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Aquaculture Economics Research in Asia

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Résumé

Cette publication contient une version revue des communications présentées à l'atelier sur la recherche intéressant l'économie de l'aquiculture en Asie, tenu à Singapour du 2 au 5 juin 1981. Les Divisions des sciences de l'agriculture, de l'alimentation et de la nutrition et des sciences sociales du Centre de recherches pour le développement international (CRDI) et le International Center for Living Aquatic Resources Management (ICLARM) ont conjointement réuni des biologistes et des économistes des pêches de neuf pays d'Asie du Sud et du Sud-Est. L'atelier visait à montrer l'utilité et à favoriser l'utilisation de l'analyse économique dans la recherche en aquiculture et à aider à augmenter les compétences de recherche en économie de l'aquiculture en Asie. L'atelier a traité surtout des analyses microéconomiques des systèmes de production aquacultureurs déjà implantés et au stade expérimental. Il a comporté aussi une revue et une discussion sommaires de quelques-unes des grandes considérations socio-économiques relatives à la contribution de l'aquiculture à la société en général et au rôle du système de marché dans l'affectation des ressources à l'aquiculture et aux autres secteurs de l'économie.

Resumen

Esta publicación es una versión editada de los trabajos presentados en Singapur, del 2 al 5 de junio de 1981, durante el taller sobre investigación en la economía de la acuicultura en Asia. Las divisiones de Ciencias Sociales y de Ciencias Agrícolas, Alimentos y Nutrición del Centro Internacional de Investigaciones para el Desarrollo, en colaboración con el International Center for Living Aquatic Resources Management (ICLARM), invitaron a biólogos y economistas especialistas en piscicultura de los países del Sur y Sudeste Asiáticos. La meta del taller era demostrar el uso del análisis económico para la investigación en acuicultura y estimular su uso, así como mejorar la capacidad de investigación en economía de la acuicultura en Asia. Se prestó atención especial a los análisis microeconómicos de sistemas de producción de acuicultura experimentales y existentes, aunque también se presentaron una reseña y discusión limitadas, relativas a algunas consideraciones socioeconómicas más amplias de la contribución de la acuicultura a la sociedad como un todo y al papel del sistema de mercado en la distribución de recursos a la acuicultura y a otros sectores.
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Economic Analysis of Integrated Pig-Fish Farming Operations in the Philippines

Ruben C. Sevilleja

The feasibility of integrating fish with backyard and commercial pig operations is analyzed based on fish yields from experimental pig-fish trials. The main thrust of the experiments was the development of appropriate technologies involving the utilization of pig manure in tilapia production. Although analysis of the experimental integrated project showed that it is operating at a loss, these results do not reflect the true economic potential of the system, because as an experimental project it was not designed to maximize profits. Using partial budgeting techniques, it is estimated that integrated fish production would increase the incomes of both backyard and commercial pig operations. However, the additional capital requirements reduce the rates of return on total investment. It appears that the larger operations will benefit more from integration than the smaller enterprises.

The integration of livestock and fish farming systems has generated interest among farmers for several reasons. Foremost among these is the efficient utilization of resources and the maximization of benefits derived from the farm. Substantial information on integrated livestock-fish farming systems has been reported (Pastakia 1978; Pullin and Shehadeh 1980; Tetangco 1980). In Southeast Asia, the systems in operation have been traditionally carried out at a subsistence level with very limited application of scientific principles. However, the adoption of modern technologies and management procedures is increasing as research data and information become more available. Notable research on the subject has been performed by Schroeder and Hepher (1979), Wynnarovich (1979, 1980), Cruz and Shehadeh (1980), and Schroeder (1980).

In the Philippines, information on integrated systems is scarce because the integration of agriculture and aquaculture farming systems is just beginning (de la Cruz 1980). It was only recently that research was initiated as a result of the recognition of the importance of aquaculture to the nation's economy.

As technologies for integrated systems are developed, their economic viability must be demonstrated to justify their adoption and application. However, detailed economic information is limited. Some examples were presented in a review made by Delmendo (1980). Lee (1980) also attempted to compare the economic efficiency of different crop-livestock-fish farming operations in Taiwan. Optimum manure loading rates and corresponding economic returns for Philippine pig-fish operations have been computed by Hopkins et al. (in press).

At this stage of aquaculture research and development, economic problems have become the major area of concern. Areas such as optimum resource allocation, efficiency of investment, operating costs, and incomes have not been clearly established. The economics of integrated fish farming systems warrant further studies to provide government and private planners with useful guidelines for future implementation. This paper aims to partly satisfy this end by presenting an economic analysis of selected integrated pig-fish farming operations.

Case Studies

Three case studies are presented: a commercial growing operation represented by the integrated pig-fish experimental project being jointly undertaken by the Freshwater Aquaculture Center (FAC) at the Central Luzon State University (CLSU) and the International Center for Living Aquatic Resources Management (ICLARM), the CLSU-FAC/ICLARM project; a backyard pig operation; and a small commercial pig breeding and growing operation. The objectives

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1Central Luzon State University, College of Inland Fisheries, Muñoz, Nueva Ecija, Philippines 2320.
of the case studies were to examine the economics of the systems and to determine the feasibility of integrating pig operations with fish production. Data from the piggery operation of the CLSU-FAC/ICLARM project were analyzed and presented in the first case study. Eight farmers were visited and interviewed to obtain information on backyard pig operations. The respondents were from within a 15-km radius of CLSU. Because of the difficulty of getting voluntary information from commercial pig breeding and growing operations, basic data from the work of Saturno (1980) were used and the costs and values were updated to 1980 levels. The fish culture sections of all the case studies were based on Hopkins et al. (in press).

Case Study 1: Commercial Growing Operation

This case study is somewhat hypothetical in that the CLSU-FAC/ICLARM project on which this study was based was not designed in a manner appropriate for a commercial growing operation. The project is a 3-ha research facility that has as its principal objective the development of viable animal–fish systems suited to the tropics by the use of replicated experiments. Data from the project were used to design and analyze an 80-head commercial growing operation. Only the size of the ponds (1 ha versus 0.1 ha in the experimental facility) was changed.

Facilities

Pig pens made of concrete and galvanized iron roofing and provided with adequate feeding and drinking facilities were constructed on top of the fishpond dikes. Each pen was connected to the pond by a short channel. Manure or waste matter was conveyed directly into the pond through the channel.

Production Management System

This study is based on Cruz and Shehadeh (1980) and Hopkins et al. (in press). Experiments were run for 180-day cycles (6 months), which correspond to the pig rearing period from weanlings (10–15 kg) to market-size pigs (80–100 kg). The weanlings (Large White–Landrace cross) were purchased from commercial breeding farms and grown according to recommended Philippine practices (PCARR 1976). Daily feeding with commercial feeds was done at the rate of 3–5% body weight. Starter ration was fed until the pigs reached an average individual weight of 20–25 kg, then a grower ration was given until each animal weighed about 55–60 kg. A finisher ration was then fed until marketing.

For each pig growing period, there were two 90-day fish culture cycles. Fish were stocked as fingerlings that weighed 1–10 g. Tilapia (Sarotherodon niloticus), which comprised 85% of the total number of fish stocked, was the main species cultured. Common carp (Cyprinus carpio) made up 14% and the remainder was composed of Opsipephalus striatus (the snakehead or "dalag"), which was stocked as a predator fish. All fish were harvested at the end of each culture cycle by draining the ponds. Daily manure loading was done simultaneously with pig pen cleaning by washing the pig wastes from the pen directly into the pond. Production functions (Table 1) relating manure input to fish yields were developed by Hopkins et al. (in press).

### Table 1. Production functions relating pig manure to yields of tilapia (Sarotherodon niloticus) and carp (Cyprinus carpio). Based on Hopkins et al. (in press).

<table>
<thead>
<tr>
<th>Manure (t/ha/90 days)</th>
<th>Yield (kg/ha/90 days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>Y = 25.915 + 132.78 X + 2.655 X^2</td>
</tr>
<tr>
<td>M</td>
<td>Log Y = 3.8209 + 0.4736 Log M + 0.1771 Log B</td>
</tr>
</tbody>
</table>

For tilapia: Y = 25.915 + 132.78 X + 2.655 X^2 where Y = net tilapia yield (kg/ha/90 days) X = fresh manure (t/ha/90 days)

For carp: Log Y = 3.8209 + 0.4736 Log M + 0.1771 Log B where Y = net carp yield (kg/ha/90 days) M = fresh manure (t/ha/90 days) B = carp biomass at stocking (kg/ha)

### Table 2. Capital costs (P) of three types of integrated pig-fish farming systems, Nueva Ecija, Philippines, 1980 (P7.40 = U.S.$1.00).

<table>
<thead>
<tr>
<th></th>
<th>Commercial growing</th>
<th>Backyard</th>
<th>Small breeding and growing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piggery</td>
<td>53000</td>
<td>2000</td>
<td>80000</td>
</tr>
<tr>
<td>Buildings per pens</td>
<td>1000</td>
<td>32</td>
<td>1600</td>
</tr>
<tr>
<td>Tools and equipment</td>
<td>7000</td>
<td>250</td>
<td>12000</td>
</tr>
<tr>
<td>Water system</td>
<td>1000</td>
<td>—</td>
<td>1400</td>
</tr>
<tr>
<td>Total</td>
<td>62000</td>
<td>2282</td>
<td>95000</td>
</tr>
</tbody>
</table>

Fishpond

<table>
<thead>
<tr>
<th></th>
<th>38360</th>
<th>2756</th>
<th>43071</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pond construction at P10.50/m³</td>
<td>2750</td>
<td>1322</td>
<td>2750</td>
</tr>
<tr>
<td>Water system</td>
<td>2772</td>
<td>975</td>
<td>3120</td>
</tr>
<tr>
<td>Nets at P26/m</td>
<td>3920</td>
<td>350</td>
<td>3850</td>
</tr>
<tr>
<td>Buckets at P35 each</td>
<td>47802</td>
<td>5403</td>
<td>52791</td>
</tr>
</tbody>
</table>

Based on actual costs updated to 1980 levels.

Based on Hopkins et al. (in press). Assumes an excavated fishpond with gravity water system. Pond sizes are 1.0 ha for the commercial growing operation, 0.12 ha for the backyard operation, and 1.3 ha for the small breeding and growing operation.
al. (in press) and are used here. In using these functions, the manure loading for the first 90-day and second 90-day periods was computed. These values were used separately to compute the appropriate fish yields for each 90-day period.

Total fish production of about 3600 kg/ha/180 days was obtained. The tilapia yield of 3000 kg/ha from the same trial was higher than the average production of 1042 kg/ha/120 days with fertilization and supplemental feeding earlier achieved at the FAC (Guerrero 1976).

## Capital Investment

The value of investment items is presented in Table 2. A total of P109 802 (P7.40 = U.S.$1.00) was invested for the facility. About 44% of the total investment was spent for the fish production facility.

## Costs and Returns

Table 3 summarizes the costs and returns of the integrated pig-fish experimental facility at the CLSU-FAC/ICLARM project. For analysis purposes, a production cycle of 8 months was considered instead of the actual 6-month experimental trials. The additional 2-month period was necessary for pond preparation, repairs, and maintenance prior to the start of the succeeding experimental/production cycle.

### Table 3 continued

<table>
<thead>
<tr>
<th></th>
<th>Commercial growing</th>
<th>Small breeding and growing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piggery Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stock/weanlings</td>
<td>27200</td>
<td>1578</td>
</tr>
<tr>
<td>Feeds</td>
<td>68551</td>
<td>2405</td>
</tr>
<tr>
<td>Labour</td>
<td>3600</td>
<td></td>
</tr>
<tr>
<td>Drugs and medicine</td>
<td>800</td>
<td>12</td>
</tr>
<tr>
<td>Fuel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repairs and depreciation</td>
<td>4000</td>
<td>231</td>
</tr>
<tr>
<td>Electricity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taxes and licences</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freight</td>
<td>1386</td>
<td></td>
</tr>
<tr>
<td>Total costs</td>
<td>105537</td>
<td>4226</td>
</tr>
<tr>
<td>Returns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pig sales</td>
<td>88200</td>
<td>5050</td>
</tr>
<tr>
<td>Sale of empty feed bags</td>
<td>1188</td>
<td></td>
</tr>
<tr>
<td>Sale of manure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total returns</td>
<td>89388</td>
<td>5050</td>
</tr>
</tbody>
</table>

*Assumes an 8-month production cycle.

The piggery aspect of the operation incurred losses; however, the income generated from fish production compensated for the piggery operation losses and resulted in a net income of P1052 (Table 3).

### Case Study 2: Backyard Pig Operation

This type of pig operation is generally engaged in by operators to augment family incomes.
Normally, it is the housewife and children who do most of the daily animal feeding and pen-clearing activities. Because this type of operation requires minimal attention, the amount of labour spent in the daily routine activities is generally considered by the operators as free (zero opportunity cost).

For this case study, the average number of animals raised was six, although operations with up to 10 head could still be considered as a backyard enterprise (Labadan 1979). Mixed-breed pigs of variable parentage are usually raised. Most of the backyard pig operators indicated rice farming as their main source of livelihood.

Capital Investment
The major investment item for a backyard pig operation was housing (Table 2). It comprised about 88% of the total investment cost. Pig pens varied from the low-cost type made of bamboo with “nipa” or “cogon” as roofing materials, to the more expensive type constructed of concrete hollow blocks with galvanized iron roofs. The former type was common among operators raising up to three head whereas those with more animals in their farm built the more expensive but more durable type. In general, the pig pens had concrete flooring to facilitate cleaning. This in turn allowed for the maintenance of better sanitary conditions.

Production/Management System
Backyard pig operations followed a simple pattern. The operators bought the desired number of animals and raised them to market size at one time. After disposing of the fattened pigs, another batch of animals was purchased and a second production cycle was carried out.

The daily ration of the animals consisted of premixed commercial feeds supplemented with corn grits, broken rice (binlid), or kitchen refuse. Also, the animals were fed daily with fresh leaves of ipil-ipil (Leucaena leucocephala), kamote (Ipomoea batatas), or kangkong (Ipomoea reptans). This system enabled the farmers to gain substantial savings on commercial feeds (BAECON 1976). It took the operators about 8 months to grow their pigs to marketable size.

Costs and Returns
The economics of this system are shown in Table 3. Expenses for the purchase of stock (6 pigs), feeds, and drugs/medicines were the only variable costs incurred by backyard pig operations. Because the operators considered their labour as free, it was not included as a cost item in the analysis. Hence, the computed net income actually represents the residual that accrued to operators for their capital, labour, management, and risk after all expenses were deducted from gross income. The net income from the operation was P824.00, equivalent on an annual basis to about 43% of the total capital investment.

Integration with Fish Production
The feasibility of integrating fish production with existing backyard pig operations was analyzed. The additional capital investment required for the fish production facility was estimated following the guidelines presented by Hopkins et al. (in press). This amount was then reduced to reflect the use of family labour (with zero opportunity cost) in pond construction.

It was estimated that manure production from the backyard pig operations is 153 and 319 kg/pig for the first and second 120-day production periods, respectively. Thus, a fishpond area of about 1200 m² is needed with six pigs. This was computed by dividing the amount of pig wastes available (about 2.8 t) by a manure loading rate of 23 t (the equivalent of 53 pigs/ha) multiplied by 10 000. Hopkins et al. (in press) concluded that if manure is limited, ponds with gravity water systems will maximize cash profits when manure is added at the rate of 53 pigs/ha.

Backyard pig raisers needed about 8 months to grow their animals from weanlings to marketable size. Hence, they can have two 120-day fish production periods. To complete the production cycle, an additional 2-month period is needed for pond preparation, repairs, and maintenance.

Using the production functions in Table 1, the fish yields were predicted on the assumption that for a given amount of manure, fish yield will be equivalent for either the 90-day or 120-day production period.

With the integration of fish production, backyard piggery raisers can increase their net incomes by P2616/10 months (Table 3). Computed on an annual basis, this amounts to P3139. With integration, the annual rate of return to operator’s capital, labour, management, and risk also increases from 43% to 54%, both higher than the opportunity cost of capital (18–20%).

Case Study 3: Small Pig Breeding and Growing Operation
This study is based on Saturno (1980). The Medina piggery farm is located in Bantug, Muñoz, province of Nueva Ecija in the Philippines. The farm started its operation in 1963 with an initial capital investment of P55 506. The 1980 replacement cost of the facilities was estimated to be P95 000, (Table 2). Of this amount, about 84%
was invested in buildings: farrowing house; sow and litter pens; boar house; growing/finishing pens; and a storage house.

Production/Management System
The farm raises both Large White and Landrace pigs and maintains its own breeders, although animals are purchased occasionally to replace poor breeders. The animals are fed mainly with a farm-mixed ration consisting of rice bran and commercial feed ingredients. The dry lot feeding system is practiced.

At any one time, the farm maintains about 162 animals of various sizes and ages with an approximate total weight of 6680 kg. Fatteners/finishers are raised to the marketable size of 70–90 kg in about 6 months. Culling is practiced to eliminate poor performers.

Costs and Returns
The major expense item for the small pig breeding and growing operation was feeds, which comprised about 63% of the total cost of production. Other major expense items were cost of replacement stock, taxes and licences, and repairs and depreciation. The total cost incurred by the farm amounted to P113,714.

Income from the piggery operation came from the sale of pigs, empty feed bags, and manure. Pig sales as the major income component were from marketed fatteners/finishers, weanlings, and culled animals. The net income generated by the farm was P12,720 or about 19.5% of total capital investment (Table 3).

Integration with Fish Production
The estimated fresh manure available in the farm was 360 kg/day or about 32 t/90 days (5.4% of total pig weight/day). Based on a manure loading rate of 25 t/ha (the equivalent of 80 pigs/ha for the second 90 days) a fishpond area of about 1.3 ha is needed for fish production. This manure loading rate was recommended by Hopkins et al. (in press) to maximize internal rate of return.

As a result of the utilization of pig wastes for fish production the farm sacrifices the income it normally derives from the sale of manure. However, the additional income to be derived from fish sales exceeds the expected additional costs to be incurred resulting from the integration plus income foregone from the sale of manure. An increase in net income of P31,450/8 months may be derived with the integration of fish production to the existing pig operation (Table 3). The annual return on investment increases from 19% for the piggery operation alone to 42% with integration.

Discussion
The promising results obtained from experiments on integrated pig-fish farming have spurred renewed interest among aquaculturists. The utilization of pig wastes as a substitute for inorganic fertilizers and commercial fish feeds is most welcome in view of the rising costs of these farm inputs.

Economic analysis of the CLSU-FAC/ICLARM project indicates that the fish production aspect of the integrated system was profitable. Indeed, in integrated systems, fish production plays a major role, frequently becoming the most profitable part of the enterprise (de la Cruz 1979). The pig production aspect, on the other hand, was not profitable. This was due to the high operating expenses incurred in the pig growing system. Weanlings and feeds were all purchased from commercial sources. Expenses for these items comprised about 91% of the total production costs. Although the beneficial effect of pigs on fish is very evident, the pig production operation should also be profitable. Producing weanlings in the farm and improving feeding efficiency by mixing feeds on the farm may decrease operating expenses and make the system more profitable.

The integration of fish production with existing piggery operations increased the incomes of both backyard and integrated breeding and growing operations within the CLSU area. Backyard pig operators, assuming that they have the capital outlay required to integrate fish production in their farms, increase their gross income by P3999 from the sale of 415 kg of tilapia and 51 kg of carp. This means an additional net income of P2616/0.12-ha fishpond/10 months. The small commercial breeding and growing operators also increase their net income by shifting to an integrated pig-fish farming system.

Conclusions
Several tentative conclusions can be drawn based on this analysis:

- In general, integrated pig-fish farming systems can increase farmers' incomes as the operation maximizes the use of resources. The utilization of pig manure not only increases fish production but also cuts the cost of fish culture operations.
- The CLSU-FAC/ICLARM integrated project is established mainly for experimental purposes. The piggery aspect of the system, however, clearly depicts the problems that commercial
growing operations must face. This type of operation, in which control of weanlings and feed quality is not in the farmer's hand, is not profitable. Purchasing weanlings cuts deeply into the profits.

- Integration of fish production with pig operations increases farm incomes. With integration, the annual rates of return on capital investment of both the backyard and commercial pig operations increased from 43% and 19% to 54% and 42%, respectively.

**Recommendations**

The ultimate objective of aquaculture research is to develop and generate technologies to accelerate the development of the industry. In most cases, however, investigators are mainly concerned with the quantification and analysis of observed data with very little or no information at all on the economic implications of the results. It may be worthwhile to note the following simple recommendations:

- The majority of production decisions are greatly dependent on economic forces. Whenever possible, production-oriented aquacultural research should include an economic component.
- Biologists in general lack background training in economics. They should seek the assistance of trained economists to analyze the economic implications of their research.
- It is very difficult to compare the economic viability of aquacultural technologies as practiced in different areas or localities. This is because the physical and economic conditions vary from place to place. In this respect, more pilot production testing of various aquacultural technologies should be done for a given locality, scale, and type of operation.

I would like to express my sincere gratitude to Kevin D. Hopkins, Ian R. Smith, and Kee-Chai Chong for their generous assistance in the preparation of this paper, and to Roger S.V. Pullin and Emmanuel M. Cruz for their helpful comments and suggestions.


Discussion

In systems of integrated farming both conflicts and complementarities occur. The objective is to maximize resource utilization. On the one hand, potential risk (e.g., disease) is associated with the system; however, on the other hand, diversification may reduce market risks. There is, therefore, a question of the extent to which integrated farming increases both risks and returns. On balance, integration may be more profitable, but the farmers must always consider the risks involved.

The paper shows that integrated farming is more beneficial to larger-scale operations. Because of the risks involved, large-scale operations necessitate better management. The returns on investment are substantially reduced with integration; therefore, expansion of the hog operation may be more attractive than integration of fish culture. Furthermore, if it is more profitable to sell hog manure in the open market, it should not be used in the integrated farm. The profitability of alternative uses/disposal of manure need further study.

Except in the partial budgeting analysis, the cost and return analysis did not include land values or any implicit rent. If land rent was subtracted, the return to investment would be lower than computed in the paper.

Pond depreciation is being used by both biologists and economists. If properly maintained, the pond over time will appreciate in value. However, if capital is invested in fishpond development, there is depreciation. Land appreciation could offset depreciation, but it is important to distinguish the two sets of values, particularly because ponds vary in the extent of their development.