000

The production cycle for each batch of broilers is 2 months. Thus, within the planning period, farmers are expected to stock 10 batches of broilers. Broiler day-old chicks (DOCs) are bought at an average price of Rp 500. At the end of the production cycle, broilers weighing 1.4-1.6 kg are sold at an average price of Rp 1,800 per kg. For layers, eggs are produced from the fifth to the 21st month. During the egg laying period, each bird produces on average 270 eggs which are then sold at an average price of Rp 1,600 per kg (1 kg = 16 eggs). Unproductive birds weighing 1.6-2.0 kg are sold at an average price of Rp 1,400 per kg. Layer DOCs are bought at an average price of Rp 700.

Cockerels or male birds are raised for 40-42 d. As in the case of broilers, cockerels were programmed for 2 months for each production cycle, including the time required to prepare the chicken shed. There were 10 batches of cockerels within the planning period and therefore 10 activities of cockerels were entered into the LP model. The average price of cockerel DOCs is Rp 250. At harvest when their average weight reaches 0.7-0.8 kg, cockerels sell for Rp 1,800 per kg.

DISPOSAL ACTIVITIES

Hired labor supplements family labor for each month in the planning period. Hence there are 21 hired labor activities in the LP matrix. Hired laborers work 5 h a day at a rate of Rp 1,500 per day.

There are three sources of borrowed capital, namely, friends/relatives, cooperatives and banks. The cost of borrowed capital varies from as high as 20%

from relatives to 14% from banks and cooperatives. It is assumed that borrowing is done in the first month of the planning period. Since own and borrowed capital are available at the beginning of the planning period, the capital requirements of subsequent months are met through cash transfer activities. Hence there are 20 cash transfer activities in the LP matrix.

Restrictions

In longyam culture, the constraints are in the form of land, capital, family labor and production (Table 2).

Table 2. Restrictions in the standard model.

Row name	Definition	Farm size		
		Small	Medium	Large
POND1 to POND7	Land available in terms of carrying capacity (maximum weight of fingerlings that can be stocked) for each period of cultivation (kg)	45	75	155
WCAP1	Working capital (x 1,000 Rp) available in first month	500	1,000	1,200
WCAP2 to WCAP21	Working capital (x 1,000 Rp) available in other months	0	0	0
BC1	Borrowed capital available from friends/relatives (x 1,000 Rp)	1,000	1,000	1,000
BC2	Borrowed capital available from cooperatives (x 1,000 Rp)	1,000	1,000	1,000
BC3	Borrowed capital available from banks (x 1,000 Rp)	15,000	15,000	15,000
LAB1 to LAB21*[1]	Family labor available each month	26	26	26
SHED1 to SHED10	Size of chicken-shed for litter system in terms of the maximum number of broilers and/or cockerels raised in each production period	100	150	320
MAXLAY	Size of chicken-shed for battery system in terms of the maximum number of layers raised in each production period	20	30	60
MAXMAS1 to MAXMAS7	Maximum weight of mas fingerlings to be cultured in each period of cultivation (kg)	20	34	70
MAXNIL1 to MAXNIL7	Maximum weight of nilem fingerlings to be cultured in each period of cultivation (kg)	13.5	22.5	46.5

*With the exception of Lab12 and Lab 14, the value for which is 25 man-days.

The opportunity for acquiring more land for fishponds through purchase is limited. Therefore, land available for longyam culture is assumed fixed. In determining the land constraint, instead of using the size of ponds, the maximum weight of the total number of fingerlings that can be stocked in each culture period (carrying capacity) is used. There are altogether seven land constraints in the model, as there are seven batches of fish than can be stocked within the planning period.

On the average, farmer's own capital available in the first month of the planning period is Rp 500,000, 1,000,000 and 1,200 for small, medium and large farms, respectively. On the other hand, a sum of Rp 1,000,000 each can be borrowed from friends/relatives and cooperatives. Credit from banks amounting to Rp 15,000,000 is also used.

Family labor provides 25 man-days for the second and 14th months and 26 man-days for other months within the planning period. Labor requirements for the different activities was computed on a per-month basis, hence there are 21 labor restrictions in the LP matrix.

The main fish species cultured in longyam are mas and nilem. Fish farmers stock approximately 45% mas and 30% nilem. The remaining 25% comprise the other three species. The respective proportion of mas and nilem in the polyculture are treated as the maximum stocking constraints. Thus there are seven production restrictions for mas and nilem.

A chicken shed is constructed over the ponds, hence the chicken enterprise does not compete with fish over the use of available land. Nevertheless the size of the shed must allow sufficient sunlight to illuminate the pond water for photosynthesis. Two systems of chicken sheds, i.e., battery and litter, are erected over the ponds to allow combinations of different chicken enterprises. The size of the shed is determined by the maximum number of broilers and cockerels (for litter) and layers (for battery) that can be stocked per raising period. Since there are 10 batches of broilers and cockerels within the planning period, there are 10 restrictions on the size of the chicken shed for the litter system. The restriction for the battery system is one since only one batch of layers is stocked during the planning period.

In total there are 7 land restrictions, 21 working capital restrictions, 3 borrowed capital restrictions, 21 labor restrictions, 10 litter shed system restrictions, and 1 battery shed system restriction.

The Aggregated Model

Mathematically the LP model can be explained as follows:

$$\begin{aligned} \text{Max} \quad &: \quad Z = C'X \\ \text{s.t.} \quad &: \quad AX \leq B \\ \text{and} \quad &\quad\ \ X \geq 0 \end{aligned}$$

$$\text{where} \quad : \quad C = [c_1 \ldots\ldots\ldots c_{100}]$$

$$X = \begin{matrix} X_1 \\ \cdot \\ \cdot \\ \cdot \\ X_{100} \end{matrix}$$

The variables are defined as:

X_1 to X_{56} = real activities
X_{57} to X_{77} = hired labor activities
X_{78} to X_{97} = cash transfer activities, and
X_{98} to X_{100} = borrowed capital activities
C_1 to C_{100} = the corresponding net revenue vector or cost vector, and

$$B_i = \begin{matrix} b_1 \\ \cdot \\ \cdot \\ \cdot \\ b_{77} \end{matrix}$$

Where:

b_1 to b_{77} = land constraints in terms of the maximum weight of fingerlings that can be stocked (carrying capacity) for each culture period;
b_8 to b_{28} = working capital restrictions;
b_{29} to b_{31} = restrictions on borrowed capital from friends/relatives, cooperatives and banks;
b_{32} to b_{52} = monthly labor restrictions;
b_{53} to b_{62} = maximum number of broilers and/or cockerels that can be raised;
b_{63} = maximum number of layers that can be raised;
b_{64} to b_{70} = restrictions on production of mas;
b_{71} to b_{77} = restrictions on production of nilem; and
A_{ij} is the matrix of input-output coefficients.

Comparison Between Existing Practices and the Optimal Plan

The enterprise mix and net revenues of the existing practices and of the optimal plans for the three farm categories (small, medium and large) are presented in Table 3. The optimal plan suggests that small farms culture 20 kg mas, 13.5 kg nilem and 11.5 kg tambakan for each production period. Through this polyculture, farmers can earn a net revenue of Rp 1,253,322 which is 4.6% higher than the existing practice.

Under the existing practice, each farmer in the survey area undertakes only one kind of chicken enterprise; whereas the optimal plan recommends that all three chicken enterprises be undertaken to improve net revenue per planning period by as much as 20% using less operating capital. As shown in Table 3, the average borrowed captial declined by 54.0%.

Under the optimal plan, farmers of medium farms can increase net revenue by 24.0% through fish polyculture (Table 3). The optimal plan also shows that, if layers and broilers were raised throughout the planning period, and cockerels only in the first and second periods of production, altogether this would generate a net revenue of Rp 9,405,225 which is higher than that gener-

ated under the existing practice from fish integrated with broilers (by 38.1%), fish integrated with layers (by 41.4%) and fish integrated with cockerels (by 60.1%).

As in small farms, there is a 44.7% reduction in borrowed capital as compared to the existing practice.

Table 3. A comparison between the existing practice and the optimal plan for different farm categories.

Item	Small farms		Medium farms		Large farms	
	Existing practice	Optimal plan	Existing practice	Optimal plan	Existing practice	Optimal plan
Fish (kg)						
Mas1	18.0	20.0	28.0	34.0	55.0	70.0
Mas2	18.0	20.0	28.0	-	55.0	70.0
Mas3	18.0	20.0	28.0	34.0	55.0	70.0
Mas4	18.0	20.0	28.0	34.0	55.0	70.0
Mas5	18.0	20.0	28.0	34.0	55.0	70.0
Mas6	18.0	20.0	28.0	34.0	55.0	70.0
Mas7	18.0	20.0	28.0	34.0	55.0	70.0
Nilem1	13.0	13.5	18.0	22.5	42.0	-
Nilem2	13.0	13.5	18.0	22.5	42.0	-
Nilem3	13.0	13.5	18.0	22.5	42.0	46.5
Nilem4	13.0	13.5	18.0	22.5	42.0	46.5
Nilem5	13.0	13.5	18.0	22.5	42.0	46.5
Nilem6	13.0	13.5	18.0	22.5	42.0	46.5
Nilem7	13.0	13.5	18.0	22.5	42.0	46.5
Tawes1	2.0	-	4.0	-	8.0	-
Tawes2	2.0	-	4.0	-	8.0	-
Tawes3	2.0	-	4.0	-	8.0	-
Tawes4	2.0	-	4.0	-	8.0	-
Tawes5	2.0	-	4.0	-	8.0	-
Tawes6	2.0	-	4.0	-	8.0	-
Tawes7	2.0	-	4.0	-	8.0	-
Tambakan1	5.0	11.5	5.0	-	25.0	-
Tambakan2	5.0	11.5	5.0	-	25.0	-
Tambakan3	5.0	11.5	5.0	-	25.0	-
Tambakan4	5.0	11.5	5.0	-	25.0	-
Tambakan5	5.0	11.5	5.0	34.0	25.0	-
Tambakan6	5.0	11.5	5.0	-	25.0	-
Tambakan7	5.0	11.5	5.0	34.0	25.0	-
Nila1	6.0	-	5.0	18.5	15.0	85.0
Nila2	6.0	-	5.0	52.5	15.0	85.0
Nila3	6.0	-	5.0	18.5	15.0	38.5
Nila4	6.0	-	5.0	18.5	15.0	38.5
Nila5	6.0	-	5.0	18.5	15.0	38.5
Nila6	6.0	-	5.0	18.5	15.0	38.5
Nila7	6.0	-	5.0	18.5	15.0	38.5
Chicken (bird)[1]						
Broiler1	750.0	762.0	1,200.0	1,014.0	1,130.0	2,417.0
Broiler2	750.0	982.0	1,200.0	1,438.0	1,130.0	3,200.0
Broiler3	750.0	1,000.0	1,200.0	1,500.0	1,130.0	3,124.0
Broiler4	750.0	1,000.0	1,200.0	1,500.0	1,130.0	3,200.0
Broiler5	750.0	1,000.0	1,200.0	1,500.0	1,130.0	3,200.0
Broiler6	750.0	1,000.0	1,200.0	1,500.0	1,130.0	3,200.0
Broiler7	750.0	1,000.0	1,200.0	1,500.0	1,130.0	3,200.0
Broiler8	750.0	1,000.0	1,200.0	1,500.0	1,130.0	3,200.0
Broiler9	750.0	1,000.0	1,200.0	1,500.0	1,130.0	3,200.0

Continued

Table 3. Continuation.

Item	Small farms		Medium farms		Large farms	
	Existing practice	Optimal plan	Existing practice	Optimal plan	Existing practice	Optimal plan
Broiler10	750.0	200.0	1,200.0	1,500.0	1,130.0	3,200.0
Layer	430.0	238.0	600.0	300.0	870.0	640.0
Cockerel1	1,050.0	18.0	1,350.0	486.0	1,170.0	783.0
Cockerel2	1,050.0	-	1,350.0	62.0	1,170.0	-
Cockerel3	1,050.0	-	1,350.0	-	1,170.0	76.0
Cockerel4	1,050.0	-	1,350.0	-	1,170.0	-
Cockerel5	1,050.0	-	1,350.0	-	1,170.0	-
Cockerel6	1,050.0	-	1,350.0	-	1,170.0	-
Cockerel7	1,050.0	-	1,350.0	-	1,170.0	-
Cockerel8	1,050.0	-	1,350.0	-	1,170.0	-
Cockerel9	1,050.0	-	1,350.0	-	1,170.0	-
Cockerel10	1,050.0	-	1,350.0	-	1,170.0	-
Owned capital (Rp)	500,000.0	500,000.0	1,000,000.0	1,000,000.0	1,200,000.0	1,200,000.0
Borrowed capital (Rp)						
Friends/ relatives	700,000.0	-	-	-	-	-
Cooperative	875,000.0	1,000,000.0	1,000,000.0	1,000,000.0	-	1,000,000.0
Bank	3,260,000.0	1,223,190.0	4,443,750.0	2,011,918.0	5,325,000.0	7,607,554.0
Total	4,835,000.0	2,223,190.0	5,443,750.0	3,011,918.0	5,325,000.0	8,607,554.0
Hired labor (man-days)		164.8		437.1		1,419.4
Fish cum broiler	14.0		105.5		136.6	
Fish cum layer	14.0		97.6		284.7	
Fish cum cockerel	14.0		105.5		136.6	
Net revenue[2] of fish culture (Rp)	1,198,400.0	1,253,322.0	1,663,816.0	2,062,845.0	3,971,191.0	4,288,623.0
Net revenue of longyam (Rp)		5,907,210.0		9,405,226.0		17,389,747.0
Fish cum broiler	4,149,650.0		6,808,216.0		8,394,011.0	
Fish cum layer	4,707,114.0		6,649,996.0		10,973,386.0	
Fish cum cockerel	3,858,050.0		5,875,816.0		6,980,701.0	

[1] Under the existing practice, farmers in the survey area raise only one kind of chicken. Under the optimal pattern, farmers have an opportunity to raise three kinds of chicken.
[2] Net revenue = gross revenue - total variable costs

For fish culture in large farms, there is a net gain of about 8% if farmers switch to the optimal plan from the existing practice. Although the net revenue from fish culture as a subsystem of longyam can be improved only marginally, longyam as a total system under the optimal plan generates a substantially higher net revenue. The rate of increase in total net revenues varies from 58.5%

(as compared to fish integrated with layers) to 149.1% (as compared to fish integrated with cockerels). The latter indicates that large farms which raise cockerels under the existing practice are the most inefficient in terms of using their resources.

Unlike in small and medium farms, the optimal solution in large farms shows a 42.9% increase in borrowed capital from banks.

Conclusions

The optimal solutions relative to the existing practice can increase total net revenue in all three farm categories, particularly for the longyam as a total system. The optimal solutions also show that large farms have a greater potential for generating higher income than small and medium farms. Under the existing practice, farmers undertake only one kind of chicken enterprise, but the optimal plan provides opportunities for farmers to undertake three kinds of chicken enterprises which could reduce risk through diversification.

Furthermore, the higher total net revenues obtained by small and medium farms in the optimal plan require less borrowed capital, i.e., 54 and 45% less, respectively, than the existing practice. On the other hand, large farms need 30% borrowed capital than what is presently required.

In the optimal plan, fish are reared in polyculture consisting of two or three species, although for some specific periods, mas and nilem are substituted by minor species such as nila.

Layers are in the basis at the maximum battery capacity. A small number of cockerels are included only during certain production periods. Hence the litter system is dominated by broilers.

The optimal plan suggests two alternative ways to augment total net revenue: increase resource availability and introduce new technology. Although land has been shown to have tremendous potential for increasing net revenue, its supply is severely limited due to high population pressure. An increase in the availability of credit would benefit large farms, but if the land is limited, this approach would not help increase net revenue.

The second alternative is to introduce new technology and management in order to increase productivity on the existing land base. Switching from the traditional to a new technology, however, requires intensive extension efforts. Evidence in the study area shows that only about 13% of the farmers learned about longyam culture through extension agents. There is therefore still much room for enhanced efforts by extension workers to develop longyam culture.

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Manuscript received 18 June 1993; accepted 11 November 1994.