Adoption and Economics of Tilapia Farming Technology in the Philippines

Ruben C. Sevilleja
Freshwater Aquaculture Center, Central Luzon State University
Nueva Ecija PHILIPPINES 3120

ABSTRACT: This paper examines the circumstances under which farmers respond to the introduction of tilapia production technology, and analyzes the manner in which the benefits from such introduction are shared and distributed among recipients. The hypothesis that the inverse relationship between yields and operational land size widely observed in agriculture is tested whether it also applies in aquaculture. The highly differentiated agrarian structure of the Philippines influences to a high degree the process of freshwater aquaculture development. More specifically, farmers adopt tilapia farming because of financial and economic incentives because tilapia production is shown to be profitable. The results on the differences between farm size in tilapia hatchery operation strongly suggest that large farms are not as productive as small farms. However, the size-productivity relationship observed under grow-out operation illustrates a situation where the productivity of factors is determined by the relations of production. Tilapia culture, notably hatchery operation, results in increasing commoditization and there is growing market orientation of aquaculture production. As a consequence, the benefits from the technology depend upon access to and ownership of factors of production resulting in variations in the level of productivity and an unequal distribution of income.

Key words: tilapia, aquaculture, technology adoption, size-productivity relationship

1. INTRODUCTION

The dominant theme in the country's attempt to attain industrialization is the "alleviation of poverty and promotion of equity" (NEDA, 1993). To achieve this goal, an agro-industrial approach is specified where the agriculture sector must develop through modernization, improvement in productivity and aggressive product diversification in order to provide the food requirements of the population.

Fisheries, particularly the aquaculture sector, ranks high in the government's development priorities (Geron, 1993). Apart from being an important source of protein, aquaculture is recognized as a source of employment and an essential component of integrated rural development (Roldan, 1983). In the midst of efforts to develop this sector is the introduction of tilapia production technologies. Tilapia now ranks second to milkfish as the most important cultured fish in the Philippines (Guerrero, 1994). The popularity of tilapia farming is associated not only with its potential as a source of food but also as an attractive investment activity (Bimbao and Smith, 1988).

As the industry develops, there are concerns about the likely consequences. It is acknowledged that the introduction of agricultural and aquacultural technologies in developing countries leads to significant economic and social changes, often with detrimental consequences to small farmers (Skladamy 1990; Boyce 1993; Naganathan et. al. 1995). The focal issue in this development process deals with the manner in which benefits and welfare are produced and distributed.

In order to have a better insight into the different aspects of aquaculture development as in the case of tilapia, an analysis of the farm organization is necessary. It is important to have an assessment of the producer as a decision-making unit and how decision is influenced by socio-economic factors. The analytical procedure applied in this study only evaluates the static efficiency effects of aquaculture (tilapia) production. Such analysis proceeds through comparisons of the relative economic efficiency of different components of the agrarian structure focusing on farm-size and tenancy-output relationship (Boyce, 1987).

This paper investigates and analyzes the effects and consequences of tilapia technology adoption among farmers leading to a better understanding of the circumstances and motivations that shape farm operators' decision making processes. Specifically, the study aims to identify the factors which influence farmers to adopt tilapia farming technology; and to compare the productivity and efficiency of tilapia farming according to size of farm and according to tenurial arrangement.

2. METHODOLOGY

The purpose of the investigation was premised on the general proposition that the existing agrarian structure influences the manner in which farmers respond to aquaculture technology. In order to address this issue, the productivity or profitability and efficiency of tilapia production per unit area of fishpond was compared between case studies including owned and tenanted farms; and among case studies including different fishpond sizes.

Evaluation of profitability follows the traditional procedure for financial analysis (Gittinger 1972). Two measures of net income are calculated: net farm income defined as total cash income minus total cash cost; and net profit which is calculated by subtracting total cost from total income (Brown, 1979). Indicators of factor productivity are measured as output per unit of input (Lee, 1982) but are expressed in monetary values. Rates of return as a measure of production efficiency were also calculated as outlined by Shang (1991).

Data for this research were collected in 1995-96 from two case study sites in Southern Tagalog and Central Luzon regions in the island of Luzon identified by purposive sampling. In 1994, these two regions accounted for 36.6 and 40.1%, respectively, of the national tilapia production of 84,493 metric tons from the freshwater aquaculture sector (BFAR, 1995). Two groups of farmers selected through stratified sampling: 50 hatchery operators in Southern Tagalog; and 37 grow-out operators in Central Luzon, comprised the respondents for this study. Data and information were collected by personal interview and through participant-observation technique.

3. ADOPTION OF TILAPIA FARMING TECHNOLOGY

Studies on factors influencing adoption technology have economic and social underpinnings. The central focus is on variables that might have influenced farmer decision-making processes which include economic and technical factors inherent in alternative technologies, and the individual's sociological characteristics. The rate of adoption of an innovation depends to a great deal upon its characteristics. It can be explained by such economic variables such as profitability (relative advantage) and social variables such as compatibility (Rogers, 1983). Feder et. al. (1985) also identified other factors such as capital and credit availability, experience and education; risk aversion; farm tenurial arrangement; and supply of supplementary inputs. In the Philippines, Chong and Lizarmundo (1982) found that education was insignificant in explaining fertilizer use rate among milkfish farmers; but Padilla (1985) claimed that mastery of new fishfarming practice is a function of experience.

3.1 Operational Strategies

The role which aquaculture plays and the contribution it provides to the livelihood patterns of farmers in the case study areas lead to an understanding of their operational strategies. Hatchery operation in Southern Tagalog fits a "focused operation" as defined by Molnar et. al. (1996) whose main features include: (a) high degree of dependence by operators on tilapia culture for their livelihood, although there is a moderate level of investment; (b) optimization of input use and adoption of technologies with moderate levels of financial risk; (c) fish farming as the only activity of some farmers; and (d) implementation of intensive practices due to high level of technical and managerial expertise of farmers.

On the other hand, grow-out farming in Central Luzon corresponds to "residual operation" designed to capture benefits such as wastes and by-products of some primary activities like rice and animal production. There is moderate investment and low dependence of farmers in the operation as reflected by the small contribution to income compared to other sources. The operation is also "complementary" to other activities because it completes the cycle of input use and resource availability in the farm; carried out for ready cash flow; and for its low labor requirement.

In tilapia hatchery operation, the high degree of specialization and relative absence of diversification implies that the question of access to and control over land is crucial in determining the well-being of the rural population. The limited land resources led farmers to adopt an available land-augmenting technology such as tilapia fingerling production. On the other hand, better access of grow-out farmers to land enables them to generate income from other sources. As shown by Ahmad and Hussain (1991), the guaranteed access to land in rural areas guaranteed the success of China in substantially protecting the population from deprivation.

3.2 Motivational Factors

Farmers provided several reasons and motivations governing their decisions to shift to or start tilapia production. Although the relative importance of reasons given by the farmers somewhat varies between hatchery operators and grow-out farmers. The over-riding motivation is profit and income incentive. These results are consistent with the findings of Marzan et. al. (1995) that fish farming provides additional income to operators. Among hatchery operators, 90% of the farmers are engaged in tilapia farming because it is more profitable (Table 1). It is also interesting to note that 68% of the farmers prefer tilapia culture because it provides a regular income. The frequency of income and the regular flow of cash to farm household is important to farmers whose only source of livelihood is hatchery operation. For grow-out operation, the major reasons for adopting tilapia farming technology are the need for additional income (81%); the use of water for irrigation purposes (78%); and the desire to produce fish for home consumption (68%).

Another prominent motivation is the aspect related to risk. Among hatchery operators, 56% consider tilapia culture as less risky compared to rice production; 43% among grow-out farmers regard tilapia farming as a means of spreading risk. The technology is also easier to manage and requires less labor.

Table 1. Motivations and reasons of hatchery and grow-out farmers for starting or shifting to tilapia production

Motivation/Reason	Hatchery	Grow-out
No. of farmers	50	37
	(% of	farmers)
More profitable	90	62
Additional income	10	81
More regular income	68	-
Easier to manage	42	38
Use of water for irrigation	-	78
Food for home consumption	-	68
Less expenses/less labor	50	41
Less risk/spread out risk	56	43

Note: Farmers provided multiple reasons

3.3 Acquisition of Technical Knowledge

Most hatchery operators (74%) acquired their farming expertise through experience as shown in Table 2. Relatives and friends (32%) are also significant sources of information. On the other hand, seminars and training (67%) provided the initial information for grow-out farmers. About 51% learned from their own experiences while about 46% obtained information from technicians. Other knowledge sources were fellow farmers; and radio and television programs. Very few reported obtaining information from books, brochures and video due to the cost and their limited availability.

3.4 Adoption Patterns

Studies of the Green Revolution show that bigger farms adopt technologies ahead of smaller farms (Farmer, 1979; Griffin, 1979). In this research, the case studies on tilapia technology adoption indicate a similar pattern.

To illustrate this, the length of experience is used as an indication of the time of adoption. As shown in Table 3, farmers with bigger landholding adopted the technology ahead of farmers operating smaller land area. Among tenure groups, sharecropping hatchery farmers are found to have adopted the technology at a later time compared to owner-operators who adopted the technology ahead of the leaseholders.

As had been established in studies regarding the introduction of new rice technology, access to land explains this trend in the pattern of adoption. However, the observation that early adoption is broadly correlated with farm size is not in itself an explanation of the process of innovation (Harriss, 1982). There are other factors such as structural conditions, including access to water and other markets, and the manner of diffusion of information influenced the total pattern of innovation which are evident in this study.

Table 2. Sources of tilapia farming information

Sources	Hatchery (% of	Grow-out response)
Own experience	74.0	51.3
Relatives/friends	32.0	27.0
Training/seminars	30.0	67.6
Other farmers	14.0	8.1
Technicians	16.0	45.9
Books/brochures/video	6.	5.4
Radio/TV	10.0	16.2

Table 3. Tilapia culture experience of farmers by size of farm and by tenure

Size of Farm and Tenure Groups	Hatchery (years of	Grow-out Experience)
Size of farm (ha):		
< 2.5	11.0	1.9
2.5 to 5.0	-	2.6
> 5.0	12.5	4.9
Tenure groups:		
Owner-operators	12.1	2.8
Leaseholders	12.2	2.6
Sharecroppers	6.9	-

3.5 Farmers' Perception of the Technology

Adoption of innovation or introduced technology can be facilitated only if the perspective of the farmers is taken into account. Grassroots decision making provides farmer opportunities to have access to and control over resources according to accepted norms within the community.

Majority of the farmers irrespective of the nature of operation expressed satisfaction with the tilapia technology. Most of them intended to continue their present scale of operation while an average of 21% of the farmers plan to expand their operations.

The foregoing responses were influenced by the degree of awareness of the operators regarding developments in the tilapia industry. The high demand for tilapia encouraged 86% and 49% of the hatchery and grow-out operators, respectively, to expand and continue producing tilapia (Table 4). The availability of improved breeds is favorable to 72% of the hatchery operators, although this is not as important to grow-out farmers. Other factors such as availability of technology and the supply of commercial feeds are also mentioned favorably by the farmers

Table 4. Encouragement factors for tilapia farming

Factors	Hatchery (% of	Grow-out responses)
Rapid growth of industry	62	38
Availability of technology	44	41
Improved breeds	72	22
High demand of product	86	49
Availability of commercial feed	58	32

4. ECONOMICS OF PRODUCTION

The essence of the problem of aquaculture development is that of enabling traditional fish farms produce a cash surplus. The development of commercial farms which are capable of producing a surplus that the farmer can save and reinvest, is therefore a key in this process.

There are many factors which contribute to the establishment of viable fish production units. Shang (1991) mentioned economic factors which affect profitability as the amount and value of output, and the cost of production. Thus, an increase in income can be achieved by higher production; a decrease in the cost of production; or a combination of both. To achieve this, a farmer must have sufficient knowledge about the various aspects of the production system. As Pillay (1990) emphasized, the application of efficient farm management is a key element to successful aquaculture operation.

4.1 Factor Productivity and Efficiency

The comparison on the productivity and efficiency of factor use among various categories of farms relate only to the sample considered in the case studies; thus, the results are only suggestive of a wider pattern. The productivity of a factor depends not only on the quantity and cost of a specific factor but also on the quantities and cost of other resources utilized in the production process.

Table 5 compares the level of input use and factor productivity for tilapia hatchery and grow-out systems. Data shows that labor and capital are utilized more intensively for hatchery farming. The average annual labor use of 160 days/ha for fingerling production is 2.6 times greater than the 62 days used for grow-out operation. Material and investment costs are also higher for hatchery compared to grow-out.

Land productivity values or the gross income derived from the operation are USD 3,649 and USD 1,574/ha/yr for hatchery and grow-out operations, respectively. This is due to the nature of the operation where there is faster and more frequent turnover of income in hatchery operation. However, labor is utilized more productively in grow-out operation.

Table 5. Factor use and productivity in tilapia production by nature of operation

	Hatchery	Grow-out
Labor input, N	160	62
Total cash cost, C	1,050	642
Total cost, TC	1,256	743
Capital investment, K	2,087	1,278
Land Productivity, I	3,649	1,574
Labor productivity, I/N	23	25
Capital productivity, I/K	3.48	2.45

N = number of days in man-days (md/ha/yr)
C = total cash cost (USD/ha/yr)
TC = total cost (includes imputed cost of owned labor), USD/ha/yr)
K = investment for pond construction, tools and equipment, from buildings and others (USD/ha)
I = annual gross income (USD/ha)
USD = US dollar equivalent to 40 Philippine pesos

Comparison by tenure is presented in Table 6. For hatchery operations, farms operated by leaseholders are the most intensive with respect to use of labor, material inputs and capital per unit area of fishpond. Leaseholders have the highest and productivity of USD 11,423/ha. This could be attributed by the fact that leased farms have the most intensive level of operation. The slightly higher land productivity of share cropped farms compared to owner-operated farms is due to the higher use of labor in tenanted farms. For grow-out operation, owner-operated farms are more productive compared to leased farms in terms of land and labor utilization. These results can be explained by the higher level of factor use by owner-operators.

The utilization of resources in hatchery operation illustrates a negative relationship between size and the quantity of labor, the amount of cost and level of capital investment with fishponds within the smallest category the highest amount. However, the opposite is observed in the use of labor as shown in Table 7.

The productivity of land decreases as the size of a hatchery farm increases. The smallest farms have the highest productivity of USD 22,233 compared to only USD 887 for the biggest farms. However, labor productivity is positively related to size. This pattern is due to the very high level of labor use in smaller fishponds.

For grow-out system, the pattern of input use (expressed in cash cost) appears to decrease initially then increases with size. The biggest farms have higher intensity of input use compared to all the smaller groups. Access to water explains this observation because bigger farms have access to tube wells and pumps which also resulted to higher land and labor productivity.

Table 6. Factor use and productivity in tilapia production by tenure

Item	Owner operated	Lease-hold	Share-cropping
Hatchery:			
Labor input	125	582	195
Total cash cost	984	2,277	850
Total cost	1,122	3,058	1,202
Capital investment	2,335	2,775	1,080
Land productivity	3,152	11,423	3,660
Labor productivity	25	20	19
Capital productivity	3.20	5.02	4.30
Grow-out:			
Labor input	61	67	
Total cash cost	662	571	
Total cost	699	627	
Capital investment	1,331	1,053	
Land productivity	1,620	1,410	
Labor productivity	26	21	
Capital productivity	2.45	2.47	

Table 7. Factor use and productivity in tilapia production by size of fishpond

	Size (ha)			
	(≤ 0.10)	(>.1 - ≤.2)	(>.2 - ≤.3)	(> 0.30)
Hatchery:				
Labor input	1,501	642	197	31
Total cash cost	4,566	2,504	1,729	293
Total cost	1,730	3,535	1,983	316
Capital investment	3,131	2,520	2,613	1,823
Land productivity	22,233	12,282	4,785	887
Labor productivity	15	19	24	28
Capital productivity	4.87	4.91	2.77	3.03
Grow-out:				
Labor input	171	102	64	26
Total cash cost	505	490	581	885
Total cost	527	515	605	926
Capital investment	3,687	2,056	1,539	964
Land productivity	1,388	1,259	1,254	2,117
Labor productivity	8	12	20	83
Capital productivity	2.75	2.57	2.16	2.39

4.2 Profitability

Tilapia production in general is a profitable enterprise. Higher profit is obtained in hatchery operation compared to grow-out operation with annual net farm income of USD 2,600 and USD 932/ha, respectively (Table 8). Among tenure group, hatchery farms operated by leaseholders are the most profitable generating an annual farm income of USD 9,147/ha (Table 9). They are also the most efficient having the highest rates of return on cost and to capital investment. On the other hand, owned farms have the lowest net income and rates of return. These results suggest that in hatchery operation, tenancy does not have a negative effect on profitability and efficiency. What this illustrates is that non-owner cultivators of fishponds are driven to maximize the benefits from their temporary use of somebody else's land. However, sharecropping farmers, although efficient, still have the disadvantage of getting only a share of the benefits from the operation.

In grow-out ponds, owned farms are more profitable compared to leased farms with annual net farm income of USD 958 and USD 839/ha, respectively. However, the efficiency of both farms appear to be similar with no significant differences.

Profitability by size is presented in Table 10. The data show that farm income decreases as the size of hatchery ponds decreases. Farms with the smallest size generated annual net farm income of USD 17,666/ha compared to UD 594 for the biggest farms. These results indicate that the inverse relationship between productivity and size commonly observed in agriculture applies in aquaculture as well; that is, as far as tilapia hatchery operation is concerned.

In grow-out operation, farms within the biggest size group earned the highest level of annual net farm income with USD 1,282/ha, with varying efficiency rates. The non-uniform picture regarding the inverse relationship between size and productivity illustrates the diversity of tilapia grow-out operation. As farmers adopt a technology, uncertainty of productivity responses increases because they are not yet familiar with the various aspects of tilapia production. Imperfect knowledge about the new technology would make achievement of an optimum combination of inputs difficult.

Table 8. Profitability of tilapia production by nature of operation

	Hatchery	**Grow-out**
Net farm income, NFI	2,600	932
Net profit, NP	2,393	832
Return to cash cost (NFI/C)	2.48	1.45
Return to total cost (NP/TC)	1.90	1.12
Return to capital investment (NFI/K)	1.25	0.73

NFI = annual gross income (I) less total cash cost (C), USD/ha/yr
NP = annual gross income (I) less total cost (TC), USD/ha/yr

Table 9. Profitability of tilapia production by various tenure groups

Item	**Owner operated**	**Lease-hold**	**Share-cropping**
Hatchery:			
Net farm income	2,165	9,147	2,810
Net profit	2,030	8,365	2,458
Return to cash cost	2.20	4.02	3.30
Return to total cost	1.81	2.74	2.06
Return to capital investment	0.93	3.30	2.60
Grow-out:			
Net farm income	958	839	
Net profit	922	783	
Return to cash cost	1.45	1.47	
Return to total cost	1.32	1.25	
Return to capital investment	0.72	0.80	

Table 10. Profitability of tilapia production by size of fishpond

	Size (ha)			
	(≤ 0.10)	(>.1 - ≤.2)	(>.2 - ≤.3)	(> 0.30)
Hatchery:				
Net farm income	17,666	9,779	3,057	594
Net profit	15,502	8,747	2,802	571
Return to cash cost	3.87	3.91	1.77	2.03
Return to total cost	2.30	2.47	1.41	1.81
Return to capital Investment	5.64	3.88	1.17	0.33
Grow-out:				
Net farm income	883	769	673	1,282
Net profit	861	744	649	1,241
Return to cash cost	1.75	1.57	1.16	1.39
Return to total cost	1.63	1.45	1.07	1.34
Return to capital Investment	0.24	0.37	0.44	1.33

5. CONCLUSION

The study is premised on the general preposition that the agrarian structure affects aquaculture development. In particular, it is designed to explore answers to the question on how the participants of the development process relate to changes in production and distribution of shares from increased income. The study investigated the relationship of tenancy and farm size to tilapia technology adoption; resource use; and land productivity and efficiency.

5.1 Tilapia Farming Technology and the Farms

The research considered the different motivational factors which influence farmers to adopt tilapia farming technology. In general, the decision to adopt the technology is mainly based on the availability of resources to the farm household. The overriding motivation is to earn more income. This means that farmers respond to prices and market forces. In this respect, it is argued that farmers who adopt tilapia farming are capable of making rational decisions disputing claims as to the irrationality of small farmers (Stevens 1977).

The study also reveals that tenure does not impede the adoption of tilapia farming technology. This finding disputes the theory proposed by Marshall (1958) and Bhaduri (1973) that tenancy is an obstacle to the adoption of technological innovation which improve production and income.

The adoption pattern of tilapia farming technology can be illustrated by differences in size of landholding. Large farms tend to adopt early, but smaller farms follow suit. These results are consistent with that of other studies which find that farm size is not a serious barrier to adoption (Berry and Cline 1979). However, the unequal distribution of ownership of land means that the total benefits which can be derived from tilapia farming are biased in favor of large farms. Herein lies the problems and dilemma which small farmer-adoptors of tilapia culture are confronted with.

5.2 Adoption Constraint and Problems

Technology adoption depends upon the cultivators' access to various factors of production; his knowledge level at adopting modern or scientific information to existing farming practices; and his capacity to integrate with the market. Results of this study show that the problems and constraints to the adoption of tilapia farming technology are mainly economic and technical in nature. With tilapia farming, producers become increasingly dependent on the market for their production inputs. Thus, the ability of the farm household to purchase the materials required in the production process depends on their access to cash, whether from their own savings or credit. In relation to this, the foremost constraint of farmers is lack of capital and the difficulty of getting access to it.

Analysis of the technical constraints reveals strong complementary among the major material inputs (feed, fertilizers and fingerlings) and water. Access to and management of water, opens up opportunities for farmers to culture tilapia. The lack of expertise is also identified as a constraint towards the application of better management techniques.

5.3 Farm Profitability and Income Differential

Results of the study show that land productivity for hatchery operation in tenanted farms exceeds that of owner-operated farms. This contradicts the common prediction that tenancy leads to allocation inefficiency and low productivity (Marshall 1965). In general, the higher land productivity and production efficiency observed in tenant farms compared to owned farms is in accord with the theory of "equal efficiency" (Cheung 1968). The study further shows that the intensity in the use of inputs is the major determining variable as far as farm productivity is concerned. This result illustrates a situation where tenancy does not limit output, but the tenure system pushes the cultivator to produce beyond the income level which satisfies the consumption needs of the family.

The hypothesized inverse relationship between size and productivity does not seem implausible in the light of the case study on hatchery operations. As far as can be ascertained, the difference in productivity by size is attributed to higher cropping intensity. In the case of grow-out operations, the direct relationship between size and productivity is explained by the more intensive use of non-labor inputs in large farms. In general, grow-out operation results in greater benefits for big farms on account of their better access to production resources.

5.4 Implication of Results

Tilapia production has provided investment opportunities to farmers because of the high rates of returns to such investments. But while the benefits of increased income became possible with the adoption of tilapia technology, the distribution of such benefits is influenced by the agrarian structure and nature of production relations. In terms of economic feasibility, and relative cost and returns to investment, the big farmers are placed in a superior position than their smaller counterparts for exploiting the benefits of tilapia farming. The big farms stand to gain more from the introduction of the technology. Consequently, the inequality among farm facilities in terms of farm income are bound to grow under the impact of tilapia technology adoption.

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