# Tilapia Farming in Jamaica

B. CHAKALALL[1] and P. NORIEGA-CURTIS[2]
[1]*Regional Fisheries Officer, FAO*
[2]*Aquaculture Consultant*

ABSTRACT

The transfer of aquaculture technology and the establishment of commercial tilapia farming as a viable industry was successful in Jamaica. Production has increased from 2.2 mt in 1977 to 1,442 mt in 1986, representing 6.3% of total fish consumption and 15 % of national production in Jamaica. Production for 1987 is estimated at 2,600 mt from 720 ha (1780 acres) of ponds.

This dramatic increase in production may be attributed to the Government of Jamaica Inland Fisheries Project, 1976-83, and other factors and circumstances that prevailed during that time. Tilapia farming was successfully introduced in Jamaica although the initial primary objective to promote rural development through small-scale aquaculture was not fully realized. The commercial sector is shaping the evolution of aquaculture on the island. Among the factors that contributed to the success were:

- profitability and rate of return on investment
- decline in marine fish production
- lack of foreign exchange
- low world market prices for sugar
- the policy of agriculture diversification
- availability of credit
- institutional support
- realistic research
- training and extension programme.

## INTRODUCTION

Jamaica is the third largest island in the Caribbean with a total land area of 10,940 km$^2$ and a population of approximately 2.3 million. It is located in the Greater Antilles approximately 145 km south of Cuba and 160 km west of Haiti (Figure 1). The island's topography consists of a highland interior, formed by a backbone of peaks and a plateau running the length of the island, surrounded by flat coastal plains. Over half the island lies more than 350 m above sea level. Its 885 km coastline is edged by long, straight cliffs, mangrove swamps and beaches.

The coastal plain is less than 3.2 km wide along most of the north coast and in some areas along the south coast. In some places the plains widen to form broad embayments, the most extensive of which are located at the eastern and western ends of the island and the Clarendon and St. Catherine plains on the south coast, where most of the tilapia farms are located. The coastal plains and interior valleys are prime agricultural lands. The most predominant forms of land use are forestry and agriculture. The three principal types of agricultural use

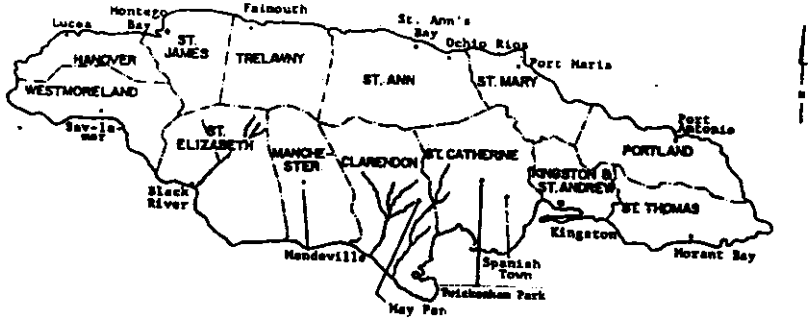


**Figure 1a.** Island of Jamaica, Parishes and Main Towns.

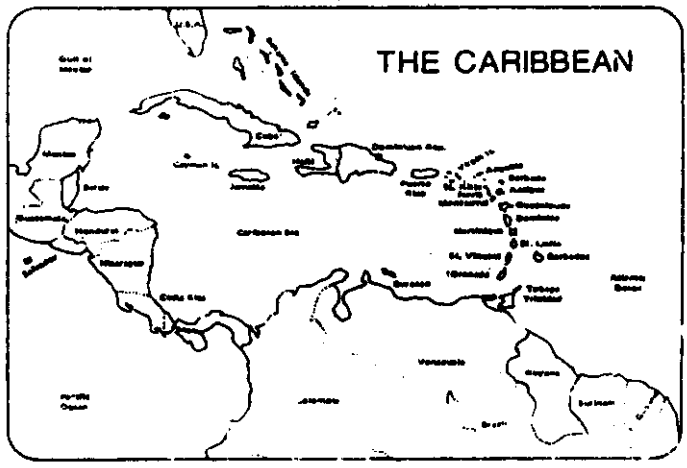


**Figure 1b.** The Caribbean.

are plantation crops, such as sugar-cane, coffee, bananas, and cocoa, mainly for export, mixed farming of food crops for domestic consumption and export, and pasture for beef and dairy cattle. Historically, agriculture has provided employment for the largest number of people. Bauxite mining, manufacturing and tourism have become the dominant sectors of the economy over the last two decades.

Like most Caribbean Islands, Jamaica has traditionally depended on marine catches to satisfy the demand for fish. Marine catches consist mainly of demersal coral reef species and to a lesser extent pelagic species. The captive fishery has been unable to meet the demand, and increases in production seems unlikely because the inshore areas which are readily accessible to the fishermen, are overfished. Also, most fishermen find offshore pelagic fishing prohibitive due to the high cost of inputs (engines, fuel, spare parts, equipment, etc.), most of which are imported.

In order to meet the demand, fish is imported. The marine catch has averaged 8,000 mt per year over the last ten years (Table 1). While domestic production has remained constant, imports have decreased. Fish importation reached its highest level in 1979 with a total of 19,000 mt and presumably would have continued to increase in proportion to demand had it not been restricted by the general unavailability of foreign exchange within the Jamaican economy. This restriction resulted in a drop in the per capita fish consumption and created a shortage in supply. In 1986, 58% of the fish consumed in Jamaica was imported at a cost of approximately US $18-20M.

The production of tilapia (*Oreochromis mossambicus*), locally known as African perch, steadily increased from 0.02% in 1977 to 15% of total fish output in 1986. Introduced to Jamaica in 1949, tilapia flourished in irrigation canals and swamps and in some small ponds with subsistence level management. A small hatchery and research facilities were constructed in 1977 with technical assistance from Auburn University. The successful transfer of aquaculture technology and the establishment of a thriving commercial tilapia farming industry in Jamaica may be attributed to the Government of Jamaica/US Agency for International Development. Inland Fisheries Project (1979-81) and the Fish Production System Development Project (1981-83). Total financial obligations for the five-year project were approximately US $9 million, 54% of which was contributed by the Government of Jamaica, with the remainder being financed through loan and grant agreements with US AID. A number of factors acted in consort to create favourable conditions for investment in fish farming and stimulated growth in aquaculture as an industry.

The majority of the farms are concentrated in the parishes of St. Catherine and Clarendon, 55.6% and 56.2% of the total number of ponds and 19.8% and 21.6% of the total surface area, respectively (Table 2). Perhaps this can be attributed to the availability of both land and water in the St. Catherine and

**Table 1.** Source and consumption of fish. ( Source: Planning Institute of Jamaica, 1987. Ministry of Agriculture, 1986).

| Year | Mean Population X 1000 | Domestic Marine Catches mt | Total imports of fish mt | Farmed Tilapia mt | Total Fish Consumption mt | Per Capita Consumption kg/Cap |
|---|---|---|---|---|---|---|
| 1977 | 2,063 | 7,956.9 | 11,600.0 | 2.2 | 19,559.1 | 9.48 |
| 1978 | 2,088 | 8,094.0 | 15,250.9 | 37.8 | 23,382.7 | 11.20 |
| 1979 | 2,112 | 7,988.1 | 19,177.3 | 25.5 | 27,190.9 | 12.87 |
| 1980 | 2,133 | 7,893.3 | 15,295.5 | 20.3 | 23,209.1 | 10.88 |
| 1981 | 2,162 | 7,772.1 | 16,588.2 | 32.4 | 24,392.7 | 11.28 |
| 1982 | 2,200 | 7,974.6 | 17,195.5 | 129.9 | 25,300.0 | 11.50 |
| 1983 | 2,241 | 8,134.4 | 13,113.6 | 147.4 | 21,395.4 | 9.55 |
| 1984 | 2,280 | 8,070.0 | 14,854.5 | 339.1 | 23,263.6 | 10.20 |
| 1985 | 2,311 | 7,967.5 | 11,876.4 | 727.9 | 20,571.8 | 8.90 |
| 1986 | 2,336 | 8,057.3 | 13,281.5 | 1441.9 | 22,780.7 | 9.75 |

**Table 2.** Distribution and surface area of fish ponds by parish (1986).

| Parish | In Production | | Out of Production | | Total | |
|---|---|---|---|---|---|---|
| | ha | % | ha | % | ha | % |
| Westmoreland | 2.0 | 0.5 | 14.6 | 16.6 | 16.6 | 3.2 |
| Hanovover | - | - | 8.4 | 9.5 | 8.4 | 1.6 |
| St.Elizabeth | 29.0 | 6.7 | 14.5 | 16.6 | 43.5 | 8.3 |
| St. James | - | - | 0.5 | 0.6 | 0.5 | 0.1 |
| St.Catherine | 260.5 | 60.0 | 33.0 | 37.4 | 293.5 | 56.2 |
| Clarendon | 110.0 | 25.3 | 6.0 | 6.9 | 116.0 | 22.2 |
| Portland | 30.3 | 7.0 | 6.5 | 7.3 | 36.8 | 7.0 |
| St. Mary | 2..5 | 0.6 | - | - | 2.5 | 0.5 |
| St. Thomas | - | - | 4.2 | 4.8 | 4.2 | 0.8 |
| St. Andrew | - | - | 0.2 | 0.3 | 0.2 | - |
| Total | 434.3 | 100.0 | 87.9 | 100.0 | 522.2 | 100.0 |

Clarendon plains which are prime agriculture lands, and the proximity of the Inland Fisheries Unit's facilities at Twickenham Park. Agricultural lands in the south coast plains of Clarendon and St. Catherine are flat or gently sloping. These characteristics suit the topographical requirements for fish pond construction and minimize excavation and earth moving costs.

## TILAPIA FARMING

In Jamaica, tilapia farming may be divided into two distinct sectors, the industrial or commercial and the subsistence fish farmer.

### Small and Subsistence Farmers Sectors

These two sectors are usually characterized by the size of the holding farmed. The small farmer holding ranges from 0.4-4.0 ha (1-10 acres) and the subsistence farmer less than 0.4 ha (1 acre). Table 3 shows the distribution and production of tilapia farms by size.

The two Government of Jamaica/US AID projects, mentioned earlier, placed emphasis on the development of these two sectors, especially in the rural areas, with the objective of generating employment and income, and improving nutrition and standard of living. Aquaculture was seen as one of the basic mechanisms for rural development.

In spite of the significant amount of effort that was apparently expended in this direction, only limited success was achieved. This was probably due to a great extent to the perception of small farmers that fish is an "extra crop" to be produced during their spare time on marginal lands and with minimal capital expenditure. Also, for many small holdings land tenure was insecure which probably contributed to minimal investment and in turn low productivity and income.

**Table 3.** Distribution and production of tilapia farms by size(1986).

| Size of Farm | ACTIVE | | | | NON-ACTIVE | | | | PRODUCTION | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. of Farms | | Total Surface | | No. of Farms | | Total Surface | | | |
| | # | % | ha | % | # | % | ha | % | mt | % |
| <0.4 ha | 11 | 9.5 | 1.5 | 0.35 | 42 | 43.8 | 6.4 | 7.29 | 3.5 | 0.2 |
| 0.4-2.0 ha | 64 | 55.1 | 63.8 | 14.69 | 47 | 49.0 | 41.3 | 46.98 | 163.9 | 11.4 |
| 2.0 - 4.0 ha | 17 | 14.7 | 44.3 | 10.21 | 3 | 3.1 | 8.2 | 9.31 | 128.1 | 8.9 |
| > 4.0 ha | 24 | 20.7 | 324.7 | 74.75 | 4 | 4.1 | 32.0 | 36.24 | 1,146.5 | 79.5 |
| Total | 116 | 100.0 | 434.3 | 100.0 | 96 | 100.0 | 87.9 | 100.0 | 1,442.0* | 100.0 |

* Total production for 1986.
Note: 1 hectare = 2.471 acres.

Of the 116 active farmers less than 10% can be called subsistence farms (Table 3). The total pond area of subsistence farmers represented only 0.4% of the total fish pond area constructed in Jamaica up to September 1987. The total production, which is mainly for self-consumption, is insignificant in terms of the total national production. In comparison, small farmers, 0.4-4.0 ha (1-10 acres) comprise 70% of the total number of farmers, 25% of total pond area and 20% of total national production. The inability of the IFU to provide fingerlings at subsidized rates, because of privatization of its farms, has seriously affected the small and subsistence farmers. Most of the non-active fish farms fall in these two categories; about 50% of the farms ranging from 0.4-2.0 ha in size are non-active (Table3).

The records at the Inland Fisheries Unit indicate that a significant amount of effort was also expended to provide extension services and training to the small farmers. However, with time and nearing the completion of the Government of Jamaica/US AID projects, these services gradually were shifted towards farmers with medium to large holdings. This was probably due to Government's emphasis on increasing production and the pressure for services which the medium and large farmers started to demand, and perhaps the involuntary attraction or natural inclination of extension personnel to be attracted to the larger and more ambitious projects. Also, the large and middle farmers were able to obtain better services in terms of credit, equipment, fingerlings and marketing advice because of their knowledge of how the bureaucratic system operates. For example, despite their greater economic capabilities, the medium and large farmers demanded more of the equipment rental services of the Inland Fisheries Unit than the small farmers.

**Commercial Sector**

Farm holdings of more than 4 ha (10 acres) form the commercial sector. Commercial farms constitute 75% of the total pond area and account for 80% of the production (Table 3).

Even though the two Government of Jamaica/US AID projects were not designed to assist the commercial sector, tilapia farming was enthusiastically embraced by a large number of private farmers and by several private and public enterprises. Commercial tilapia farming was responsible for shaping the evolution of aquaculture in Jamaica. Tilapia farming was demonstrated to be highly profitable and yielded a significant rate of return on investment in comparison to other areas of the agricultural sector, such as sugar-cane farming. In addition, commercial farmers occupied good, fertile and accessible land, and had easier access to finance, preferential markets such as hotels and supermarket chains, and other services.

Aquaculture Jamaica Ltd., Aqualapia Jamaica Ltd., C & T MultiFarms, Jamaica Broilers Ltd., Sunfish Hatcheries Ltd., and Mitchell Town Fish Farm

are some of the larger private companies involved in commercial tilapia production.

**Production System**

The production system employed by the majority of fish farmers in Jamaica was the result of the adaptive research conducted by the Inland Fisheries Unit during the course of the Government of Jamaica/US AID projects. This research effort was oriented towards designing a system that would produce food fish as efficiently as the physical, financial and cultural conditions at the time would permit. The system comprises breeding, nursery and grow-out stages. The ponds used for these three different stages are similar in design and shape with the only difference being in their dimensions.

*Design*

In general, most farms are similar in design with variations attributed to the specific topographic and hydrologic characteristics of the farm site and its size. The basic design consists of a set of ponds draining into an open central channel from which the water could be recycled when a new production cycle is initiated. Drainage and irrigation of ponds may be by gravity or by pump, depending on the topography.

Equipment such as pumps, nets, cages, scales, aerators,and fibreglass tanks, used by most fish farmers are very similar and are either owned by the farmer or rented from the IFU. Except for cages, most of the equipment is imported either through the Fisheries Co-operative Society, the Jamaica Agriculture Society or by the farmer. The main constraint related to equipment is the high cost.

*Broodstock*

Initially, tilapia cultivation began with the dark *Oreochromis mossambicus* but then switched to the lighter coloured *O. niloticus* (silver perch) in order to gain consumer acceptance. The red tilapia hybrid is the fish of choice by the farmers because of consumer acceptance. Broodstock fish are stocked in earthen ponds at densities of 7,500 to 10,000 per ha (3,000 to 4,000 per acre) with a sex ratio of three females to one male. After about four to six weeks the sexually mature fish starts to reproduce and remains active for approximately six months. Throughout this time, fry are harvested weekly with a 6 mm mesh seine dragged along the embankments of the pond. Reported yields were 128,000 to 150,000 mixed-sex fry/ha/week (52,000 to 61,000 mixed-sex fry/acre/week).

*Nursery*

Originally the fry were allowed to remain in the brood ponds until they reached the size when they could be visually differentiated by sex. The male fingerlings would then be stocked into grow-out ponds.

This system was modified to increase overall production and to obtain uniform-sized fingerlings for stocking the production ponds. The harvested fry are now stocked in nursery ponds at a density of 170,000 to 180,000 per ha (68,000 to 73,000/acre). These are reared for approximately ten weeks to a size of 20-50 kg at which they can be visually sorted by examination of the genital papillae. Supplementary feed is provided at a decreasing proportion of body weight (6%-3%).

Initially the IFU provided fingerlings to farmers at subsidized rates. This was discontinued when Mitchell Town farm was divested and Mylersfield farm was put up for divestment. This encouraged, indeed required, private sector to get involved in commercial fingerling production. Sunfish Hatcheries is dedicated to fingerling production using hormone sex reversal techniques. It is playing an important role in the industry by providing seed stock to grow-out farms. The IFU has conducted an economic analysis of the results obtained from commercial fingerling production using hand sexed and hormone sex reversal techniques, respectively (Tables 4 & 5). With a 50% survival rate the net profit from a 5.3 ha (13 acre) farm is much higher than that generated from a similar size grow-out pond (Table 5).

*Grow-out*

Monosex culture is practiced in earthen ponds which range from 0.08 to 1 ha (0.2 to 2.5 acres) in size. Ponds are stocked with 15,000 male fingerlings per ha (6,000/acre),which are fed a pelleted commercial fish feed at a daily rate of 3% body weight and reared for about 12 to 15 weeks at which time the fish reaches an average size of about 225 to 340 g (1/2 to 3/4 lb). Some farmers allow an additional 3 to 4 weeks to increase the average size to about 454 g (1 lb). A 454 g fish can be filleted and fetches a higher price.

Market-size fish are harvested by seining the pond while it is being drained. The remainder of the fish are collected when draining is completed. Yields from production ponds vary widely from 1,685 to 2,245 kg per ha per crop (3,500 to 4,000 lb/acre/crop) for the "better managed" farms.

*Marketing*

Initially, farmers sold their fish live on the pond embankments to wholesalers and higglers (vendors), who retailed them at approximately half the price paid for marine species. Fish were kept in cages in a pond until purchased. As production increased at a faster rate than pond-embankment sales could handle, the IFU assisted farmers by setting up a rudimentary market at Twickenham Park. Since Jamaican consumers prefer live fish, farmers would keep their fish alive in aerated fibreglass tanks until the fish were sold. The large farmers, who employ sales co-ordinators, sell directly to hotels and supermarkets. In 1988, it was reported that one commercial producer has started

**Table 4** . Costs and returns from hand-sexed tilapia fingerling production. (Updated estimates based on data from: Pompa, T.J. (ED) 1984, Commercial Tilapia Farmers and Landell Mills Associates, 1986). *US$1 = J$5.50

| | Hand-Sexed |
|---|---|
| **INITIAL INVESTMENT** | J$* |
| Construction | 183,200 |
| Equipment | 144,700 |
| Total Investment | 327,900 |
| | |
| **PRODUCTION COSTS** | |
| FIXED COSTS | |
| Loan Repayment | |
| (15%, 10 yr, 80% of initial cost borrowed) | 68,495 |
| Land Lease @ $60.70/ha ($150/acre) | 2,500 |
| Pond Maintenance | 2,000 |
| Depreciation(straightline/yr) | 24,200 |
| Interest on average production capital | |
| (25%/yr, 80% of capital borrowed) | 15,495 |
| Total Production Costs | 112,690 |
| | |
| VARIABLE COSTS | |
| Broadstock @ $1.00 x 9,890/ha x 2 | |
| cycles(@ $1.00 x 4,000/acre x 2 cycles) | 16,000 |
| Feed (@ $1,500.00/ton) | 67,500 |
| Fertilizer,833 kg/ha/yr @ $0.99/kg, | |
| (742 lb/acre/yr @ $0.45/lb) | 4,340 |
| Fuel/Utilities | 15,000 |
| Maintenance of Equipment | 5,000 |
| Labour | 31,000 |
| Supplies | 2,000 |
| Contingency (10%) | 14,100 |
| Total Variable Costs | 154,940 |
| TOTAL PRODUCTION COSTS | 267,630 |

| Survival of Fingerlings | 30% | 33% | 40% | 50% |
|---|---|---|---|---|
| Production of Male Fingerlings | 556,200 | 618,000 | 741,600 | 927,000 |
| Unit cost/male fingerling | 0.48 | 0.43 | 0.36 | 0.29 |
| GROSS INCOME | | | | |
| (@$0.40/FINGERLING) | 222,480 | 247,000 | 296,640 | 370,800 |
| PROFIT | (-45,150) | (-20,430) | 29,010 | 103,170 |
| Rate of Return on Investment | - | - | 9% | 31% |
| Size of Farm: | 5.3 ha (13 acres) | | | |
| Brood Ponds | 0.8 ha ( 2 acres) | | | |
| Nursery Ponds | 4.0 ha (10 acres) | | | |
| Holding Ponds | 0.4 ha ( 1 acre) | | | |
| Stocking density of brood fish: | 9,890 fish/ha (4,000 fish/acre) | | | |
| Sex ratio: | 3 females: 1 male | | | |
| Productive period: | 6 months | | | |
| Rate of Production: | 128,000 fry/ha/week (52,000 fry/acre/week) | | | |

**Table 5** . Costs and returns from tilapia fingerling production. (Updated estimates based on data from: Popma, T.J. (ED) 1984, Commercial Tilapia Farmers and Landell Mills Associates, 1986). US$1 = J$5.50

| | Hormone Sex Reversal | | | |
|---|---|---|---|---|
| **INITIAL INVESTMENT** | J$* | | | |
| Construction | 219,840 | | | |
| Equipment | 144,700 | | | |
| Total Investment | 364,540 | | | |
| | | | | |
| **PRODUCTION COSTS** | | | | |
| FIXED COSTS | | | | |
| Loan Repayment | | | | |
| (15%, 10 yr, 80% of initial costs borrowed) | 76,148 | | | |
| Land Lease @ $60.70/ha ($150/acre) | 2,500 | | | |
| Pond Maintenance | 2,000 | | | |
| Depreciation(straight line/yr) | 24,200 | | | |
| Interest on average production capital | | | | |
| (25% year, 80% of capital borrowed) | 25,717 | | | |
| Total Fixed Costs | 130,565 | | | |
| | | | | |
| VARIABLE COSTS | | | | |
| Broodstock | | | | |
| (@ $1.00 x 9.889/ha x 2 cycles) | 16,000 | | | |
| Feed (@ $1,500.00/ton) | 135,000 | | | |
| Hormones | 20,000 | | | |
| Fertilizer (833 kg/ha/yr @ $0.99/kg) | 4,340 | | | |
| Fuel/Utilities | 15,000 | | | |
| Maintenance of Equipment | 5,000 | | | |
| Labour | 31,000 | | | |
| Supplies | 2,000 | | | |
| Contingency (10%) | 28,000 | | | |
| Total Variable Costs | 257,170 | | | |
| TOTAL PRODUCTION COSTS | 387,735 | | | |
| | | | | |
| Survival of Fingerlings | 30% | 33% | 40% | 50% |
| Production of 90% Male Fingerlings | 1,001,160 | 1,112,400 | 1,334,880 | 1,668,600 |
| Unit cost/male fingerling($) | 0.39 | 0.35 | 0.29 | 0.23 |
| Gross Income (@$0.40/fingerling) | 400,000 | 444,960 | 553,952 | 667,440 |
| PROFIT | (12,729) | (57,225) | 166,216 | 279,705 |
| Rate of Return on Investment | 9 | 21 | 49 | 78 |
| Size of Farm: | 5.3 ha (13 acres) | | | |
| Brood Ponds | 0.8 ha ( 2 acres) | | | |
| Nursery Ponds | 4.0 ha (10 acres) | | | |
| Holding Ponds | 0.4 ha ( 1 acre) | | | |
| Stocking density of brood fish: 9,890 fish/ha (4,000 fish/acre) | | | | |
| Sex ratio: 3 females: 1 male Productive period: 6 months | | | | |
| Rate of Production: 128,000 fry/ha/week (52,000 fry/acre/week) | | | | |

to export tilapia fillets to Miami.

The Agricultural Marketing Corporation (AMC), a marketing agency under the Ministry of Agriculture, also assisted farmers in the marketing of tilapia. Whenever at least half a ton of fish was harvested, the AMC would collect and transport the fish in refrigerated trucks to its processing plant in Kingston for processing and sale through its outlets. The retail price ranged from J$11.00-13.00 per kg (J$5.00-6.00/lb), for whole live fish in 1987.

Some fish vendors (higglers) started to alternate their marine fish sales with tilapia because of the seasonality of marine supplies. These attempts were relatively unsuccessful at first because consumers believed that the fish were caught in the swampy areas surrounding Kingston and elsewhere. However, the higglers persevered and eventually succeeded; some even ceased marketing marine fish. Over the years a relationship has developed between the farmers and higglers which presently constitutes an important marketing and distribution mechanism for tilapia. Many farmers, especially those who lack vehicles for transporting their fish, rely solely on the higglers for the marketing of their entire crop. Higglers are also playing an important role in the distribution of tilapia to rural and urban areas and also, because of their strong bargaining position and negotiating skills, have helped to maintain the price of tilapia attractive to customers.

The five year Agricultural Policy and Production Plan 1984-88, envisaged that large private sector enterprises would eventually become involved in the marketing of farmed raised fish. The objectives of the market development strategy elaborated by the IFU and the Marketing Division of the Ministry of Agriculture were:

1. Formulate and carry out a detailed market survey of consumer preferences;
2. Set up grades and standards for fish, shrimp and oysters;
3. Promote distribution/producer links with cold storage facilities for freshwater fish;
4. Explore export markets for processed fish, shrimp and oysters; and
5. Investigate the feasibility of utilizing by-products of processing plants as a shrimp/fish meal for use in animal feeds.

In general terms, these objectives still remain valid. Consumer acceptability of tilapia is established and the demand for this fish will continue to exceed its supply in the short-term. This does not imply that the marketing of tilapia should not receive attention by public and private sectors in order to develop a well organized system of marketing and distribution.

## INSTITUTIONAL SUPPORT

Several governmental agencies are concerned with aquaculture development in Jamaica. Some are directly involved in promoting aquaculture and providing the necessary technical and financial support and advice.

**Fisheries Division**

The Fisheries Division of the Ministry of Agriculture is responsible for promoting fisheries development through administration, training, management, research, services to fishermen and monitoring of the fishery resources.

**Inland Fisheries Unit (IFU)**

The IFU of the Ministry of Agriculture was established to promote and foster the development of fish farming through the provision of services and technical support, with emphasis on small farmers. IFU's programme concentrated on research, extension, training, equipment rental, fingerling production and distribution, commercial production and marketing advisory services. The IFU was given "special project" status and was set up as a separate discrete unit reporting directly to the Production and Extension Department of the Ministry of Agriculture. This arrangement facilitated closer linkages with the Regional Directors, Executive Agriculture Officers and the Extension Service of the Ministry. This status and linkages played a strong role in the acceptance of fish farming by the farmers.

**Water Resources Division**

The Water Resources Division of the Ministry of Local Government collects data and provides technical information and support to other governmental agencies on water resources.

**Underground Water Authority**

Underground Water Authority is a statutory body established under the Underground Water Authority Act (1962) to provide for the conservation and controlled exploitation of ground water resources. Both surface and ground water requirements for aquaculture expansion were considered in the preparation of the "Water Resources Development Master Plan."

**AGRO-21 Corporation Ltd. (AGRO-21)**

AGRO-21 is a statutory body jointly funded by the Government of Jamaica and US AID. Its primary objective is to restructure the country's agriculture by employing improved technology and a programme of crop diversification with emphasis on crops for export. Under this programme, private investors have been encouraged to become involved in the development of aquaculture. AGRO-21 has catalyzed and facilitated private sector investment in aquaculture

by preparing investment profiles for tilapia, grass carp (*Ctenopharyngodon idella*), and freshwater prawn (*Macrobrachium rosenbergii*). These profiles containing both technical, and economic information showing potential returns on investment. AGRO-21 also undertakes infrastructure development (irrigation systems, reservoirs, wells, etc.) and fish pond construction on Government lands for lease to potential fish farmers.

**Agriculture Credit Bank of Jamaica (ACB)**

The ACB was established by the Government of Jamaica in 1981 as a central body to channel credit to the agriculture sector, which includes aquaculture, at preferential rates. Its primary function is to finance the development of the agriculture sector. The ACB obtains funds from international agencies and lends these funds through intermediaries, such as commercial banks, to the agriculture sector.

**Jamaica National Investment Promotion Ltd. (JNIP)**

The JNIP is a government agency responsible for developing strategies and implementing programs to encourage private sector investment from both local and foreign sources. In the case of aquaculture, its Agribusiness Division attempts to channel investments to tilapia and freshwater prawn production by providing basic information on investment opportunities, evaluating project proposals to determine economic viability, and making recommendations to a joint ministerial committee regarding financial and other tax incentives to which the potential investor may be eligible.

**University of West Indies (UWI)**

The UWI is a regional tertiary educational institution with campuses in Barbados, Jamaica and Trinidad & Tobago. The zoology department of the Mona Campus in Jamaica offers a course in aquaculture in the final year of its degree programme. Through an informal agreement, and with the collaboration and assistance of IFU'S staff, the department utilizes the aquaculture laboratory and field facilities of the IFU for teaching and research.

## PROFITABILIY

Like any other economic activity, profitability is an essential requirement for fish farming to become an established business. This applies not only to the large commercial ventures but also to small scale aquaculture. Profitability of semi-intensive tilapia culture systems in Jamaica, expressed as rate of return on investment is high and increases with the size of the farm, mainly because of economies of scale (Table 6). Commercial farms use more labour, fertilizer and supplemental feeds than small scale operations. Despite relatively high production costs, the cost of production per unit of product is lower since total

**Table 6.** Costs of and returns from tilapia culture in Jamaica (J$*). (Updated estimates bases on data from: Popma, T.J. (Ed) 1984, Commercial Tilapia Farmers and Landell Mills Associates, 1986). * US$1 = J$5.50

| | | | | |
|---|---|---|---|---|
| **TOTAL POND SURFACE AREA, ha** | | | | |
| (acre) | 5.26(13) | 10.52(26) | 20.23(50) | 40.46(100) |
| Brood Ponds | 0.20(0.5) | 0.40(1) | 0.80(2) | 1.61(4) |
| Nursery Ponds | 1.01(2.5) | 2.02(5) | 4.04(10) | 8.09(20) |
| Production Ponds | 4.04(10) | 8.09(20) | 15.37(38) | 30.75(76) |
| **INITIAL INVESTMENT** | | | | |
| Construction | 183,200 | 170,800 | 667,000 | 1,294,000 |
| Equipment | 144,700 | 180,700 | 272,000 | 417,000 |
| Total Investment | 327,900 | 551,500 | 939,000 | 1,711,500 |
| **PRODUCTION COSTS** | | | | |
| FIXED COSTS | | | | |
| Loan Repayment (15%,10 year, 80% of initial costs borrowed) | 68,496 | 115,202 | 196,147 | 357,513 |
| Land Lease @ J$60.70/ha (J$150/acre) | 2,500 | 5,000 | 9,000 | 18,000 |
| Pond Maintenance | 2,000 | 4,275 | 7,500 | 15,000 |
| Depreciation(straightline/year) | 24,200 | 34,700 | 55,000 | 83,400 |
| Interest on average prod. capital (25%/year, 80% of capital borrowed) 177,580 | | 25,500 | 50,670 | 93,960 |
| Total Fixed Costs | 122,595 | 209,847 | 361,607 | 651,493 |
| VARIABLE COSTS | | | | |
| Broodstock(@J$1.00 x 9,890/ha) | 2,000 | 4,000 | 8,000 | 16,000 |
| Feed(@ J$150,000/ton) | 172,500 | 345,000 | 658,500 | 1,317,000 |
| Fertilizer(833 kg/ha/yr J$0.99/kg) | 4,300 | 8,600 | 16,700 | 33,400 |
| Fuel/Utilities | 15,000 | 30,000 | 60,000 | 100,000 |
| Maintenance of Equipment | 5,000 | 8,000 | 10,000 | 20,000 |
| Labour (manager) | 15,000 | 20,000 | 20,000 | 25,000 |
| (regular) | 12,000 | 21,000 | 56,000 | 70,000 |
| (casual) | 4,000 | - | - | - |
| (security) | - | 21,000 | 21,000 | 28,000 |
| Supplies | 2,000 | 3,000 | 4,000 | 5,000 |
| Contingency | 23,000 | 46,100 | 85,000 | 161,400 |
| Total Variable Costs | 255,000 | 506,700 | 939,600 | 1,775,800 |
| TOTAL PRODUCTION COSTS | 377,695 | 716,547 | 1,301,207 | 2,427,293 |
| Annual Fish Production(kg) (3,931 kg/ha x 3 crops/year) | 47,728 | 95,455 | 181,364 | 362,727 |
| GROSS INCOME (@ J$8.80/kg) wholesale at farm gate) | 420,000 | 840,000 | 1,596,000 | 3,192,000 |

**Table 6.** Ctd.

| NET PROFIT | 42,305 | 123,453 | 294,793 | 764,707 |
|---|---|---|---|---|
| Production Cost/kg | 7.92 | 7.50 | 7.17 | 6.69 |
| RATE OF RETURN ON INVESTMENT | 13% | 22% | 31% | 45% |
| Break EvenOutput(kg) | 35,490 | 60,098 | 99,912 | 166,865 |
| % of Total Capacity | 74% | 63% | 55% | 46% |
| Amount of Feed per year (tons) | | | | |
| Broodstock | 2.5 | 5 | 10 | 20 |
| Fingerlings | 7.5 | 15 | 30 | 60 |
| Grow out fish | 105.0 | 210 | 399 | 798 |
| Total | 115.0 | 230 | 439 | 878 |

production is also higher.

In many instances, particularly for species that respond well to low quality inputs such as tilapia, production costs can be reduced through more intensive use of animal manures and other agro-industrial by-products as sources of fertilizer and feed. An economic analysis showed favorable results from preliminary work in Jamaica on the use of swine manure (Table 7). The IFU is encouraging farmers to use, as much as possible, animal manure as a substitute for inorganic fertilizers.

Profitability will always be the main concern of aquaculturists and potential investors. Increase in profitability can be equated to increasing fish yields per unit area, which depends on the stocking, survival, and growth rates and feed conversion efficiency of the species under cultivation. Improving all three rates will produce an increase in fish yield. Productivity could be increased through adaptive modernization and intensification as was demonstrated through experimental work done in Jamaica. Table 8 gives a comparative economic analysis of the results obtained with three different kinds of feed.

## DEMAND AND CONSUMER ACCEPTANCE

Fish is a traditional element of the Jamaican diet and cannot be easily substituted by other protein foods. It is preferred in a fresh whole form, although dried salted fish is also well accepted. Frozen fish is bought as a last resort although iced fish is accepted if the gills are pink and the eyes are not sunken. With the advent of urban concentration, the possibility of obtaining fish directly from the fisherman or vendors (higglers) has diminished. However, fish can be found in supermarkets in chilled or frozen form.

The assumption that a domestic market for tilapia exists because of the large

**Table 7.** Costs and returns from tilapia culture in Jamaica. (Updated estimates based on data from: Pompa, T.J., (Ed.) 1984, Commercial Tilapia Farmers and Landell Mills Associates, 1986). * US$1 = J$5.50

Inorganic vs Organic Fertilization

| | (J$/ha/Year)* 5-20-5 | Swine Manure |
|---|---|---|
| FIXED COSTS | | |
| Loan Repayment | 13,017 | 13,017 |
| Land Lease | 474 | 474 |
| Pond Maintenace | 381 | 381 |
| Depreciation | 4,596 | 4,596 |
| | 18,468 | 18,468 |
| VARIABLE COSTS | | |
| Fingerlings (@ $0.40 each) | 17,791 | 14,018 |
| Feed (@ $1,316/ton) | 36,423 | 16,321 |
| Fertilizer (833 kg/ha/yr $0.99/kg) | 823 | 0 |
| Fuel | 2,852 | 2,852 |
| Maintenance | 951 | 951 |
| Labour | 5,893 | 5,893 |
| Supplies | 381 | 381 |
| Interest | 7,161 | 4,448 |
| Contingency | 6,511 | 4,043 |
| | 78,786 | 48,907 |
| ANNUAL TOTAL PRODUCTION COSTS | 79,254 | 67,375 |
| RETURNS | | |
| Fish Production (kg) | 14,151 | 14,410 |
| Gross Income (@ $8.36/kg) | 118,302 | 120,475 |
| PROFIT | 21,048 | 53,099 |
| Duration of Production cycle (weeks) | 17 | 22 |
| Feed Consumed (tons/yr) | 11.2 | 5.0 |
| Feed Conversion Ratio | 1.8 | 0.8 |
| Stocking Density | 14,825 fish/ha (6,000 fish/acre) | 14,825 fish/ha (6,000 fish/acre) |

**Table 8.** Costs and returns from tilapia culture in Jamaica. (Updated estimates based on data from: Popma, T.J. (Ed.) 1984, Commercial Tilapia Farmers and Landell Mills Associates, 1986). * US$1 = J$5.50

Results Obtained with Three Different Feeds

| | (J$/ha/year)* | | |
|---|---|---|---|
| | Fish Feed | Chicken Feed | Mash[1] |
| FIXED COSTS | | | |
| Loan Repayment | 13,017 | 13,017 | 13,017 |
| Land Lease | 474 | 474 | 474 |
| Pond Maintenace | 381 | 381 | 381 |
| Depreciation | 4,596 | 4,596 | 4,596 |
| | 18,468 | 18,468 | 18,468 |
| VARIABLE COSTS | | | |
| Fingerlings | 17,791 | 17,791 | 17,791 |
| Feed | 36,423 | 34,233 | 22,822 |
| Fertilizer | 823 | 823 | 823 |
| Fuel | 2,852 | 2,852 | 2,852 |
| Maintenance | 951 | 951 | 951 |
| Labour | 5,893 | 5,893 | 5,893 |
| Supplies | 381 | 381 | 381 |
| Interest | 7,161 | 6,919 | 5,666 |
| Contingency | 6,511 | 6,291 | 5,152 |
| | 78,786 | 76,134 | 62,311 |
| ANNUAL TOTAL PRODUCTION COSTS | 97,254 | 94,602 | 80,799 |
| Fish Production (kg) | 14,151 | 9,928 | 10,187 |
| Gross Income (@ $8.36/kg) | 118,303 | 82,998 | 85,165 |
| PROFIT | 21,048 | (-11,604) | 4,366 |

[1]The diet contained wheat middlings, soybean meal and brewers grain (4:3:3)

volume of fish imports needed to satisfy demand is true. However, it should be noted that fish imports comprise a wide range of species that are processed as dried, smoked, salted, gutted, canned and frozen products. The demand for these products may not be satisfied in all the interior areas of Jamaica by live tilapia; processing will be necessary.

The initial reaction towards tilapia by the general public was negative. It was considered an unattractive and tasteless fish, when compared to marine species. To counter this image, the IFU and AGRO-21 mounted a promotion campaign to attract consumers. The substitution of the dark *O. mossambicus* by the lighter coloured *O. niloticus* (silver perch) and by the red tilapia hybrid

helped to create a more positive image of the fish and to win consumer acceptance. Also, changing the name to silver perch, St. Peter's fish, red fish and snapper assisted in creating this positive image, since red fish and snapper are associated with marine species.

The IFU solicited the assistance of a number of agencies in promoting tilapia. A booklet containing recipes was prepared by IFU and published by the Jamaican Information Service (JIS). A commercial farm assisted in the production of a video aimed at consumers. The video outlined some of the advantages of using tilapia; its nutritional content and demonstrated methods of preparation that were familiar to the public. The JIS and AGRO-21 also produced videos promoting tilapia farming as an advertisement aimed at potential investors. These promotional materials were used by the national TV station. Demonstrations on the preparation, cooking, and tasting sessions were also used to promote the use of tilapia.

Institutions such as hospitals, prisons and schools that could not afford to buy marine fish, but wished to diversify their menu, were also the target of the IFU promotion campaign. They were attracted by the lower price, uniform size and regularity of supply, and were probably the first clients of commercially produced tilapia. Some schools and the Tamarind Farm Prison constructed their own fish ponds.

## DIVERSIFICATION OF AGRICULTURE

As a result of the decline in prices in the world market, the production of sugar cane, Jamaica's major export crop, decreased from a peak of 500,000 tons in 1965 to an average of 200,000 tons for the 1984-1987 period. At current cost of production and world prices, sugar cane production does not offer attractive investment opportunities, and in many instances, depending on yield and efficiency, the industry is operating at a loss.

The Government of Jamaica has taken steps to ensure that the quota of sugar cane is produced more intensively and uses the surplus land for other crops and aquaculture. Agencies, such as AGRO-21, Agriculture Credit Bank and Jamaica National Investment Promotion Ltd., were established to promote the diversification programme. Government's overall policy was supportive of a general shift away from sugar cane, pursued simultaneously through divestment of land and the promotion of private investment through paragovernmental institutions such as AGRO-21 Ltd. and National Investment Bank of Jamaica Ltd. (NIBJ). Government maintains final ownership of land by leasing rather than selling and in some instances through direct participation of state agencies. For example, the NIBJ is involved in Jamaica Aqualapia Ltd. and Jamaica Aquaculture Ltd. AGRO-21 Ltd. undertook the divestment of the former IFU-operated Mitchell Town fish farm, which is now operating as a private commercial enterprise.

Empirical observations indicate that aquaculture is a success: a farmer from St. Catherine has converted all 22 ha (55 acres) of his sugar cane farm into tilapia production ponds and acknowledges that he is making more money from tilapia farming than he has ever made from sugar cane or rice farming. Policies encouraging agriculture diversification to other crops, however, have not yet been economically evaluated and perhaps have not been operating long enough to classify aquaculture as one of the most viable alternatives. Competition for use of prime agriculture lands is increasing and as a result a policy decision must be made very soon to determine if prime agriculture land should be used for aquaculture or for growing other crops for export, such as vegetables for export to North America during winter. Tilapia production can be increased by employing better management practices and by putting the existing non-active fish ponds into production.

## WATER SUPPLY

Tilapia farming requires a good source of fresh to moderately brackish water (0-10%.). Water requirements are generally high for pond culture varying between 40,000-1,000,000 $m^3$/acre of fish pond. By re-circulating water within the farm these values may be reduced by about two-thirds. Net water consumption for aquaculture is minimal when compared to losses due to evaporation and seepage, provided that discharge water from ponds is recirculated.

In Jamaica of un-polluted surface or ground water are appropriate for raising tilapia with respect to both physical and chemical properties. Prior to July 1986, when the National Irrigation Commission was established, the management of water resources was the responsibility of a statutory board, the Underground Water Authority and five regional authorities. The National Irrigation Commission, comprising representatives of the Ministry of Agriculture, AGRO-21, Underground Water Authority and users of water, has the responsibility for managing the island's water resources. In preparing the Water Resources Development Master Plan for Jamaica, the Underground Water Authority allocated both surface and ground water for aquaculture. The present national demand for water not to be considered a constraint for the expansion of aquaculture (Table 9).

## CREDIT

Funds for agriculture and rural development have been made available to Jamaica by a number of international aid agencies, such as IFAD, CIDA, IDB, US AID and CDB. In order to consolidate and channel credit to the agriculture sector through a central body, the Government established the Agriculture Credit Bank of Jamaica Ltd. (ACB) in 1981. The objective was to provide credit to the agriculture sector, which included inland fisheries and aquaculture, on a timely basis and at preferential rates.

**Table 9.** Projected water demand for fish farming. (Source: Water Resources Development Master Plan, 1985).

| Year | WATER DEMAND M $m^3/y$ Fish Farming | Total National | 1985 Supply | Developmental Needs |
|---|---|---|---|---|
| 1985 | 18.6(2.35%) | 790.7 | 560 | 230.7 |
| 1990 | 38.5 (4.37%) | 881.4 | 560 | 321.4 |
| 2000 | 39.5(5.23%) | 1,138.3 | 560 | 576.3 |
| 2015 | 77.0(6.16%) | 1,249.7 | 560 | 689.7 |

The ACB obtains funds from international and local sources and lends these funds through financial intermediaries, such as commercial banks and People's Co-operative Banks (PCBs), to the agriculture sector. Agro-industry loans, which include loans to fish farming, are available to finance existing and new agri-business operations, to conduct pre-investment studies for the identification and development of new projects and to provide consulting services for ongoing agri-business operations. While interest rates on non-preferential commercial loans ranged from 25-28%, ADB loans for agriculture development ranged from 12-15%.

PCBs were responsible for administering the Ministry of Agriculture's Crop-Lien Programme to farmers with no more than five acres of land and who were not in arrears in any other credit programme. The PCB set a ceiling of J$15,000 (US $2728) for loans available to individual fish farmers. This programme also allowed fish farmers to receive loans in kind, for items such as fertilizers, feed and equipment.

Most of the loans for large commercial fish farming operations were handled through the National Commercial Bank (NCB), which had on staff a professionally trained aquaculturist to handle all requests for fish farming loans description of the management and operation of the farm from seed stock to marketing, before it would consider any loan application.

The Jamaica Agriculture Development Foundation (JADF) was set up in 1984 as a non-profit foundation to provide venture capital and research grants for commercially viable agriculture projects. The JADF has invested in tilapia fingerling production operation, which is now playing a critical role within the industry by providing a regular supply of seed stock to farmers.

Adequate credit was and is available to the aquaculture industry and potential investors. However, there are complaints from both the lenders and borrowers. The major complaint is the length of time and delay in loan approvals and disbursements which deters many fish farmers from applying for preferential loans and instead forces them to seek non-preferential commercial loans. Some farmers claim that the loan limit set by the PCBs is too low because

fish farming is a capital intensive operation. In addition, land tenure and ownership for small farmers need to be resolved in relation to collateral, which is a requirement for loan eligibility. Delinquency in loan repayments is said to be one of the most serious problems.

## FEED AND FERTILIZER

Fish feed is produced by three main manufacturers of animal feed, Master Blend, Seprod Ltd., and Jet Pet Ltd. using mainly imported ingredients and by-products of their animal feed manufacturing process. The price of formulated fish feed directly affects the profitability of fish farming because feed accounts for approximately 50% of production costs (Table 6). In view of the rising cost of imports to the Jamaican public, the Government of Jamaica re-introduced a subsidy in 1986 in order to keep the price of feed down. Fish feed is also subjected to the Price Control Act in order to avoid sudden and steep increases in price.

Competition between the fish feed manufacturers has led to improvement in diet formulation to suit the needs of the industry and probably also has prevented monopolistic strategies. A number of tests conducted by IFU were not conclusive as to which of the available commercial brands of feed produced better results under standard conditions for raising tilapia.

Fertilizer (triple superphosphate) requirements for fish farming are estimated at 576 mt for 1987 and 936 mt for 1988. This is about 1% of the total requirement for the agriculture sector. Fertilizer should not become a limiting factor in tilapia farming because of the Government's policy to modernize agriculture and increase production. At the same time the IFU is encouraging the substitution of chemical fertilizers by organic fertilizers and animal manure.

## RESEARCH, EXTENSION, AND TRAINING

The Inland Fisheries Unit (IFU) of the Ministry of Agriculture is the agency responsible for the promotion and development of fish farming in Jamaica. Through the Government of Jamaica/US AID projects, IFU initiated a research, extension and training programme in 1979. The training and extension programme was based on the principle that the creation of a cadre of well-trained producers (farmers), technicians and extension agents was critical for establishing efficient aquaculture farms.

The extension service could only function effectively with an ongoing research programme. The IFU's adaptive research programme was directed towards devising a production system that was compatible with the physical and cultural conditions that existed in Jamaica. This resulted in the production system described in the section on tilapia farming, which is now employed by the majority of farmers. The IFU was able to demonstrate that tilapia farming was profitable utilising the production techniques developed through adaptive

research. The Zoology Department of UWI also utilises the IFU's facilities to conduct research.

The results of the applied research conducted by IFU at its research facilities at Twickenham Park could only reach the farmers through an efficient extension service. The IFU established an independent extension branch because tilapia cultivation technology was completely new to most farmers. Therefore farmers required regular assistance and close supervision until they had acquired the necessary technical skills. Also, most farmers were reluctant to become involved in a relatively unknown and capital intensive type of farming, the technology for which was only available through IFU. The extension service catered to all farmers and had one extension agent stationed in every parish.

The majority of the technical personel at the IFU during the Government of Jamaica/US AID projects were involved in extension. The senior officers had graduate training and all the extension officers were graduates of the Jamaica School of Agriculture (JSA) and thus had some exposure to aquaculture before joining the IFU. However, they received four months of in-service training before assignment to the various parishes. The pond construction specialists were also JSA graduates who received specialised training in land surveying, pond design and construction.

Extension services included site evaluation and surveying, supervising pond construction, provision of fingerlings, advisory farm visits, rental of fish handling and other equipment, and assistance in stocking, sampling, harvesting and marketing. These services were gradually withdrawn as the farmers became capable of conducting these procedures themselves.

The IFU managed two tilapia production farms: Mylersfield and Mitchell Town, and a research facility at Twickenham Park. As part of the extension service the IFU provided farmers with fingerlings at subsidised prices. This service was discontinued because both farms were divested. The private sector stepped in to fill the void.

Initially, the training courses offered by the IFU were production oriented. As the industry grew, the demand for trained personnel in various disciplines and levels increased, especially for farm managers. Institutions such as UWI and the College of Agriculture have the capability to satisfy this need. For example, with assistance from FAO and in collaboration with IFU, the Zoology Department of UWI held a twelve-week practical course in tilapia cultivation in 1988 for natural science graduates. The objective was to provide participients with specialized knowledge for the world of agriculture work and at the same time encourage the University to become involved in this type of training on a regular basis. AGRO-21 has offered ad hoc informal training to farmers, technicians, and extension agents.

As the aquaculture industry expanded, the competition for trained personnel meant increased salaries, benefits and better work conditions. After the

completion of the Government of Jamaica/US AID project, the IFU lost its "special project" status leading to a decrease in salaries and a substantial budget cut. As a result, IFU lost most of its technical and some of its support staff to the private sector. The small and subsistence farmers suffered most because they were more dependent on the IFU for technical assistance and support services.

A policy decision needs to be taken to reorganise the IFU and probably incorporate it within the Ministry of Agriculture, Fisheries Division, and to provide the necessary incentives to attract and keep qualified staff.

The success of and experiences of Jamaica can and are being used to promote aquaculture development in the region through the Caribbean Technical Co-operation Network in Artisanal Fisheries and Aquaculture, sponsored by the FAO Regional Office for Latin America and the Caribbean. Jamaica is the Co-ordinator for the Network in aquaculture. The Network is based on the TCDC (Technical Co-operation among Developing Countries) concept, with emphasis on training and technology. Since the initiation of the Network, a number of study tours, training courses for extension officers, farmers, natural science graduate students and decision makers have been held since 1986.

## CONCLUSION

Jamaica possesses the following aquaculture characteristics which are attributed to "aquaculturally developed countries" (FAO, 1984):

1. The technical and economic risks of the predominant form of finfish production are stable and well understood by a large segment of the population;
2. The product is acceptable to a large segment of the population;
3. The central government is supportive of the aquaculture sector;
4. The market price is relatively stable and the returns to the producer are appropriate to the risk.

Tilapia farming was successfully introduced in Jamaica although the initial primary objective to promote rural development through small-scale aquaculture was not fully realised. The commercial sector is shaping the evolution of aquaculture on the island. Fish farming, whether small-scale or commercial, should be treated as a business venture and not be seen as an additional crop that can be produced during spare time. It requires vigilance, effort and time like any other form of agriculture production.

Looking at Jamaica, one can conclude that the identification and planning of major aquaculture development projects requires an interdisciplinary effort and that projects should address biological, biotechnical, market, environmental (physical, biological), and socioeconomic (socio-political, cultural) factors. Choice of species for cultivation and the trade-offs associated with introduced

species should be addressed.

The main agency responsible for promoting aquaculture development and providing the necessary services must be allowed some flexibility and autonomy in its operations. When numerous agencies are involved, there is need for coordination in order to prevent overlap. Also, the risks involved in the transfer of a new technology must be shared with the user, especially in the initial stages when the technology is only available through one national agency. However, incentives should be gradually withdrawn to avoid it dependence. The need for continuous research and extension can never be overemphasized.

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