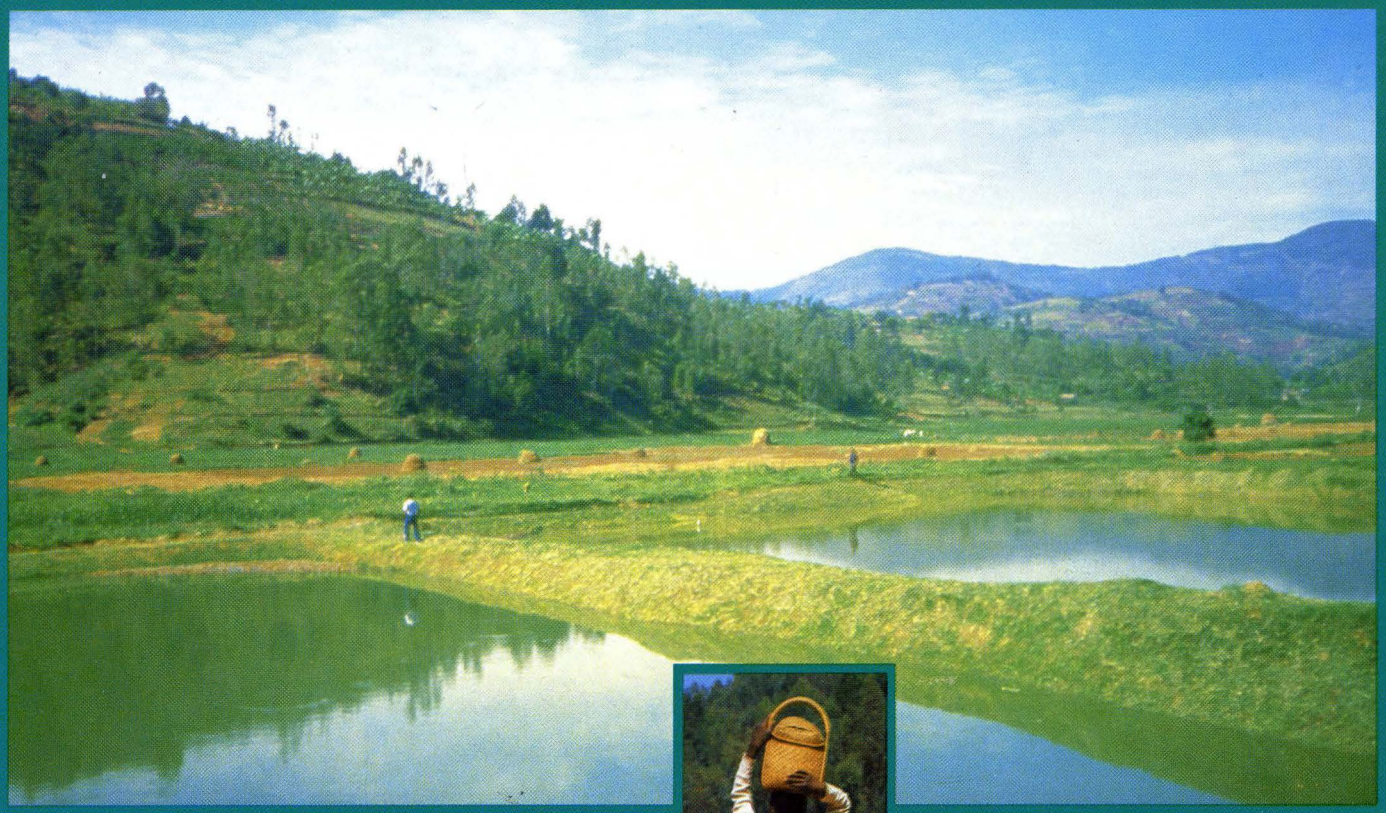
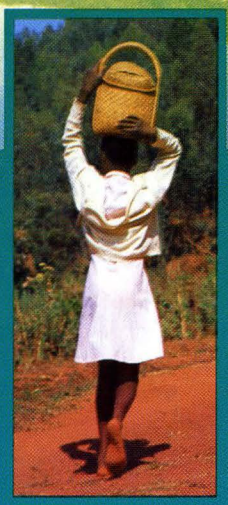
Rwanda National Fish Culture Project





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COUNTRY STATISTICS

Population: 1986 estimate of 6,500,000 with an average annual growth rate 3.8%.

Surface Area: 26, 338 km².

Average Density: 321 persons per km² for arable land (1984 estimation). Some communes have average densities of over 750 persons per km².

Elevation: 1,000-4,000 m.

Rainfall: 700-2,000 mm.

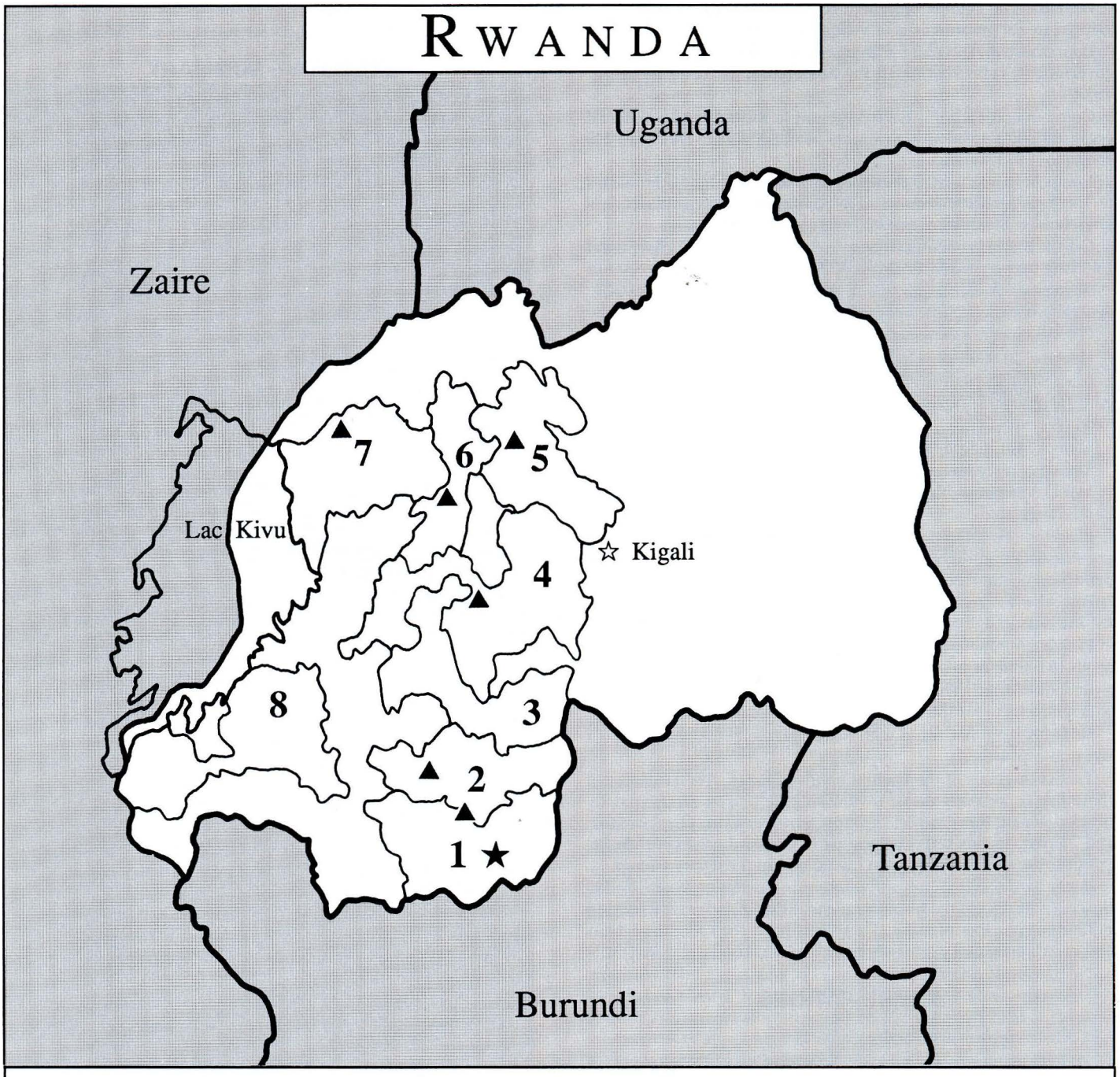
Capital: Kigali, population 183,095 (1986 estimate).

Principal Exports: Coffee, tea, tungsten, tin.

Predominant Religions: Roman Catholic, 56%; Protestant 12%; Islam, 9%; Animist, 23%.

Protein Consumption: Estimated 2.1 grams of animal protein consumed per person per day.

Principal Capture Fisheries : (1) Lake Kivu—887 of its 2,370 km² lie in Rwanda—produces an estimated 200 tons annually; (2) Lake Ihema— 9,000 ha fishery in Eastern Rwanda produces 150-200 tons yearly; (3) an additional 14,500 ha of lakes in the north and east have annual productions of roughly 800 tons.



GLOSSARY OF TERMS

Agronome A-2: A graduate of an agricultural secondary school. For the fish culture program, these individuals received additional training in aquaculture at the *Centre de la Formation* Piscicole at Bouak´e (Ivory Coast). They are regional supervisors for the aquaculture extension program.

Aquaculture (fish culture): The husbandry of aquatic organisms under controlled conditions.

Are: A surface area of 100 m^2 or 0.01 hectare.

Bloom: A rapid increase in the plankton population.

Biomass: The amount of living matter expressed as weight of organic material per unit area or volume of water.

Bourgmestre: The chief administrator at the commune level of government, representing all the branches of the central government.

Commune: An administrative subunit in Rwandan governmental organization; equivalent to a county or department. There are 140 communes in Rwanda.

Compost: A mixture of decaying organic matter applied to water to increase fertility. It is usually composed of by-products and household wastes, dried grasses, and animal manures.

Congo: Name in common usage during the Belgan colonial period referring to the present Republic of Zaïre.

Fingerling: A fish larger than a fry but not of a marketable size, generally between 2 and 25 cm long.

Fry: A young or newly hatched fish.

Hectare: 10,000 m^2 = 100 ares.

Integrated aquaculture: Aquaculture associated with other agricultural practices; typically linked with gardens, animal husbandry, and/or forestry.

Marais: Wet bottomlands.

Moniteur piscicole: An aquacultural extension agent.

Monk: A structure through which ponds are drained and/or water depths regulated.

Plankton: Free-floating, minute aquatic plants and animals that are suspended in the water column. These form the basis of a fishpond food chain.

Polyculture: Rearing two or more fish species simultaneously in the same pond.

Prefecture: The major administrative divisions of Rwanda, analogous to a state or province. There are ten prefectures in Rwanda.

Ruanda-Urundi: The name applied to the former Belgan colony which now includes the countries of Rwanda and Burundi.

Seine: A large net fitted with floats and weights drawn through water to capture fish.

Tilapia: A genus of the Cichlid family of fishes. The taxonomy of these fish is presently under review and the tilapias are frequently divided among three generic groups: *Sarotherodon, Oreochronus*, and *Tilapia*. In this text, conforming to standard usage in U.S. literature, the three genera are retained within the genus *Tilapia*.

Water hardness (calcium and magnesium hardness): Expressed as the concentration of the bivalent anions, calcium and magnesium, in milligrams per liter of water. These ions bond with alkaline cations and bicarbonate and contribute to buffering capacity of water.

ABBREVIATIONS

CERAI: Technical secondary schools.

ELADEP: Empoissonnement des Lacs du Pays et Developpement de la Pêche (Canadian project "Stocking of Country's Lakes and Development of Fisheries").

FAO: Food and Agriculture Organization of the United Nations.

FRW: Rwandan franc (approximately 75 FRW = $1. 00).

GOR: Government of Rwanda.

ICA: Auburn University's International Center for Aquaculture.

IDRC: International Development Research Centre.

ISAR: Institute for Agricultural Research.

MINAGRI: Ministry of Agriculture, Livestock Production and Forests.

PPN: Rwanda National Fish Culture Project.

T&V: Training and Visit Method of Extension Programing.

UNDP: United Nations Development Program.

UNR: National University of Rwanda.

USAID: United States Agency for International Development.

EXECUTIVE SUMMARY

This report documents 5 years of involvement in aquacultural development in the Republic of Rwanda by Auburn University's International Center for Aquaculture. From May 1983 through February 1988 the Center provided technical assistance to the Rwanda National Fish Culture Project (PPN) which was jointly funded by the Government of Rwanda and USAID.

PPN has demonstrated conclusively that fish culture in higher, cooler altitudes with limited inputs is technically sound, economically feasible, and socially acceptable. Few aquacultural development efforts on the African Continent have had similar success.

Earlier aquacultural projects did not develop production systems appropriate to Rwandan climate and needs. In 1982, several thousand private fishponds were in operation, as well as numerous government facilities. However, there were few trained technicians, little functional infrastructure, and no agreement on an effective technological package appropriate for Rwandan conditions. Pressure on limited agricultural resources demanded that this situation be improved.

The goal of the PPN was to develop profitable fish culture activities. Project initiatives included training personnel, improving infrastructure and facilities, developing an appropriate technological package, and strengthening the extension program to deliver the technology to farmers.

During the 5 years of the project, aquacultural production in the targeted area increased by 425 percent. At these increased production levels, profitable harvests were obtained by farmers using previously underutilized inputs. A relatively cold tolerant fish (*Tilapia nilotica*, Egyptian strain) was introduced and pond management practices recommended which were suited to the environment and available resources. The extension program was upgraded and redirected to better meet the requirements for extending fish culture technology to farmers and focused on technology that could easily be adopted by farmers.

Acceptable fish growth was obtained from ponds at elevations up to 2,200 m if nutrient inputs were adequate. When nutrients were applied as recommended and water properly managed, productions of 20-25 kg per are per year were obtained by fish farmers.

The management technology generated a farm enterprise with a 41 percent internal rate of return, while the increased cost to the government compared to the production increase presented a 27 percent internal rate of return.

Under the project, 1,061 fishponds were renovated and 661 new ponds were built. Fifty-five extension agents, eight regional extension supervisors, and six fish station managers were trained. The National Fish Culture Center benefited from new installations, better equipping it for training and demonstrations. Six regional stations were renovated and four stations fully equipped and provided with offices, storerooms, and fish holding facilities.

The project established integration of aquaculture and agriculture that efficiently used limited resources to maximize output.

Rwanda National Fish Culture Project

Hishamunda Nathanaël and John F. Moehl, Jr.[1]

INTRODUCTION

This report describes the status of the Rwandan National Fish Culture Project (*Projet Pisciculture Nationae*, PPN) at the completion of long-term technical assistance provided to the Government of Rwanda (GOR) by Auburn University from May 1983 through February 1988. The project was funded by a grant from the United States Agency for International Development (USAID).

Rwanda offers a unique environment for aquaculture. Its high elevations provide a cool climate which influences fish growth and reproduction. Its mountainous terrain imposes limitations on pond size and logistics. Its high population density, the highest in Africa, results in demographic pressure on all resources including land and water. Subsistence agriculture is practiced by most of its people, but few nutrient inputs are available for any form of animal husbandry, including fish culture. Most fishponds are found at altitudes of 1,300 to 2,500 m where nighttime air temperatures can fall below 10°C and the afternoon air temperature rarely reaches 35°C.

Aquacultural techniques developed for more tropical climates were introduced over 40 years ago to Rwanda. With limited technology available to optimize production in the Rwandan environment, fish yields were consistently low. In the period 1971 to 1981, there were three major aquacultural development efforts funded by outside donors and numerous smaller interventions. Appendix 1 gives a brief history of Rwandan aquaculture.

With a reported 1,000 to 3,000 rural fishponds throughout the country, the GOR continued to seek assistance in establishing an economically viable aquacultural program. After preliminary studies, GOR and USAID jointly implemented PPN in January 1983.

PROJECT DESCRIPTION

Pre-project Conditions

In 1982, GOR reported 1,492 private fishponds with a total surface area of 120 ha, producing an estimated 4 kg per are per harvest, and 26 government-supported fish stations comprising 276 ponds with a total station area of 700 ha (39). Many government facilities were in disrepair due to inadequate funding. At least seven different species of fishes were being cultured, including carps, tilapias, and *Clarias*, but seed and stock quality were mediocre. Tilapia were most often raised in unmanaged rural ponds, with other fish species grown on stations. Fish prices were low, often less than 100 FRW per kg. Little infrastructure was in place to support farmers through an extension program or to produce and distribute seed. The following year the PPN was established with a mandate to provide farmers with those services required to increase production.

In the three prefectures where project activities began in 1983 there were 14 extension agents, eight of whom were untrained, working in an area with 947 rural fishponds. There were no qualified managers at the five fish stations in the region. Fish handling and holding equipment was unavailable. There were few appropriate training facilities or materials. Records for rural ponds and stations were unreliable.

By the end of 1984 baseline figures had been established: PPN had inventoried 1,569 rural fishponds in five of the country's 10 prefectures and documented a pre-project production of 3.4 kg per are per yr (Hishamunda and Moehl, Appendix 2). All of the country's fish stations had been visited and assessed. Tilapia stocks had been isolated for seed production and assessment of each species.

Purpose

The project's purpose and outputs reported in the Project Paper were amended in an Amplified Project Description (November 1985), which states that "the purpose of the Rwanda Fish Culture Project is to develop the capacity of Rwandan farm families to build and maintain productive on-farm fishponds. The most important constraint to achieving this purpose is inadequate training of farmers in improved techniques of fish culture. To address this problem, the project will improve fish culture extension in Rwanda by the promotion of appropriate stocking, pond fertilization, and regular feeding and water regulation."

Implementation Strategy

The project focused on existing fish farmers and their ponds. A pond management strategy that maximized production within temperature and input limitations was identified and transferred to farmers through a revitalized extension service. Success with these farmers led to a moderate number of new ponds being constructed each year.

Technical assistance to the PPN was directed toward training and extension. This assistance was provided by Auburn University's International Center for Aquaculture. Two long-term advisors for training and extension were present in Rwanda for a total of 110 person-months of service.[2] Five short-term consultants assisted the project for a total of five person-months. These consultants provided assistance in fish production, hatchery management, water-borne disease, and rural sociology. Reports of the long-term advisors and short-term consultants are listed in Appendix 2.

[1]Hishamunda is director of the Rwandan National Fish Culture Project and Noehl is an extension specialist with Auburn University's Technical Assistance Program.

[2]Ms. K.L. Veverica served as the ICA training advisor to the PPN, and J.F. Moehl, Jr. as extension advisor.

Project management was the responsibility of a host-country director. He assumed administrative and fiscal accountability, as well as responsibility for project direction. In mid-1984 both expatriate technical advisors were assigned counterparts. The training advisor completed work and departed Rwanda in June 1987, while the extension advisor continued with the project until February 1988.

PPN was designed as a national project with pilot activities in three prefectures the first year, expanding until all 10 prefectures were incorporated by the fourth year. Ten aquacultural stations, each with five extension agents and a supervisor, were targeted for operation in the first phase of a national program. As field experience was gained, it became apparent that this planning would not lead to the goal of improving yields for Rwandan fish-farming families since: (1) PPN's prime directive was to renovate existing ponds and these were not uniformly distributed throughout the country, and (2) to allow for GOR follow-up, a national infrastructure was required. This assessment was verified during the mid-project evaluation in 1985, with the result that the program of the Extension Service was restructured into eight "aquacultural zones" which included approximately 75 percent of existing fishponds, with centralized station management and extension coordination. Appendix 3 lists participating zones and communes.

Intended Beneficiaries

Farmers were the intended beneficiaries of PPN activities. More than 95 percent of Rwanda's population is rural and most are subsistence farmers, Gow et al (*12*). The average farm has an area of 1.21 ha (*44*). Farms are located on hills with the home surrounded by gardens. Farmers grow a variety of crops. Coffee is nearly a universal cash crop. In certain regions, tea, pyrithium, and white potatoes are important cash crops. Most families raise animals including cows, goats, pigs, and poultry. An "average" farm family has a total monetized income of 55,441 FRW annually, of which coffee contributes 4,023 FRW.

Hillside plots are augmented by plots in the bottomlands (marais), but the latter are publicly owned with use allocated by the local government administrator (*Bourgmestre*). Agriculture in the marais is often practiced collectively to allow access to the rich valleys to as many farmers as possible. Fishponds are located in the marais. Molnar and Rubagumya (Appendix 2) found that 67 percent of the fish farmers they interviewed had three or more plots in the marais, with colocase, cabbage, and sweet potatoes the crops most frequently cultivated.

Two-thirds of the ponds are operated collectively. Land tenure schemes, attempting to divide a diminishing asset among many, resulted in an unfavorable ratio of fish farmers to the area cultivated. In extreme cases, more than 50 families share a 4-are fishpond. This provided little benefit for participating families and did not encourage farmers to devote effort to raising fish. PPN urged local administrators to make larger land allotments to families engaging in aquaculture, or to assign plots to fewer families. In many cases new efforts were successful, but use patterns of established ponds could not be changed. The ratio for existing ponds remained slightly more than one are per family. By 1988 production information had led to recommendations for a minimum of 2 ares per family.

The average fishpond is a hand-dug diversion pond with a water area of roughly 4 ares. At a current price of 150 FRW per kilogram of fresh fish, compared to 180 FRW per kg for beef, marketable fish (100 g each or larger) from an average pond are worth 7,395 FRW, using 1987 figures. This is equivalent to 14 percent of the yearly monetized family income.

The staple diet consists of beans with sweet or white potatoes. Meat consumption is intermittent. Fish are a recent entry into traditional diets with the exception of some lacustrine areas. No taboo toward eating fish was noted, although knowledge of methods of preparation was limited. A good demand for fish was noted throughout the country, but was higher in urban centers with more ready cash,. Frequently, two-thirds or more of the fish crop is sold. Fish sales are more common from collective ponds as cash is easily divided among members. Fish farming involves all family members. Roles according to sex or age are not clearly defined.

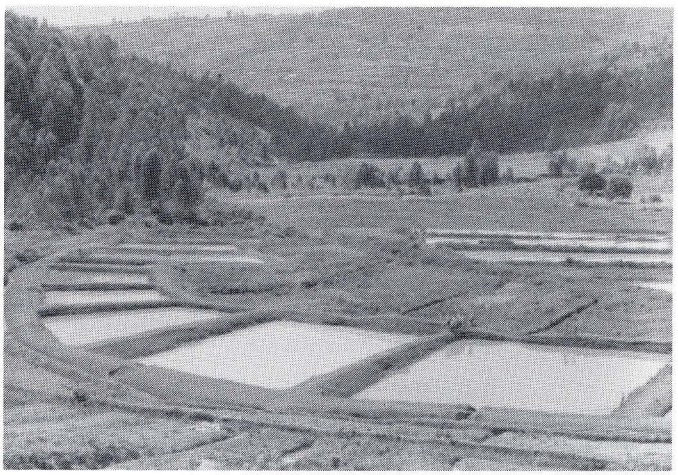


FIG. 1. Publicly owned valleys, or marais, in Rwanda are the sites for fishponds, which are often collectively managed.

PROJECT ACCOMPLISHMENTS

Outputs

Substantial progress was made toward achieving the project purpose. An extension program was initiated and a fishpond management system identified which met the needs of the Rwandan fish farmer. Extension agents and supervisors were trained, fielded, and equipped, and six regional stations were modernized to support extension efforts and provide farmers high quality fish seed.

The Amplified Project Description stipulates the following outputs as means for achieving the project purpose:

(1) "The average annual yield of fish will increase by approximately 2-3 kg per are per year of intervention. From a pre-project level of 3-5 kg per are, yields will increase to 12-15 kg per are by the fourth year."

Result: Average production from the 458 rural fishponds harvested in 1987 was 14.5 kg per are per year, a 425 percent increase over pre-project production of 3.4 kg per are per year.

(2) "80 percent of the functional fishponds existing in the zones of intervention at the beginning of the project will be actively farmed using improved fish culture techniques promoted by the extension service. This is approximately 1,000 ponds or a water surface area of 40 hectares."

Result: 67 percent of fishponds in zones of intervention were active[3] in the project. These 1,582 active ponds, with a total water area of 55 ha, exceed the stipulated output level by 167 percent.

(3) "The rate of construction of new ponds per year will average 3-5 percent of the existing ponds by the end of the project. Total pond numbers in the country may not change at this rate as some very poorly constructed ponds will be subtracted from total pond numbers as they are 'declassified' and returned to agriculture."

Result: 661 ponds were built, exceeding the 394 new starts targeted.

(4) "The fish culture extension service will be entirely funded from the Government of Rwanda's recurrent budget. This service will concentrate its efforts in the designated regions of Rwanda which have been selected based on the number of fishponds existing in the area and overall potential for fish culture. As trained person-

[3] "Active" ponds were those which had been incorporated into the PPN extension program at their operators' request and which were managed according to project-prescribed practices.

FIG. 2. The Extension Service provided guidance to farmers in appropriate fish pond construction techniques, with construction often done collectively during organized work days.

nel become available, the project will begin activities in eight regions of the country."

Result: GOR is funding 80 percent of the fish culture extension program. USAID supported aquaculture activities in 1987 for the sum of 3,500,000 FRW of the estimated recurrent budgets of 17,000,000 FRW.

(5) "Six regional fish stations will be supported by the project to support the extension service. This will be accomplished through pond renovation or construction of holding tanks and storerooms as appropriate."

Result: Improvements and renovations were made at all six of the designated stations. Redirection of the extension program and budget limitations prevented full-scale renovations at Ndorwa and Bwafu.

(6) "The project will assist local administrators in establishing new sites for fish culture. However, these new sites will promote the integration of fish culture with other uses of the wetlands and demonstrate good water and land management techniques in the marais."

Result: This output was satisfactorily accomplished through several activities: (1) 30 Bourgmesters attended a seminar on the planning and development of new aquacultural sites; (2) representatives from six other agricultural projects participated in short-term training sessions where site development and integrated aquaculture were stressed; (3) direct technical assistance was supplied to 10 communes and institutions (e.g. prisons, youth centers, schools) where integrated aquacultural schemes were undertaken.

(7) "A system of record keeping for fish culture-related statistics will be established at all levels and maintained."

Result: A comprehensive aquacultural data base was developed. Standardized reporting procedures included: (1) monthly extension agent reports, (2) monthly supervisor reports, (3) monthly station reports, (4) detailed station pond records, (5) individual private pond records, (6) pond management evaluations, (7) calendar for extension agent work schedule, (8) pond census, (9) fingerling orders, and (10) pond harvest worksheets.

(8) "Suitable training at Kigembe National Center will be conducted for all levels of extension agents and farmers."

Result: 55 extension agents received training and participated in periodic refresher courses at the National Center. Six fish station managers were trained, and eight extension supervisors received orientation after returning from second-country training. Numerous special training sessions were conducted at the Kigembe National Center for a variety of participants. Three prototype farmer training sessions were conducted.

(9) The project will promote farmer training in fish culture through several efforts including:

(a) "Improving the quality of the Extension Service by training extension personnel, supplying them with needed transport and equipment, and improving their supervision and support."

Result: All extension agents and supervisors received equipment and means of transport. Revolving funds were established for many of the items prone to heavy use to insure that they would be available in the future. Supervision of both agents and their immediate supervisors was improved by the establishment of a well structured extension program. Improved supervision of agents by regional supervisors was only partially achieved. Supervisors were the weakest link in the chain and demonstrated little desire to perform well. Furthermore, supervisors' position within the GOR hierarchy made it difficult to insist on an improved performance.

(b) "Providing farmers with high quality fingerlings supplied from project-supported stations, demonstrating the importance of good pond management, and enabling more progressive farmers to attend training sessions to increase their technical competence."

Result: Two hatcheries were established, appropriate hatchery techniques developed for Rwandan conditions, and over 600,000 quality fingerlings distributed to farmers. Each hatchery was capable of producing 15,000 fingerling per month. Station ponds were managed using techniques extended to farmers for whom demonstrations were conducted.

(c) Providing technical assistance to agricultural and rural training institutions such as CERAI's and other youth training institutions as requested and as feasible given overall project financing.

Result: The project gave two-part training programs for 24 CERAI teachers. Based on the success of these, a full-time training program with 36 sessions was organized by MINAGRI. PPN worked closely with the Butare Youth Center in developing an integrated aquacultural program.

The External Technical Evaluation of PPN in January 1988 (31) concluded that "of the project's 14 outputs... only three were not 100% realized". Of those three partially attained outputs, one dealt with the GOR's ability to assume responsibility for future operational costs which was outside their responsibilities.

TRAINING

The Training Service was established to train field staff as well as to inform various technical or bureaucratic sectors about aquaculture. Training occurred both in-country and outside Rwanda. Training was targeted for two levels of extensionists: monitors (*moniteurs piscicoles*) and agronomes (regional supervisors). The latter received training in Ivory Coast at project expense, while the former were trained at the National Fish Culture Center at Kigembe. Senior project staff participated in an Aquaculture Training Program at Auburn University.

In-Country Training

A training center was constructed at the National Fish Culture Center at Kigembe. Facilities included a classroom, dormitory, and dining room. The training emphasis was to prepare monitors to work at the communal level. These agents completed a 3-month applied technical training program at the National Fish Culture Center prior to accepting field assignments.

Because of the urgent need for competent field staff, training be-

gan simultaneously with efforts to identify the most appropriate technical "package." As new and more efficient practices were developed, staff were introduced to these through workshops.

The role of monitors was not well defined in 1983 when the first training program began. Consequently, some trainees were more suited to this job than others; the weaknesses of some provided insight into necessary qualifications for future candidates. In 1985, the Training Service established criteria for acceptance to enter training. These were: (1) the candidate be a resident of the area to which he/she would be assigned upon the completion of training; (2) he/she must have completed at least 3 years of post-primary education (including French language capability, the language in which training was conducted); and (3) he/she must pass an entrance test which insured basic language and quantitative skills. Fifty-five monitors were trained during the four training sessions from 1983 to 1987 to satisfy the needs of the extension program.

Monitor training emphasized practical fish culture skills. Each trainee was assigned a fishpond to manage during the course of the program. Trainees participated in pond construction as well as routine management activities at Kigembe or other regional stations. Technical material presented during training was incorporated in *La Pisciculture au Rwanda Manuel a l'Intention des Vulgarisateurs*, a technical manual prepared by the PPN Training Service in collaboration with the USAID-financed Agriculture Education Project and the Ministry of Agriculture.

The Training Service obtained and distributed equipment to monitors which cost 36,690 FRW per agent. This included a bicycle, a backpack, minnow seine, dipnet, spring scale, hand level, thermometer, and rubber boots. High quality materials were chosen and replacements made available for purchase by monitors at a reasonable price. Since bicycles lasted 2 years with heavy use, a revolving fund was established for the purchase of replacements.

Workshops or refresher courses (*recyclages*) of 3-5 days were held for monitors as needed, generally twice a year. During these sessions, field experiences were put into perspective and technical information updated. Project staff proposed institutionalizing these so that an agent would attend semi-annual sessions during the first 2 years in the field; these were to be followed by annual workshops, with a minimum of five workshops per agent.

The PPN Training Service organized and conducted other types of training. These included: (1) orientations for agronomes upon their return from Ivory Coast; (2) caucuses (*perfectionnements*) for regional agronomes to encourage exchange of ideas and inform them of new techniques; (3) short courses for station managers to upgrade their technical skills and coordinate station activities; (4) two 2-week sessions for teachers at agricultural technical schools (CERAI's); (5) short courses in pond construction for agricultural field workers in communes where aquacultural development was planned; (6) instruction for staff from other projects which had an interest in fish culture; (7) seminars for government technicians and administrators in which basic principles of aquaculture were presented—271 people participated in these training activities.

Second-Country Training

Agronomes received second-country training. These graduates from agricultural secondary school participated in a 9-month aquacultural specialization course at the *Centre Formation Piscicole* in Bouake (Ivory Coast). They continued training at the National Fish Culture Center (Kigembe) where general aquacultural techniques were adapted to local conditions. Eight agronomes received project-funded training.

Counterpart staff were recipients of overseas training. They participated in the Aquacultural Training Program (ATP) offered by Auburn University's International Center for Aquaculture from March to July 1985 and took field trips to aquacultural operations in the United States and Jamaica.

Second-country training included visits to neighboring countries with ongoing aquacultural projects, and participation in aquacultural conferences. Senior project staff made a 10-day visit in 1985 to Projet Piscicole Familiale, the joint USAID/Peace Corps aquacultural project in the Kivu Region of Zaïre with similar conditions to those in Rwanda. This began a technical exchange program which encouraged PPN to host a High Altitude Fish Culture Conference in 1986; participants included representatives of the Zaïre Project, a delegation from the Burundi Peace Corps Inland Fisheries Program, the Associate Director of the International Center for Aquaculture, with PPN, MINAGRI, and UNR aquacultural personnel. Collaboration between aquacultural agents in "Les Pays des Grands Lacs" (Rwanda, Burundi, and Zaïre) continued to develop. Each had programs that were operating under similar constraints. As more field data became available, a second High Altitude Fish Culture Conference was hosted by Peace Corps Burundi in Bujumbura in 1987.

Extension Program

Prior to PPN there was no structured aquacultural extension program. Few aquacultural technologies suited to the unique Rwandan environment had been identified. The first step in establishing an effective extension program was to determine what appropriate technologies should be extended. At the same time, an extension strategy needed to be elaborated and infrastructure put into place to facilitate the transfer of this technology to farmers.

Factors Limiting Fish Production

The first limiting factor for fish production in Rwanda is the quantity and quality of nutrient inputs. High quality fish seed and adequate quantities of fertilizer and feed enable farmers to obtain productions of 20 - 25 kg per are per year. Productions greater than 40 kg per are per year have been obtained by exceptional fish farmers and at stations associating animal husbandry with fish culture where large quantities of manure were available. Productions less than 10 kg per are per year resulted when recommended management practices were not followed.

The effect of temperature on production appeared to be less than initially thought. Many aquaculturists have stated that temperatures less than 20°C are below optimum for tilapia culture (3,8,36). Morning pond temperatures in Rwanda typically fall below this point and growth was acceptable. Fish grew 0.5-0.7 g per day under normal conditions and 1.3 g per day in well manured ponds (Hanson, et. al 1987, Appendix 2). Temperature effects were more pronounced at hatcheries where reproduction was reduced during the colder months of the dry season. Productions may also be influenced by soft, acidic water encountered in areas outside the volcanic region of the North, duration of direct sunlight, amount of aluminum in the soil, and other micro-environmental factors.

Pond Management Package

The project purpose was to provide farmers with support for obtaining the highest possible productions from fishponds with the lowest possible input. Requirements included effective use of available inputs, moderate expenditures of time by farmers, and no cash investment except for improved fish seed.

Tilapia were chosen as the culture fish because: (1) several species were already present in the country, (2) they feed low on the food chain and would benefit from those inputs available, (3) production of seed required no special facilities, (4) they had good market value, and (5) they were resistant to stress. A series of yield trials was designed and implemented at project-managed stations to determine which tilapia species had the best performance under farmer-simulated conditions. The results demonstrated that *Tilapia nilotica* was the most appropriate fish to culture. *T. nilotica* was indigenous to Rwanda (35). Fish at the stations and in the wild were found to be

crops were used to compost the pond.

Several community-level aquacultural development projects, as well as PPN facilities, implemented this integrated scheme with favorable results. When the garden/pond association was expanded to include some form of animal husbandry, further benefits were gained with the animals providing a source of manure when tethered or penned on levees. Fishponds associated with animal husbandry units at project stations and some communal sites produced well. Farmers were more limited when integrating animal husbandry with fish production since animals were rarely left on the pond bank at night. Animals often remained in the family compound with manure carried to the pond.

Extension Methodology

The extension program was based on the premise that effective transfer of ideas from agent to farmer required frequent and close contact. This required agents to spend time with relatively few farmers in a small geographic area. In mountainous country, travelling by bicycle, this meant working in a "zone" with a 15-km radius. Within this zone, the agent visited 10-15 sites once a week. The agent's visitation schedule was determined by the location of fishponds in his/her zone. The zone was structured with pond sites situated on five radial routes like the spokes of a wheel, with the agent's home at the hub. Each day of the week the agent traveled along one route. This schedule was repeated weekly with a specified route being followed the same day of each week. Frequently, several fishponds were located in a marais. Two or three marais could be visited on a given day. This corresponded to 35-40 fishponds per agent per week. Experience indicated that an extension agent could service no more than 50 pond units.

As the agent's initial group of fish-farming families experienced successful harvests and as yields increased, the frequency of visits was decreased from once a week to twice a month. New pond units were then added to the agent's visitation schedule.

The work zones of 8-10 extension agents comprised an "aquacultural region," Appendix 3. These regions did not follow administrative boundaries but were based upon the locations of practicing fish farmers. Each aquacultural region was supervised by an agronome who visited each agent twice a month to assess his/her performance. Agronomes were principal aquacultural officers for their regions. They maintained contacts with government officials, coordinated the distribution of fingerlings and materials, and organized and presided over monthly meetings with the agents when monthly reports were collected, corrected, and collated. They submitted monthly summaries of aquacultural activities in their regions to project headquarters at Kigembe.

Agronomes were the weakest link in the extension hierarchy. Their responsibilities were in line with their capabilities, but they demonstrated a keen lack of interest in field work. Few administrative options were available to insure acceptable performance and, in spite of efforts to correct the situation, their contribution was negligible.

Aquacultural Facilities

Aquacultural facilities were a necessary part of the infrastructure for an effective extension program. Ruremesha (39) identified 26 fish cultural centers. All were visited and evaluated for their possible role in a national aquacultural program (Moehl 1984, Appendix 2). Recommendations were made for the best use of each (Moehl and Hanson 1986, Moehl 1986, Appendix 2) and six were selected for PPN operations, table 1. Selection was based upon size, physical state, geographic location, accessibility, and project need. Each station was selected with a specific role in mind: Nkungu, the largest, for trials of food fish production and marketing. Rugeramigozi, with the largest number of ponds of the same size, for production trials of different management systems. Ndorwa, at 2,200 m, was inaccessible, but provided valuable information about growth and reproduction at high altitude. Runyinya, Rushashi, and Bwafu were designated as hatcheries, each to supply a region of the country with fingerlings. As experience was gained in hatchery operations and fish transport techniques improved, the small Bwafu facility was phased down since the region could be supplied by Runyinya.

TABLE 1. PPN REGIONAL AQUACULTURE FACILITIES

Station	Region	Ponds	Water surface	Date PPN activities began	Altitude (m)
		No.	Are		
1. Runyinya	Butare South	11	1.0	June 1983	1,760
2. Nkungu	Butare East/West	15	2.1	June 1983	1,650
3. Rugeramigozi	Gitarama	16	1.4	June 1983	1,830
4. Rushashi	Rushashi	8	1.2	November 1984	1,750
5. Ndorwa	Gisenyi (North)	14	0.6	December 1985	2,200
6. Bwafu	Gisenyi (South)	6	0.5	December 1985	1,560

PPN activities at the first four stations listed in table 1 included : (1) renovating ponds and water supply canals, building an office, storeroom, and holding tank complex; (2) installing water regulatory devices such as sluce gates, dams, overflows; (3) installing inlets and PVC standpipe drains; (4) fully equipping the facility with supplies, nets, graders, scales, record books, etc. All stations had gardens which were used with adjoining animal husbandry units to demonstrate integrated fish culture.

The six stations were operated by well-trained managers under the direct supervision of the Extension Service. These individuals, with limited formal education, did an excellent job of supervising day-to-day activities and keeping current and comprehensive records.

Tilapia nilotica (Egyptian strain) were kept at Runyinya Station where efforts were made for rapid multiplication for distribution of seed to farmers and for use in production trials. Hatchery techniques were developed for producing 13,000 to 15,000 fingerlings monthly. These fingerlings were mechanically graded for size after harvest from brood ponds and nursery ponds and before transport to farmers. Uniform size fish at stocking ensured more uniform size fish at harvest. With Runyinya hatchery in the south and Rushashi in the north, sufficient capacity was available for producing 30,000 fingerlings a month, the country's estimated need.

From 1984 to 1987, 607,052 fingerlings were distributed to farmers. These fish were sold at a subsidized price of 3 FRW each, delivered to the farmer. Transport to farmers was done with a locally built 750-l transport tank with mechanical agitation for large orders, or in plastic bags with oxygen for smaller numbers. Production costs were 3.9 FRW per fingerling, exclusive of transport.

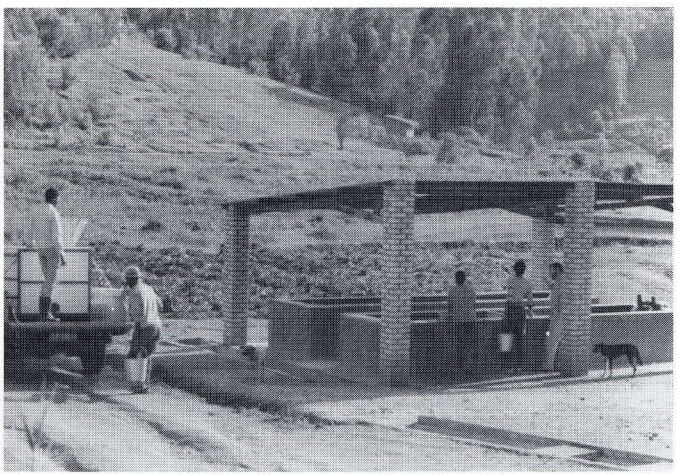


FIG. 5. Fish holding facilities were built at project-supported fish stations from which fish seed was transported for stocking private farmers' ponds.

Kigembe Station played a significant role in PPN activities. This facility was project headquarters and training center, and became the most prominent integrated aquacultural facility in the country with large-scale demonstrations of fish-pig, fish-duck, fish-chicken, and fish-goat culture. Production from several integrated ponds exceeded 40 kg per are per year and the sale of animals and eggs helped to defray station operating costs. Extensive gardening also was done to demonstrate integration and generate revenue. The station had recreational fish-out ponds and outdoor grills which attracted many customers.

Financial Analysis

The production of tilapia resulted in net positive returns to farmers resources. Spread over 25 years, the net present value of investment was 21,197 FRW. The net returns were negative in the first 2 years, but returns were greater than costs for years 3 to 25. The net benefit investment ratio was 17.1. The project is acceptable since the net investment ratio is greater than 1.

The internal rate of return for the farmer's investment yielded 41 percent. This more than justifies the farmer's investment in this enterprise since it is greater than the opportunity cost of capital, which is about 15 percent for Rwanda (most AID projects require an IRR of 15 percent). The net present value for the farmer's aquacultural operation, calculated at 15 percent, was 21,197 FWR: both the IRR and NPV are calculated in Appendix 7.

The discounted net returns to individual farmers were multiplied by the number of farmers expected to participate in the project to obtain the returns to project. GOR expenditures were subtracted to obtain the net returns to project. An additional number of ponds to be put into production throughout the life of the project was extrapolated, based upon the number of active project ponds, until the total number of active ponds equals the number of ponds inventoried by the project in areas of activity. The internal rate of return was 27 percent. This is greater than the opportunity costs of capital. The increase in production was due mainly to an increase in extension effort. The extension effort was the result of the hiring of monitors. The net present value for the government's investment, calculated at 15 percent, was 19,564,849 FRW.

The initial cost to government was comprised of donor contributions plus those of GOR. The GOR contributions paid for some salaries, facilities, and administrative costs. Recurrent costs for the project were minimal. The GOR should be able to continue the financing of the project after donor contributions cease. It is estimated that GOR contributions can be met easily if adjustments are made to administrative costs. Administrative costs are a major component of the GOR contribution.

Table 2. Returns for a Four-are Pond for Two Production Levels[1]

Item	Production level	
	14.5 kg/are/yr	20.0 kg/are/yr
Gross returns	7,844	10,559
Operating costs	3,614	5,018
Revenue above operating costs	4,230	5,541
Depreciation	345	345
Gross returns to management and capital	3,885	5,096
Management costs	1,350	2,250
Returns to capital	2,535	2,846

[1]Further information is presented in Appendix 6.

Economic Considerations

In 1987, nearly one-fifth of all farmers surpassed 20 kg per are per year, and a survey of their management practices indicated that they were doing nothing extraordinary other than following closely the technologies extended. There has been a definite trend towards increased production over time. Results from station trials and farmers ponds indicated that the "low input" management package employed was capable of producing 20-25 kg per are per year. Farmers producing less than 10 kg per are per year will probably abandon fish culture as they realize that these productions are not competitive with alternative marais crops. Table 3 compares a fish culture production of 20 kg per are per year with alternative uses of a marais plot.

Table 3. Annual Gross Returns Per Are from Marais Crops Produced from Farmers Common Rotation Practices, 1987

System	Yield (kg/are)		Value/kg		Gross Returns per are (FRW)
	Crop I	Crop II	Crop I	Crop II	
a) Bean/bean[1,2]	8	8	33	33	528
b) Bean/sorghum[1,2]	8	11.5	33	35	667
c) Bean/corn[1,2]	8	13	33	18	498
d) Sweet potato/sweet potato[2,3]	70	70	11	11	1,540
e) Sweet potato/soy[2,3]	70	8	11	34	1,042
f) Rice/rice[3,4]	27	27	25	25	1,350
Fish (annualized yield, food fish only)		20		150	2,445

SOURCES: [1]ISAR, June 1987; [2]SESA, February, 1987; [3]Rutunga et al., May 1987; [4]Nyarwaya, March 1987.

It is difficult to make comparisons of fish culture with alternative uses of land and labor since data are lacking. All are labor intensive. Most foodstuffs are grown on raised beds in the marais. The volume of soil in these beds is roughly equal to that in a pond levee, the latter being built once and the former being tilled once a season. Rice paddies have smaller levees, but routine maintenance is greater. For most crops, no pesticides or organic fertilizers are used, although this is being tried in some areas. For all alternatives the most important factors are land and labor. With an agrarian population there is a considerable labor surplus in rural areas and little real competition for this resource. Land is the most limiting factor and therefore rational farmers will choose crops with high returns to land, table 4.

Fish farming is a profitable activity for the Rwandan farmer, competing favorably with alternative marais crops. It has no defined season and harvests can be planned to coincide with periods when farmers have little income from other crops. Although it does not compete for labor under present conditions, and offers good returns to land, it does ultimately compete with other crops for organic fertilizers. The balance has shifted in fish culture's favor for the moment and, if integrated aquaculture becomes accepted, competition should be reduced, or even cease, as mutually advantageous relationships develop.

The project represents an appropriate use of the country's resources, taking into consideration the objectives and constraints facing the economy. A national goal is to improve income/nutrition in the rural areas. The project supplies a cheap source of high quality protein. The price per kilogram of fish is relatively high, but when compared to a kilogram of protein from other sources, the price of

Table 4. Gross Returns to Land and Labor, a Comparison of Various Agricultural Crops with Fish Culture

Crop	Gross returns to land (000 FRW/ha)	Gross returns to labor (FRW/day)
Fish (Tilapia)	71.2	528
Yams*	105.4	NA
Cassava	90.9	520
Rice	73.9	NA
Taro	70.0	NA
White potatoes	63.9	376
Sweet potatoes	50.2	314
Soy beans	31.0	NA
Dry beans	25.3	168
Sorghum	23.2	166
Dry corn	20.4	151

*Source for agricultural crops: World Bank 1985 in Wilcock and Ndoreyaho 1986.

fish compares favorably. Fish are 35 percent protein while there is 23 percent protein in beef.

Fish production is sustainable if it utilizes local resources such as animal wastes and is complementary to overall animal production through integrated aquacultural practices. Fish production does not require imports and is not a drain on national foreign reserves.

The fact that fish played a minor role in traditional diets has not led to major barriers to fish consumption, but in some cases there was a lack of knowledge of preparation and cooking. A pilot program held in 1986 at communal nutrition centers to demonstrate fish preparation met with approval and a larger program was planned.

Fresh fish marketing was only cursorily examined. Nkungu Station sustained a small local market through a program of frequent partial harvests with mechanical grading to remove marketable fish. Fish with an average weight of 120 g easily sold for 150 FRW per kg. Fish smaller than 100 g were difficult to sell, even at reduced prices. Size preference did vary from one region of the country to another. A notable exception was the lakeshore areas of Lake Kivu where smaller fish were acceptable, probably due to a tradition of eating the small *Haplochromis* sp. which inhabit the lake. Fish weighing 120 g are readily attainable by farmers in 7-9 months following the recommended management package.

As fish production continues to increase, marketing will become an increasingly important issue. With a stratified market structure where there is high demand, ready cash in the few urban centers, and low cash flow in the much larger rural areas, market studies are warranted.

OBSERVATIONS AND RECOMMENDATIONS

A national aquacultural strategy would have greatly facilitated achievement of PPN objectives. A well-defined policy is needed to support fish farmers and provide direction for future development.

Aquacultural activities must focus on integration. Efficient use of resources is critical to Rwanda's future. Multiple and integrated use of resources results in an efficient balance between input and output. Future aquacultural development depends to a large extent upon how well aquaculture is integrated with other agricultural production.

A new caliber of extension agent will be needed as integrated aquaculture is more fully defined and instilled into farm agricultural systems. It is both advantageous to the farmer and cost effective to GOR that one agent deal with the farmer concerning the various components of an integrated system. Existing aquacultural monitors are uniquely qualified for this with solid technical backgrounds and work experience in the marais. They should receive further training in agronomy, animal science, and agricultural engineering at the Kigembe Center and assume the role of marais development worker.

Providing quality fingerlings to farmers is a key to success. Hatcheries must be adequately funded to produce and transport fingerlings. Privatization of fingerling production should be evaluated. This could be implemented in several ways, each requiring different levels of government support; farmers could produce fingerlings from hatchery-produced fry or could assume all hatchery functions.

Of 12 A-2 level agronomes assigned to the project, none exhibited exceptional desire to help the project attain its goals. Other projects have indicated similar problems with people of this level. Individuals with secondary technical school training are under qualified for most mid-level positions, but apparently feel that field activities are below their standing.

Three field assistants are needed to fill the void at the national level after the departure of long-term advisors. These should be of the A-1 or A-0 level.

A computer should be installed at Kigembe to efficiently treat the large quantity of information on file and the continued volume of documentation arriving monthly.

Tilapia nilotica is the fish of choice for the Rwandan fish farmer. As experience with mixed sex monoculture grows and rural production continues to increase, consideration should be given to introducing monosex or polyculture. These alternatives would permit further production increases, but would place greater demands upon GOR to supply the required seed stock and provide extension services. If GOR cannot continue to support the existing infrastructure, such a step would be ill-advised.

Marketing development is essential to provide further opportunities for growth of the industry and entry of new producers.

To insure that revenues from fishponds contribute significantly to family income and stimulate continued interest, each family should have fishponds of 2-4 ares surface area.

Farmers producing less than 10 kg per are per year should be dropped from the program. Experience has indicated that a farmer who cannot exceed this level after three harvests does not choose to have aquaculture as an important activity on his/her farm.

The GOR should privatize many of the fish stations it now manages. Of the more than 20 facilities receiving varied degrees of government support, no more than four are necessary; the others are a severe financial drain.

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APPENDIX 1

History of Fish Culture in Rwanda

In 1923 colonial rule of the Central African region of Ruanda-Urundi was assumed by Belgium when Germany, the initial colonizer, was forced to surrender its colonies. The Belgiums brought with them many practices they had employed in the tropical Congo, a colony they had held for the previous 40 years. Among these was fish culture, an activity that was hoped would lead to increased labor efficiency where protein malnutrition was considered to be chronic, Charpy (7). Huet (14), a pioneer Belgian aquaculturist, visited Ruanda-Urundi and remarked that the area had a good potential for aquaculture. The colonial administration encouraged the construction of fishponds, and by the end of the 1950's, over 2,000 ponds were recorded as producing an average of 4 kg per are per year (2). Although these results were considered mediocre (15), fish culture continued to be practiced after the territory became the present-day nations of Rwanda and Burundi in 1962.

In the 1960's fish culture entered a state of suspended activity. This loss of inertia was attributed to: (1) a lack of cooperation on the part of farmers because fish culture was pressed upon them; (2) the introduction of fish culture during a period when fish consumption was not widely practiced; (3) a lack of trained personnel; and (4) inadequate technical understanding on the part of farmers (20). Meschkat (30) reported that 448 ponds had been constructed in Rwanda since 1950, but few were operational at the time of his writing.

Beginning in 1967, the Food and Agriculture Organization of the United Nations (FAO) undertook the first in a series of fisheries development projects. The initial intervention, carried out through 1970, consisted of a survey and appraisal of inland fishery resources. The results, reported by de Vries (9), included data on experiments with no less than seven culture species, including common carp and three tilapias: *Tilapia rendalli*, *T. macrochir*, and *T. nilotica*. The first two species were introduced from Congo with only *T. nilotica* being an indigenous species, Philippart and Ruwet (35). Productions of tilapia in monoculture were reported as being 4.5-5.8 kg per are per year. A follow-up project was implemented in 1972-73 and was reported by Dunn (10). This venture was oriented toward capture fisheries with aquaculture a peripheral activity; potential production for the rural sector was estimated as 5-40 kg per are per year. FAO was again active in 1975 when C. Reizer (37) spent 2 months developing a strategy for increased fish production. Reizer noted that "family" fish culture was not well developed and that yields generally were quite poor.

Mahy (26), a fisheries biologist having a long-standing association with both the FAO and Canadian development efforts, noted that there was a certain dissatisfaction with FAO efforts as no provisions were made for the continuation of aquaculture nor was any applied research undertaken to determine the most appropriate culture system. He continued with this theme in 1982 and estimated that fishponds in Rwanda could produce 21 kg per are per year based upon Van der Lingen's (49) hypothesis that fertilized and fed tilapia ponds would be seven times more productive than natural waters.

In 1978, the ELADEP (Empoissonnement des Lacs du Pays et Developpement de la Peche) project was funded by the Canadian International Development Research Centre (IDRC). This project, which focused upon lake fisheries, continued through 1981. Aquacultural related topics included such things as fingerling production and diet studies, Mahy (27). Some fisheries extension agents were trained during this program, but no aquacultural extension program was implemented. At the time of this project, the GOR reported 2,662 fishponds in the country (Ministere de l'Agriculture et de l'Elevage Rapport Annuel 1978).

At this same time, the Government of Rwanda (GOR) was investigating numerous avenues to rejuvenate its aquaculture program. A Peace Corps volunteer from Zaire was loaned to Rwanda to assist with an assessment of the fish culture potential. A team of North Koreans was assisted by GOR staff in their efforts to develop an effective program of grass carp seed production. Numerous volunteer organizations began "micro-projects," working at the communal level to develop fish culture in a few selected sites.

At the request of GOR and with the support of USAID, FAO sent a team to Rwanda in 1980 to evaluate the feasibility of a small-scale rural fish culture development project. The team found that there had been a stagnation of fish culture due to the lack of extension to fish farmers of appropriate farming techniques, with the result that they obtained disappointing results for the past 20 years, Schmidt and Vincke (43). Nonetheless, interest in fish culture among farmers was reported to be high and it was decided that there were no major biological or technical constraints to fish farming.

APPENDIX 2:

LIST OF DOCUMENTS PRESENTED

Over and beyond periodic reports and project situation memorandums, technical assistance has participated in the preparation of the following pertinent PPN documentation:

(1) Impact of Fish Ponds on Public Health in Rwanda with Specific Reference to Shistosomiasis, Emile A. Malek, October 1, 1983. A review of the potential for water-borne diseases associated with aquaculture based on a consultancy by Dr. Malek, an International Center for Aquaculture short-term technical consultant.

(2) Recommendations for Rwanda Fish Culture Project's Extension Program, J. Moehl, January 23, 1984. Proposal for a redefinition of the project's geographic structuring and extension operations.

(3) Review of the Rwanda Fish Culture Project, D.D. Moss, March 6, 1984. The first of four project reviews and status reports undertaken by Dr. Moss, the Associate Director of the International Center for Aquaculture.

(4) Trip Report: A Summary of Visits to Rwanda National Fish Stations, J. Moehl, March 23, 1984. An appraisal of all Rwandan aquaculture facilities and recommendations as to which should benefit from PPN intervention.

(5) TA Team Recommendations for a Project Policy, K. Veverica, March 30, 1984. A proposal presented to USAID and the Rwandan Government for a realignment of project activities based upon the Technical Assistance Team's experience in-country.

(6) Trip Report: Center for Fisheries Training, Bouake, Ivory Coast, J. Moehl, July 1984. An assessment of the Bouake training center where PPN A-2 agronomes undergo aquaculture specialization, with emphasis as to how this center could provide the project with a maximum of pertinent assistance.

(7) Yield Trials as a Part of the Rwanda Fish Culture Project, R.O. Phelps, October 23, 1984. A report prepared by an International Center for Aquaculture consultant proposing yield trials that would be the most appropriate to develop an aquaculture "package" tailored for Rwanda's needs.

(8) Review of the Rwanda Fish Culture Project, D.D. Moss, February 1985. The second annual project review undertaken by Moss.

(9) Excerpts from Annual Report of the Extension Service, 1984, Rwanda Fish Culture Project, N. Hishamunda and J. Moehl. Article in the "ICA Communicae", Vol. 8, No. 1, January - March 1985.

(10) Proposed Rotary Project for Integrated Aquaculture in Rwanda, J. Moehl, August 17, 1985. A proposal for a possible Rotary International intervention in aquaculture in Rwanda.

(11) Reply to Fish Culture Socio-Economic Survey Report of June 1985, J. Moehl, September 1, 1985. A rebuttal to a socio-economic assessment of the project undertaken by USAID/Kigali.

(12) Review of the Rwanda Fish Culture Project, D. D. Moss, March 1986. The third annual International Center for Aquaculture review.

(13) La Pisciculture au Rwanda: Manuel a l'Intention des Vuloarisateurs, K. Veverica, J.B. Kabagambe, J.P. Caillaud, L. Filion, and C. Mukakarara, May 1986. A fish culture technical manuel prepared jointly by PPN, USAID's Agriculture Education Project, and the Ministry of Agriculture's Division of Fisheries and Fish Culture.

(14) Rwanda Women in Aquaculture, K. Veverica. Article appearing ln the "ICA Communicae," Vol 9, No. 1-2, January - June 1986.

(15) Extension Strategy, J. Moehl, October 4, 1986. A summary of the PPN extension planning and activities prepared for USAID/ Kigali.

(16) Re-Organization of Rwanda Aquaculture Facilities, J. Moehl and B. Hanson, October 18, 1986. Proposal for the use of aquaculture facilities with special emphasis upon the Rwanda National University research facility at Rwasave and how it could best assist current extension efforts, prepared for USAID/Kigali and the Rwandan Government.

(17) Proposal for the Restructuring of Rwanda National Aquaculture Facilities, J. Moehl, October 19, 1986. Recommendations for the use and/or disinvestment (i.e. privitization) of governmental fish stations prepared for USAID/Kigali and the Rwandan Government.

(18) Technical Review of the Proposal: l'Amenagement de la Ferme Piscicole de Mututu. J. Moehl, October 21, 1986. suggestions prepared at the request of USAID/Kigali regarding the use of PL480 funds for the construction and operation of a commercial-scale fish farm at Mututu.

(19) Rwanda Fish Culture Project. K. Veverica and J. Moehl, November 1986. A publicity brochure prepared for PPN by the International Center for Aquaculture.

(20) Rwanda Fish Culture Project Technical, Social, and Institutional Issues Affecting Delivery of Fish Farming Extension Services, J. J. Molnar and B.L. Nerrie, February 1987. International Center for Aquaculture consultants discussing technical and social aspects of PPN activities.

(21) Review of Rwanda Fish Culture Project, D.D. Moss, February 1987. Fourth annual project review.

(22) Establishment of a Fish Culture Extension Service in Africa's Most Densely Populated Country, K.L. Veverica, J.F. Moehl Jr., N. Hishamunda, and P. Nyirahabimana, February 1987. First of three articles prepared for, and presented to, The Second International Symposium on Tilapia in Aquaculture (ISAT II).

(23) Pond Culture of Tilapia in a High Altitude, Equatorial African Country, B.J. Hanson, J.F. Moehl Jr., K. L. Veverica, F. Rwangano, and M. Van Speybroek, February 1987. Second of the ISAT II articles.

(24) Development of Appropriate Pond Management Techniques for use By Rural Rwandan Farmers. J.F. Moehl Jr., K.L. Veverica, B. Hanson, and N. Hishamunda, February 1987. Third ISAT II article.

(25) Fish Culture in Rwanda: The Economic Overview, N. Hishamunda, P. Nyirahabimana, and J. Moehl, August 1987. The first in a series of Technical Service Papers (TSP) designed to be informative and technically apt documents underscoring the uniqueness of the Rwandan aquaculture situation and efforts PPN has made to develop a worthwhile farmer-oriented program.

(26) Fish Culture In Rwanda: Rural Fishpond Management, N. Hishamunda, P. Nyirahablmana, and J. Moehl, October 1987. The second TSP document.

(27) Aquaculture and the Marais: Patterns of Organization. Allocation and Use of Valley Land Under Conditions of Resource Scarcity and Ecological Complexity, J.J. Molnar and A. Rubagumya, October 1987. An appraisal of aquaculture within the framework of wetlands development prepared by the International Center for Aquaculture and Cornell University.

(28) Fish Culture in Rwanda: Aquaculture Extension, N. Hishamunda and J.Moehl, November 1987. TSP No. 3.

(29) Fish Culture in Rwanda: Hatchery Management—Runyinya Station, N. Hishamunda and J. Moehl. December 1987. TSP No. 4.

(30) Rwanda National Fish Culture Project Final Report for Auburn University Technical Assistance. J. Moehl, January 1988. Report prepared for USAID/Kigali upon the departure of the last long-term technical advisor.

APPENDIX 3
FIELD PROGRAM: AREA OF ACTIVITY

Region	Commune	Total no. ponds	No. active ponds	Production kg/are/yr	Year PPN active
Cyangugu	Gatare	18	8	10.7	1987
	Gishoma	64	32	21.2	1987
	Karengera	38	9	–	1987
	Kamembe	36	34	9.2	1986
Rushashi	Tare	29	24	13.1	1985
	Rushashi	48	26	17.1	1985
	Musasa	41	25	13.4	1985
	Shyrongi	42	40	19.1	1985
	Nyamugali	55	32	–	1986
	Cyungo	85	31	9.0	1986
Gitarama	Mugina	7	5	–	1987
	Nyamabuye	36	16	15.0	1985
	Runda*	66	27	11.8	1984
	Kayenzi*	37	29	14.8	1984
	Musambira*	20	6	12.5	1984
	Mukingi	25	16	23.5	1985
	Taba*	26	10	14.2	1984
	Bulinga	62	60	15.8	1984
	Mushubati	55	35	11.2	1986
	Kigoma	26	25	5.9	1987
	Kivumu	80	30	16.5	1986
	Bwakira	78	25	17.4	1987
Nyabisindu	Musange*	13	8	–	1984
	Masango	33	27	11.1	1984
	Nyabisindu	21	15	15.5	1984
	Ntyazo	34	28	13.2	1985
	Rusatira	28	24	16.0	1985
	Karambo*	2	2	–	1984
	Muyira	49	43	25.9	1985
	Murama	38	34	14.6	1987
Gisenyi North	Kayove	18	13	–	1986
	Giciye	21	16	18.4	1986
	Kanama[2]	124	124	11.4	1984
	Karago	52	35	11.9	1986
	Nyamyumba	40	21	25.6	1986
Gisenyi South	Satinski	26	13	19.9	1986
	Kibilira	38	22	17.6	1986
	Cyabingo	31	31	14.3	1987
	Nyakabanda	53	47	19.7	1986
Butare East/	Shyanda	42	21	–	1985
West	Ruhashya*	19	9	8.6	1984
	Nyamagabe	26	17	16.8	1985
	Mbazi*	36	32	11.1	1984
	Kinyamakara	38	17	14.0	1984
	Ngoma	16	16	10.8	1986
	Huye	14	11	7.6	1985
	Maraba	26	26	14.0	1986
Butare South	Muganza	90	46	14,3	1984
	Gishamvu	63	36	15.4	1984
	Nyaruhergeri[2]	113	79	11.4	1985
	Kibayi	58	43	12.8	1984
	Rwamiko*	44	28	14.1	1984
	Runyinya	75	59	10.4	1985
	Kigembe	86	78	12.0	1985
	Mubuga	24	16	10.9	1984

NOTE: *Communes which share a monitor with another (i.e. an agent with a two-commune zone).

[2]Communes where two agents are assigned to that one commune.

–When no production is noted, no harvests for active ponds have been recorded.

APPENDIX 4
SUMMARY OF POND MANAGEMENT PRACTICES FOR *TILAPIA NILOTICA* CULTURE IN RWANDA

Practice	Component	Recommendation
Water regulation . .	Shallow end depth	40-50 cm
	Deep end depth	<120-150 cm
	Control mechanism	"on/off" method no flow-through
Fertilization (= composting) . . .	Compost enclosure	not located at inlet one per are 10% of area of pond enclosed
	Initial application	minimum of 0.5-1.0 m^3/are
	Subsequent applications	10% by volume, weekly
	Quality (minimum)	80% vegetable matter, 20% manure
	Mixing	well mixed daily
Feeding	Quality	whatever available e.g. leaves, household wastes
	Quantity	as much as possible
	Frequency (minimum)	once a day, five days a week
Stocking	Size	10 +/– g.
	Initial density	1 fish/1.5 m^2
	Maximum density	1 fish/m^2
Harvesting	Partial (sampling)	As from 4th month
	Complete	After 7-9 months

APPENDIX 5
EVALUATION OF RURAL POND MANAGEMENT

Tables A and B below summarize the results of three evaluations that were undertaken by the PPN Extension service to determine to what degree the management practices being extended were being adopted. The scope of the 1987 evaluation was further broadened to compare the management techniques of average and better fish farmers in an effort to ascertain whether the higher-yield producers were employing different techniques than lower-yield producers.

Table A. Evaluation of rural fishpond management practices, 1984 and 1985

Practice	1984	1985
Structured inlet present	22/38 = 58%	18/26 = 69%
Structured overflow present	20/38 = 53	15/26 = 58
Good water regulation	17/38 = 45	12/26 = 46
Good quantity of compost	6/38 = 16	6/26 = 23
Good plankton bloom	6/38 = 16	7/26 = 27
Good quantity of feed	10/38 = 26	2/26 = 8
Good weed control	31/38 = 82	25/26 = 96

NOTE: For the 1985 evaluation, the questions were posed in a yes/no fashion (i.e. good water regulation—yes or no); for the 1984 evaluation, items 1-4 were evaluated on the basis of 1-5 points given for each practice (5 being excellent). Ponds with good practices indicated above were those that received 4 or 5 points out of the possible 5.

Table B. Results of 1987 rural fishpond evaluation

Practice	Score	
	Average farmers	Better farmers
Proper inlet installed	22/28 = 79%	14/15 = 93%
Good water regulation	22/28 = 79	13/15 = 87
Good quality of compost	19/28 = 68	14/15 = 93
Good quantity of compost	14/28 = 50	9/15 = 60
Good plankton bloom	10/28 = 36	11/15 = 73
Good quantity of feed	8/28 = 29	6/15 = 40
Feed at least 5 times/week	11/28 = 39	8/15 = 53

NOTE: Ponds for 17 different extension agents were evaluated, a number corresponding to one-third of the agents in the field. Two ponds per agent were selected at random, with no regard to production. If possible, a third pond was selected whose last harvest had been ≥20 kg/are/yr (i.e. a "high producer"). A total of 43 ponds was evaluated: 28 average producers with a mean of 13.8 kg/are/yr and 15 superior producers with a mean of 28 kg/are/yr.

APPENDIX 6
FISHPOND MODEL ENTERPRISE BUDGETS

Item	Good production level 20 kg/are/yr	1987 production level 14.5 kg/are/yr
	FRW	FRW
Inputs:		
Pond depreciation[1]	345	345
Fertilizer	2,817[2a]	1,413[2b]
Periodic labor[3]	1,400	1,400
Management labor[4]	2,250	1,350
Fingerlings[5]	801	801
Total	7,613	5,309
Outputs:		
Food fish	8,770[6a]	6,528[6b]
Fingerling[7]	1,789	1,316
Total	10,559	7,844
Net Returns	2,946	2,535

[1]Pond and canal construction costs are 2,500 FRW/are depreciated over 25 yr. The figure presented is for 9 months. Comparable renovation costs would be 1875 FRW/are.

[2a]Fertilizer as compost is applied at an initial rate of 1.0 m^3/are with additions of 10% by volume. Costs as opportunity labor costs for collecting the composting materials are calculated at 100 FRW/m^3.

[2b]Fertilizer as compost is applied at an initial rate of 0.5 m^3/are with additions of 10% by volume. Costs as opportunity labor costs for collecting the composting materials are calculated at 100 FRW/m^3.

[3]This includes 14 person days of labor input for harvesting, marketing, and pond maintenance, calculated at 100 FRW/day.

[4]This includes daily labor for managing the pond: feeding, fertilizing, regulating water, etc. This is calculated at 3 hr/wk, 100 FRW/8-hr day.

[5]Fingerlings are stocked at one fish per 1.5 m^2 and cost 3 FRW each.

[6a]Based upon net production of 20.0 kg/are/yr, 17.4 kg would be harvested per are, or 69.6 kg/pond. 84% of the harvest is marketable fish which is sold for 150 FRW/kg (yield = productivity · 10/12 + 0.67).

[6b]Based upon net production of 14.5 kg/are/yr, 12.8 kg would be harvested per are, or 51.2 kg/pond. 84% of the harvest is marketable fish which is sold for 150 FRW/kg (yield = productivity · 10/12 + 0.67).

[7]16% of the harvest is fingerlings, of this 10% is used for restocking the pond and 6% are sold. Average weight of fingerlings is 7 g. Fingerlings are sold for 3 FRW each.

APPENDIX 7
FINANCIAL ANALYSIS

	Returns per pond													Increase due to project			Returns to government			
Year	Renovation	Seed	Mos. of production	Labor	Harvest/ maintenance	Total costs	Production level (net)	Yield (gross)	Harvest	Food fish	Fingerlings	Total returns	Net returns	Returns to PPN = net − 684	Total ponds	Active ponds	Net returns active ponds	GOR budget	Net increase	Returns for increase (= net returns − net increase)
	FRW	FRW		FRW	FRW	FRW	kg/are/yr	kg/are	kg	FRW	FRW	FRW	FRW	FRW	No.	No.	FRW	Mil. FRW	Mil. FRW	FRW
0				896	400	1,296	3.4	4.1	16.4	1,980		1,980	684		947	0	0	10		
1	7,500	801	3	458		8,759							−8,759	−9,443	1,568	849	−7,436,391	12	2	−9,436,391
2			6	1,374	1,400		6.6	6.2	24.7	3,112	635	3,747	−362	−1,046	1,229	809	−292,858	14	4	−4,292,858
			5	1,335		4,109														
3			4	1,068	1,400		12.6	11.2	44.8	5,645	1,152	6,797	2,180	1,496	1,795	1,150	2,507,000	15	5	−2,493,000
			7	2,149		4,617														
4			2	614	1,400		14.5	12.8	51.2	6,528	1,316	17,553	10,877	10,193	2,408	1,623	17,653,371	17	7	10,653,371
			9	4,662		6,676	18.4	16	64	8,064	1,645									
5			9	5,067	2,800		20	17.4	69.6	8,770	1,789	10,559	2,101	1,417	2,408	1,785	3,750,285	17	7	−3,249,715
			1	591		8,458														
6			8	4,728	1,400		22	19	76	9,576	1,954	11,530	3,539	2,855	2,408	1,964	6,950,596	17	7	−49,404
			3	1,863		7,991														
7			6	3,726	1,400		24	20.7	82.8	10,433	2,129	12,562	4,251	3,567	2,408	2,160	9,182,160	17	7	2,182,160
			5	3,185		8,311														
8			4	2,548	1,400		25	21.5	86	10,836	2,211	13,047	4,640	3,956	2,408	2,367	10,982,880	17	7	3,982,880
			7	4,459		8,407														
9			2	1,274	1,400		25	21.5	86	10,836	2,211	26,094	17,687	17,003	2,614	2,367	41,865,129	17	7	34,865,129
			9	5,733		8,407	25	21.5	86	10,836	2,211									
10			9	5,733	2,800		25	21.5	86	10,836	2,211	13,047	3,877	3,193	2,614	2,614	10,134,478	17	7	3,134,478
			1	637		9,170														
11						8,407						13,047	4,640	3,956	2,614	2,614	12,128,960	17	7	5,128,960
12						8,407						13,047	4,640	3,956	2,614	2,614	12,128,960	17	7	5,128,960
13						8,407						13,047	4,640	3,956	2,614	2,614	12,128,960	17	7	5,128,960
14						8,407						26,094	17,687	17,003	2,614	2,614	46,233,818	17	7	39,233,818
15						9,170						13,047	3,877	3,193	2,614	2,614	10,134,478	17	7	3,134,476
16						8,407						13,047	4,640	3,956	2,614	2,614	12,128,960	17	7	5,128,960
17						8,407						13,047	4,640	3,956	2,614	2,614	12,128,960	17	7	5,128,960
18						8,407						13,047	4,640	3,956	2,614	2,614	12,128,960	17	7	5,128,960
19						8,407						26,094	17,687	17,003	2,614	2,614	46,233,818	17	7	39,233,818
20						9,170						13,047	3,877	3,193	2,614	2,614	10,134,478	17	7	3,134,478
21						8,407						13,047	4,640	3,956	2,614	2,614	12,128,960	17	7	5,128,960
22						8,407						13,047	4,640	3,956	2,614	2,614	12,128,960	17	7	5,128,960
23						8,407						13,047	4,640	3,956	2,614	2,614	12,128,960	17	7	5,128,960
24						8,407						26,094	17,687	17,003	2,614	2,614	46,233,818	17	7	39,233,818
25						9,170						13,047	3,877	3,193	2,614	2,614	10,134,478	17	7	3,134,478
											INT RR =		0.41256529					IRR =		0.2760826807485
											NPV =		21,197.1458					NPY =		19,564,849.304529

APPENDIX 8
SUMMARY OF RURAL POND DATA FOR PPN REGIONS OF ACTIVITY 1983 THROUGH 1987

Item	Year				
	1983	1984	1985	1986	1987
(1) Total number of rural fishponds inventoried ...	945	1,568	1,229	1,795	2,365
(2) Total area (ares)	352	4,381	4,916	6,235	8,425
(3) Number of ponds active in project.....	0	849	809	1,150	1,582
(4) Number of ponds renovated	0	136	235	364	327
(5) Number of ponds constructed.....	0	42	87	186	346
(6) Number of ponds harvested	0	165	242	415	458
(7) Average production (kg/ are/yr)	–	3.4	6.6	12.6	14.5
(8) Production of food fish (kg).....	–	1,010	5,058	10,939	21,680
(9) Number of ponds stocked	0	378	398	657	790
(10) Number of fingerlings stocked	0	89,051	89,317	158,828	273,272
(11) Number of private fishponds.....	–	584	301	442	686
(12) Number of fish farmers farming collectively managed ponds	–	–	3,764	4,979	8,356