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SUSTAINABLE AQUACULTURE FOR A SECURE FUTURE

Aquaculture Extension in Rwanda

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Abstract

This report discusses the first phase of the National Fish Culture Project in Rwanda that extended from 1983 through 1988. The project focused solely on fish culture and endeavored to improve fish production in existing ponds through a dynamic extension service. Physical, social, and economic constraints to fish culture in Rwanda are presented in addition to background on the project's extension strategy and a description of the extension agent training. Fifty-five extension agents were trained and upon completion of the project, approximately 3,000 ponds had been covered through the project's extension efforts. Through the four-year duration of the project, average pond productivity increased 3.4 to 14.5 kg are^{-1} yr^{-1}. A 41% internal rate of return was calculated for fish culture as a farm enterprise. The increased cost to maintain the extension program in comparison with the increase in fish production resulted in a 27% internal rate of return to the government of Rwanda. Finally, recommendations for future fish culture projects are discussed in addition to a five-phase aquaculture development plan.

Introduction

Background of the Rwanda National Fish Culture Project

The Rwanda National Fish Culture Project began in 1983. This project was bilaterally funded by the United States Agency for International Develop–ment (USAID) and the government of Rwanda. It continued through 1988 and then received reduced funding for a second phase that was part of a Natural Resources Management Project. Several previous fish culture projects had been operating in Rwanda, including two that were funded by the Food and Agriculture Organization of the United Nations (FAO) and one that was funded by the government of Canada, but none of these projects demonstrated success. Fish culture was one of several activities that these projects were involved with and there was little or no focus on extension. The Rwanda National Fish Culture Project, in contrast, focused solely on fish culture and sought to improve fish production in existing ponds through a dynamic extension service. Hishamunda and Moehl (1989) provide a very good description of this project and its activities.

This project was designed as a "classical" fish culture extension project. Ponds were renovated and put back into production and extension agents were trained in small-scale fish culture practices.

Rwanda is a high elevation, equatorial country that ranges from approximately 900 to 4700 meters above sea level. Most of the country is at elevations between 1300 and 2000 meters. The terrain consists of hills and valleys; the valleys are called *marais.* Water seeps out of the hills and a main drain runs through the valleys. Ponds are usually sited at the margin between valley and hill and water is channeled from the main drain to fill the ponds.

Constraints to Fish Culture

At first glance, the constraints to fish culture in Rwanda seem to be overwhelming (Table 1). Con-straints fell into the realms of physical and social and economic.

Physical Constraints to Fish Culture

Cool temperatures, acid soils, and soft water pose challenges to fish culture in Rwanda. The minimum air temperature ranges from 6 to 15°C and

Table 1. Physical, social, and economic constraints to fish culture development in Rwanda.

Constraints to Fish Culture Development
• Cool climate, acid soils
• Lack of inputs
• Lack of land tenure
• Multiple owners
• Fish not traditional food
• Poor cash flow

the maximum ranges from 28 to 30°C. Pond water temperatures are usually in the low twenties; soil pH is usually 4 to 5; and surface waters have total alkalinities of 10-20 mg l^{-1} as $CaCO_3$.

Social and Economic Constraints

1. High population density. Rwanda is the most densely populated country in Africa. The average farm size is less than 1 hectare per family which results in a paucity of available inputs.

2. Private ownership is not allowed in the *marais* and construction is prohibited. Farmers' homes are therefore at a distance from their fish ponds. Additionally, the absence of land tenure discourages farmers from investing in land improvements. The Rwandan government does allocate land to farmers; however, because of the nation's high population density, land is apt to be allocated to groups of farmers. The goal of this allocation strategy is to satisfy many people with a small amount of land. While the groups are not exactly forced upon the farmers, the land allocation strategy pressures farmers to form groups.

3. Fish was not a traditional food in Rwanda. People needed to be taught to clean and prepare fish. Also, taboos still existed regarding the consumption of fish. For example, children were often punished if they consumed fish because the parents thought it would cause the cows to stop giving milk.

4. Poor cash flow in the rural areas hindered both purchase of inputs and sales of fish. Typically fish sales were limited to a few days per month when government employees and teachers were paid.

Many of these same constraints actually favored fish culture over other forms of agriculture. The physical constraints affecting fish culture also impeded the production of other agricultural crops, so few modes of production outperformed fish culture. The scarcity of inputs was easier to overcome in fish culture than in animal husbandry because pond culture, even with minimal amounts of feeds and fertilizers, produces quite efficiently. Additionally, a wide variety of inputs can be used in fish culture. The pond itself is also able to generate by-products that can be used for other agricultural practices (e.g., left-over compost makes a good soil amendment). Although the *marais* land was far from farmers' homes and thievery of crops and fish was quite possible, farmers stated that fish were more difficult for people to steal than something like cabbages. To prevent thievery, farmers harvested their crops prematurely, which resulted in even lower yields of subsistence crops grown in the *marai*s. Because of limited cash in rural areas, farmers viewed fish farming as a way to generate much-needed income.

Extension Activities

Background on Extension Strategy

Because of the time constraints imposed by the project agreement (four years to obtain results), it was not practical to first research a technical package and then extend it. Moreover, the information base for small-scale tilapia production is fairly well-developed. The main consideration for tilapia culture involved determining refinements to pond management that would address the high elevation and relatively cool environment. The first group of extension agents trained helped to develop the extension package.

The government of Rwanda employed more than 50 agents for fish culture and fisheries extension. Of the more than 50 extension agents, many were illiterate and / or inadequately trained in fish culture. To select participants for the new fish culture extension agent training program, extension agents employed by the Rwandan government and working in the zones to be covered by the first phase were given an entrance test. Those who failed the test lost their posting. New agents were selected to replace them. Most of the newly selected individuals were recent graduates of vocational agriculture schools and their formal education tended to extend three years beyond primary school. To address the high cost of transportation and the rural population's minimal experience with formal education, an unwritten policy of the government of Rwanda required large numbers of extension personnel. The number of university graduates was not sufficient to

Table 2. The National Fish Culture Project management package extended to farmers to integrate with farm activities.

Management Package
• Water regulation
• Composting
• Feed as available
• Low stocking rates
• Complete harvest by 9 months
• Culture species: *Oreochromis niloticus*

provide extension to the desired population, now could the government afford to pay the salaries of hundreds of university-trained personnel. Plus, within the Rwandan context, employing such a large number of university graduates for fish culture extension could cause a misallocation of scarce human resources. Also, university-trained personnel expected government "perks", such as vehicles, that could not be supplied.

Extension Agent Training

Training was intensive and practical (Table 2). We conducted three-month trainings of groups of 12 to 20 individuals, including school teachers, and people from all levels. The trainings were mostly conducted in the field; classroom work constituted only one-quarter, or 100 hours, of the training period. Extension agents practiced pond site selection and stake-out, construction, and renovation. They helped renovate fingerling production centers and gained experience with many of the appropriate materials used in pond construction. They transported fish by truck, by bicycle, and on foot. They practiced extension methods with farmers, who then evaluated them. Trainees had their own pond to manage; they cleaned, cooked, preserved, and ate their own fish. Additionally, they went on field trips to visit extension agents from previous training sessions who had been working for several months. The field trips were especially useful because they instilled pride in the experienced extension agents. The training design was intended to provide a place for extension agents to develop camaraderie and a sense of pride in their work. The training was conducted by experienced, enthusiastic and energetic trainers who tried to promote a service attitude in the trainees (e.g., helping farmers instead of enforcing "laws" or "rules"). The selection of trainers was very important; they were integral to the success of the training program. One might think that training field technicians does not require a great effort and that anyone can do it. On the contrary, the best trainers available should be used to train extension agents.

Review courses, conducted annually, were very important for improving and refining the management package. An evaluation form for rural ponds—an extremely valuable training tool—was developed to help extension agents and farmers review pond management.

Extension Strategy

While ponds were drained for renovations and restocking, the extension agents conducted a census of all the ponds in their areas and gathered data on yields. They helped farmers get their ponds back into production and taught effective pond management with the existing, locally available inputs. The main goal of the project was to "get the fish on the table." To attain this goal, the first group of agents was sent out with a fairly simple management package to extend (Table 3). Improvements were made to the management package as the extension advisors received feedback from the field. The fish culture management package integrated with normal farm activities, which most farmers recognized (Molnar et al., 1994). Water flow control was stressed to alleviate some of the problems associated with cool, soft water and to conserve nutrients released from the pond inputs. The project distributed the species that were already being cultured in the ponds, *Tilapia rendalli* and *O. macrochir*. Later in the project, after some fish culture trials were completed to compare culture species, Nile tilapia (*O. niloticus*) was offered to fish farmers. Nile tilapia grew better than *O. macrochir* in farm trial and station trials with simple inputs such as grasses and small amounts of manure (Moehl, 1989). Nile tilapia's superior growth was probably

Table 3. Characteristics of the National Fish Culture Project extension agent training.

Extension Agent Training
• Groups of 12 to 20
• Intensive (3 months)
• Fieldwork constituted 75% of training
• Manage own ponds
• Instill service attitude
• Enthusiastic trainers

Table 4. The National Fish Culture Project extension strategy.

Extension Strategy
• Weekly visits
• 30 to 50 ponds per agent
• 8 to 10 agents per zone
• 6 regional stations
• Fish ponds as income sources

due to its more omnivorous feeding habits. Prior to 1984, the Rwandan government was supplying fingerlings free of charge; however, this policy changed at the time Nile tilapia fingerlings were made available. Because Nile tilapia fingerlings were in short supply, there was no active promotion to persuade farmers to buy them. Nonetheless, farmers assumed that because Nile tilapia fingerlings cost money, they were better. Consequently, farmers were eager to purchase the newly available culture species.

The extension agents made weekly visits to groups of farmers (similar to the field days presented by Campbell, 1995) (Table 4). Frequent visits were necessary during pond renovation and the first few production cycles; however, as farmers developed enough skills to manage their own ponds, extension visits became less frequent, thereby allowing extension agents to expand their efforts to new groups of farmers. As farmers gained more experience, extension visits to their valleys would shift first to a bi-weekly and then, ultimately, a monthly visit schedule, allowing the extension agents to include other valleys in the program. Extensionists made a special effort to include women in their activities, so that women weren't inadvertently excluded from fish

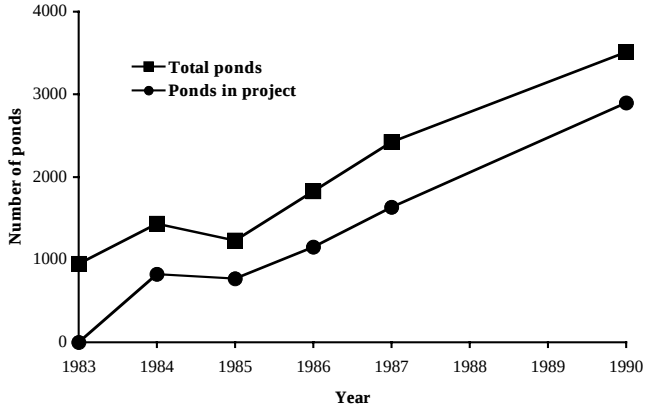

Figure 1. Ponds visited by National Fish Culture Project extension agents, 1983-1990.

culture. One reason that fish culture may have taken off so well despite the constraints mentioned earlier, was that the extension agents were reliable in making their scheduled visits and did work alongside the farmers at the ponds. More than half of the fish farmers surveyed reported that the *only* visits they received from government-sponsored extensionists were from the National Fish Culture Project extension agents (Molnar et al., 1994). Farmers have been witnessed fleeing from the *marais* when the *agronome* (agricultural extension agent) was said to be in the area.

Results

A total of 55 extension agents passed training. They worked required to work with the majority of the ponds in their zone; however, they were not required to increase the total number of ponds. The increase in the total number of ponds in the project reflects the increase in area covered by extension agents (Figure 1). Overall, the project worked with approximately 3,000 ponds and was able to cover approximately two-thirds of the country. In Rwanda, over 15,000 people were visited by tilapia culture extension agents. Due to the collective management of ponds, the total number of people involved in fish farming was 10 to 20 thousand (the higher number when members of schools and prisons were counted). Approximately 24% of the fish farmers were women (Veverica, 1988).

Average pond yields steadily increased without a notable increase in inputs. Over the first four years of the project, average pond productivity went from 3.4 to 14.5 kg are^{-1} yr^{-1}; after the fourth year the rate of increase slowed down (Figure 2). Figures from 1990 indicate that pond productivity averaged 16 kg are^{-1} yr^{-1}. This level of productivity is consistent with expected yields of well-managed ponds receiving very low quality inputs (e.g., grasses supplemented with very small amounts of manure). Farmers using brewer's waste from sorghum beer achieved yields over 25 kg are^{-1} yr^{-1}. Farmers rather than government stations held the record net yield (65 kg are^{-1} yr^{-1}), which was achieved with inputs of tender green leaves, goat manure, and brewer's wastes. Farmer knowledge of fish culture practices was evidenced by their understanding of the relationship between inputs and yields (Molnar et al., 1994).

As farmers gained confidence in their ability to obtain fingerlings for restocking, either from their own

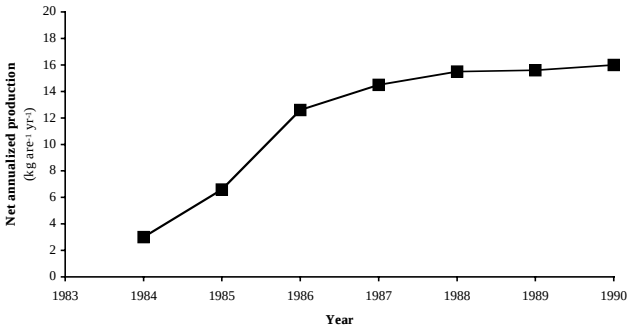

Figure 2. Average fish yields from ponds visited by National Fish Culture Project extension agents, 1983-1990.

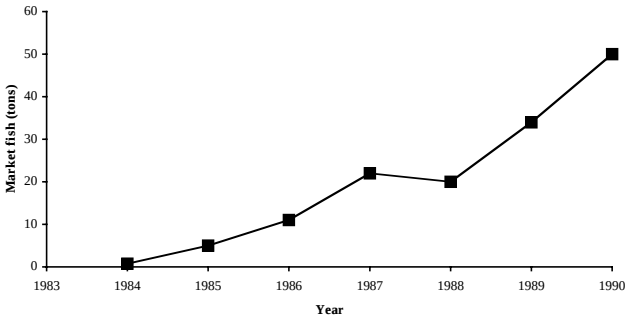

Figure 3. Market-size fish harvested from ponds visited by National Fish Culture Project extension agents, 1983-1990.

ponds or from other farmers nearby, they began to follow the advice of the extension agents and drain their ponds at shorter intervals. Indeed, the best net annualized yields were obtained from ponds in which the culture cycle was reduced to approximately seven months. Shortened culture cycles may be the primary reason for the increase in net annualized yields (Hishamunda et al., 1996). About 90% of all fingerlings used to restock ponds were produced by the farmers themselves. (Mpawenimana and Karamaga, 1997). The government stations continued to supply farmers with fingerlings, especially in areas where fish farming was just starting.

Increases in average production leveled off approximately six years after initiation of the National Fish Culture Project. This may have been due to the limited inputs available to farmers. Additionally, extension agents had not been trained in the intricacies of more intensive fish culture, so farmers lacked the information necessary to intensify their fish culture systems.

As farmers became more independent of the extension agents, it was difficult to keep track of the production of food fish and fingerlings. If we take the average net annual yield, a conservative number, is multiplied by the total surface area of ponds, and then 80% of this number is taken as marketable fish and the remaining 20% as fingerlings, then estimated production exceeded 130 t per year. Extension agents, however, only observed a harvest of approximately 50 t, so this is what appeared in their reports (Figure 3).

Other Developments and Discussion

The results of the extension project were encouraging. Hishamunda and Moehl (1989) calculated a 41% internal rate of return for fish culture as a farm enterprise. The increased cost to the government of Rwanda to maintain the extension program compared with the increase in fish production resulted in a 27% internal rate of return.

A farmer training program was financed in a second phase of the National Fish Culture Project. Farmers who had produced several crops of fish were targeted for this training, as opposed to new farmers. More than 100 farmers attended the training sessions, which were conducted by university-trained Rwandese nationals.

The demand for fresh fish increased greatly, exceeding supply in most areas. Farmer concerns about insufficient available inputs to increase yields indicated a sound understanding of basic pond management. In terms of fish production, total harvest had increased but reported net yields had leveled off. Some of the government stations were privatized, as the extension service had recommended several years before.

Project Recommendations

With the benefit of hindsight we were able to identify aspects of the project that we think should have been done differently. At the end of the technical assistance contract, the two technical assistants from the US left the project, which left only two university-trained Rwandese nationals to supervise 55 extension agents and conduct farmer training sessions. Some mid-level supervisors could have assisted with the work, but these individuals were relics from the dysfunctional agricultural extension service and were notably disinterested in extension. Future projects should ensure that staff levels can be maintained before technical assistants are removed from the project.

In addition to the lack of personnel, another factor that led to decreased supervision of extension agents was the high rate of turnover of directorate staff. At the beginning of the project, someone from the project directorate visited extension agents in the field at least once per year. As the staff of the directorate turned over, field visits to extension agents virtually ceased. Beginning in 1991, new directors of the fish culture project were named almost yearly and their vested interest in the fish culture extension service was negligible. The fish culture extension agents received less and less attention from their supervisors; they were no longer convinced they were different from the agriculture extension agents and began to behave the same way (e.g., levying fines on farmers and staying in the office). A directorate staff that has a vested interest in fish culture extension is important for effective supervision of extension agents, without which their motivation can wane.

Many donors began to intervene in fish culture and, consequently, contradictory management recommendations were promoted in some areas. For example, one extension manual recommended that farmers let water "trickle " continually into their ponds. Another recommended that farmers cut their pond levee slopes so that they would be vertical. Most projects did not mention fertilization as a technique to increase fish production. One project suggested that long, narrow ponds were inherently more productive than other geometrical shapes. The fish culture extension service could not track all the projects that involved fish culture extension, and hence it was difficult to coordinate and provide consistent information. There were, however, some nongovernmental organizations (NGOs) that sought advice from the fish culture extension service and did whatever they could to help the extension effort.

Although there were no formal links between research and extension services, the individuals involved in each had worked together previously and maintained informal relations and contacts. With the changes in the project directorship, these personal relationships were no longer intact and more formal links between research and extension became necessary. Formal links were especially important because of the need for research-based information on more intensive systems. Therefore, steering committees were set up for both research and extension. The steering committees were also to help coordinate efforts of the various projects and NGOs working with fish culture. The official sign-off to establish the steering committee was delayed with the outbreak of the war in Rwanda.

Although the project was not designed this way, the first five years involved the most intervention. During this period, ponds were renovated or constructed and farmers learned the basics of pond management. Intense, field-level, one-on-one contacts were necessary to achieve this; however, as farmers increased their knowledge and were able to obtain information on their own, extension agents with a few years of secondary school education tended not to be well-enough educated to serve the farmers. Instead, fewer, more highly trained individuals were needed. Some experts have gone so far as to propose buying out the extension agents and giving them a one-time "retirement stipend", whey they could use to start their own farm if they were so inclined. Some people thought these agents would make good commercial fingerling producers. Theoretically, good extension agents work themselves out of a job; however, it would be socially unacceptable to lay them off. In Rwanda, transferring extension agents to other zones was not seriously considered because of social constraints that make it difficult for outsiders (defined as people from another commune) to be trusted.

Five-Phase Aquaculture Development Plan

Moehl (1993) proposed a five-phase aquaculture development plan; the first four phases should be implemented with the support of a donor agency. The first phase involves a pilot-scale project, which identifies production technologies, trains personnel, and begins fish seed production. During this phase or the second phase (regional or "local" implementation), major limitations and false assumptions should be identified. National implementation should be initiated in the third phase; phase four involves project refinements and preparation for national takeover of the entire project. Inclusion of the project into the nation program constitutes the final phase of the project.

Moehl (1993) contends that the lack of a national strategy for fish culture development in Rwanda would lead to the eventual abandonment of the extension program financed by USAID despite the achievement of all the project goals. Based on this contention, he recommends that development agencies refrain from funding programs if no nation-

al strategy for continued project implementation is in place. It is important to note, however, that bureaucrats may not realize the potential of a project at the pilot scale until they see the project goals achieved at a regional or national scale. Therefore, they may not provide adequate resources to fish culture development if they were required to formulate a national strategy too early in the process. As an alternative, approval of donor-financing for national implementation should be contingent on the formulation of a national strategy prior to completion of the second phase of development, "regional implementation" (as proposed by Moehl, 1993). The necessity for a national strategy formulated by nationals is undeniable.

Project progression from pilot-scale to local to national level is indeed logical; political pressures to implement projects at the national level should not be bowed to. It is unfortunate that political pressures often come from the donor agency itself. Additionally, extension that provides intensive, weekly instruction to farmers followed by less intensive, monthly visits and finally farmer-led learning is a cogent sequence and should be considered during the formation of a national strategy.

Summary

Despite the seemingly overwhelming constraints to aquaculture at the onset, the National Fish Culture Project introduced effective pond management techniques that integrated with farm activities and increased average pond productivity from 3.4 to 14.5 kg are^{-1} yr^{-1}. The following highlights the factors that contributed to the project's success:

- The goal of the project was attainable—the project's intention was to "get the fish on the table";
- The fish culture management package was integrated with farm activities;
- Appropriate pond management techniques were stressed, such as water flow control and the distribution of culture species that were familiar to farmers (*Oreochromis* spp.) and that grew well with simple inputs (e.g., grasses and small amounts of manure);
- The intensive and practical extension agent training focused predominantly on field rather than classroom experience. (Agents practiced pond site selection, stake-out, construction, and renovation in addition to managing their own ponds and cleaning, preparing, cooking, and eating their own fish.);
- The extension strategy included weekly visits to farmers during pond renovation and the initial production cycles, special efforts were made to include women in aquaculture, and extension agents worked alongside farmers at their ponds.

The economic outcome of the National Fish Culture Project was also encouraging—Hishamunda and Moehl (1989) calculated a 41% rate of return for fish culture as a farm enterprise. Additionally, the increased cost incurred to fund the project in comparison with the increase in fish production resulted in a 27% rate of return to the government of Rwanda.

Based on the process and outcome of the National Fish Culture Project in Rwanda the following recommendations can be offered regarding the initiation of future projects:

- Prior to initiation of a project, it is beneficial to ensure that host country staffing levels will be maintained after technical assistants are removed from the project;
- A directorate staff that has a vested interest in fish culture is essential for the effective supervising of extension agents;
- Collaboration between all organizations involved in fish culture extension is important so that the information disseminated to farmers is consistent;
- The maintenance of linkages between research and extension is vital for the further development of more intensive fish culture systems and the coordination of efforts between various organizations involved in aquaculture development.

Ideally projects should proceed from pilot to local to national scale; however, often donor agencies will apply political pressure to implement a project at the national level. These pressures should not be bowed to if at all possible. Once a project is ready to be implemented at the national scale intensive extension involving weekly visits with farmers followed by less intensive monthly visits, and finally farmer-led information exchange should be fostered.

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