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AQUACULTURE AS A FARMING SYSTEM: POTENTIALS AND LIMITATIONS OF THE FSR APPROACH

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Aquaculture is the husbandary of fish or other water-based species in a controlled environment (Shell, 1983; Lovell, 1979). Aquaculture or fish farming can be contrasted with marine or capture fisheries which exploit naturally occurring populations in an unmanaged environment. Aquaculture may be practiced in ponds, cages, or enclosed sections of rivers or lakes, in fresh, brackish, or salty water (Brown, 1977).

Farming systems research (FSR) is a prescriptive model of combining research and extension activities toward agricultural development (Shaner et al., 1982; Andrews and Hildebrand, 1982; Norman et al., 1983). The approach is characterized by an emphasis on interdisciplinary activity among biological and social scientists, giving particular attention to indigenous managerial know-how. The primary aim of FSR is to increase the overall productivity of the farming system and to increase the welfare of the individual farm family in the context of both private and societal goals and within the constraints of the existing farming system.

The purpose of this paper is to explore the relevance of the farming systems concept for aquacultural development. We review the origins and fundamental precepts of the farming systems approach. One objective, therefore, will be to attempt to apply the FSR model to the practice of aquacultural development. Aquacultural technology is examined in terms of indigenous knowledge systems and the unique institutional and infrastructural requirements of fish farming, although many times aquaculture is introduced de novo and indigenous knowledge systems do not exist. Aquaculture, like irrigation systems (Coward, 1983) and some pastoral enterprises, sometimes is premised on group and community organizational mechanisms that have not been reconciled with the FSR concept. Finally, we consider the major stages in the FSR process, identifying the special needs and characteristics of fish farming to be considered in undertaking a FSR approach to aquacultural development.

AQUACULTURE AS A SOURCE OF FOOD

Aquaculture has been a traditional source of food in some parts of the world, particularly China, Southeast Asia, Japan, and a number of places in the Pacific. Aquaculture, as a farming activity, may be distinguished from capture fisheries in which fish are taken from naturally occurring populations in streams, rivers, lakes, coastal waters, or the open ocean.

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The world catch of fish was approximately 4 million metric tons in 1900. With increased effort and improved technology, the total world capture harvest of aquatic plants and animals (excluding whales) from the oceans and freshwaters increased to 10 million tons in 1930; to 20 million tons in 1950, and to 70 million tons in 1970. Since 1970, the total world fish harvest has fluctuated around 70 million tons annually, ten percent of which is produced from aquaculture.

Fishery scientists generally agree that further increase in the world fish catch is doubtful given present technology, high energy costs, and the replacement characteristics of the fishery resource (Jackson, 1981). Furthermore, it does not seem practical to increase the catch from natural waters without seriously damaging the capacity of wild stocks to maintain themselves. As the world population and the demand for fish increases, aquaculture has the potential to be an increasingly important source of supply (Shell, 1975).

Fish is the only major animal food whose availability continues to be determined by capture of wild stocks. Following the history of domestication and application of production technology to other species, fish culture seems to be an inevitable next step in the progression of animal agriculture. Aquaculture is rapidly evolving toward the level of domestication and understanding already reached with more traditional forms of animal husbandry.

The Production Process

Many kinds of fish and seafood can be produced through aquaculture including lobster, shrimp, trout, salmon, crawfish, flounder, and catfish. In developing countries, tilapia, carp, and milk fish are among the most appropriate and most frequently cultured species. The aquacultural production system has several parallels to the pastoral husbandry of livestock in a confined area, although there are a number of unique characteristics as well.

Aquaculture requires suitable species, nutrients, good water quality, and control of predators and disease. The fish are contained in a tank, cage, or pond and nutrition is supplied directly as manufactured feed, or indirectly through fertilization of the water to induce growth of a planktonic "pasture," which is "grazed" by fish. When they reach an appropriate size the fish are removed and then consumed by the household, directly marketed, sold to a middleman, or sent to a processing plant. Fish are harvested by net, by draining the pond, trapping, or even by hook-and-line, depending on the level of production intensity (Smith and Peterson, 1982:3-4).

In some instances, fish are continuously harvested from a single pond to meet family or community food needs. In others, a series of ponds is employed to simultaneously produce seedstock (or fry) and grow other crops of fish to marketable size for regular harvest (Lovshin and Pretto, 1983). The production system then involves brood, nursery, and

grow-out ponds that assure a stock of fingerlings to regularly replace the harvest of market-size fish .

There are nearly as many variations in methods for fish farming as there are for growing other crops. Fish farms may be operated by an individual, family, cooperative, or large business. The environment may be artificial (a constructed pond, irrigation impoundment, or a concrete tank) or natural (existing ponds, bays, or protected waterways). Floating cages, raft systems, net enclosures, or other structures may be used to segregate and control fish populations (see Figure 1).

The intensity of the production system may vary widely. Basic low intensity systems add no fertilizer of feed to the pond, simply stocking fish and harvesting at an appropriate time. More intensive management adds animal waste or chemical fertilizer to enhance the growth of plankton for increased fish production. A highly intensive system may supplement or supplant naturally occurring nutrients with grain or other exogenous sources of nutrition. As intensity increases, the timing and care of management practices become increasingly critical; disease, oxygen, and other water quality requirements must be more closely monitored. High intensity systems generally mean higher costs and higher risks for the producer.

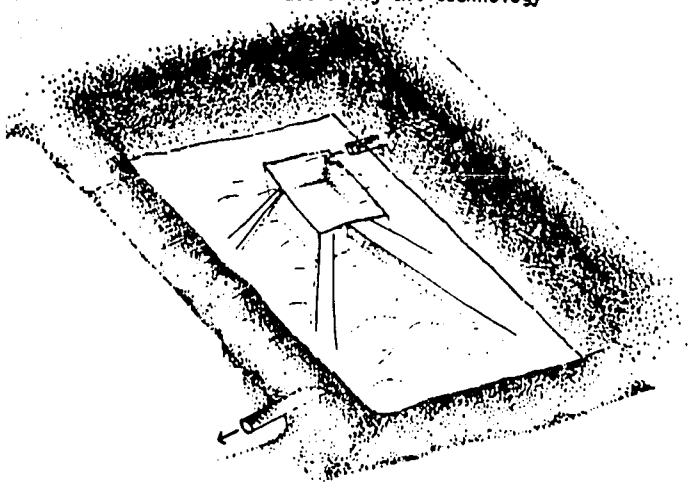
A significant amount of fish farming takes place in conjunction with other crops and animals (Pullin and Shehadeh, 1980). Integrated livestock-fish, fowl-fish, and rice-fish farming systems have been practiced for centuries in Asia (Delmendo, 1980). Aside from crop production, many Asian small farmers have a few head of livestock (cattle, buffalo, or pigs) and small flocks of ducks or chickens. Where there is adequate water supply, a small fishpond is maintained.

As a system where practically nothing is wasted, integrated aquaculture maintains an ecological balance and generates a variety of food products which often provides some cash income (McDowell and Hildebrand, 1980). The fish eat naturally occurring plants or algae combined with kitchen leftovers. Animal manure serves as a fertilizer for the crops, vegetables, and fishponds (Delmendo, 1980:59). The manure fosters the growth of algae which are in turn consumed by the fish (see Figure 2).

Aquaculture as Development

Although the primary motivation for aquacultural development often is to improve the food supply and increase income, the introduction of aquaculture may not have the pervasive effect in a community or region that may accompany the introduction of new agricultural crops. Fish farming supplements, but does not replace traditional food sources, and a smaller part of the population is involved in production. Aquaculture does have the potential to provide more calories and to enhance the availability of protein for some undernourished segments of the population (Smith and Peterson, 1982:2-3; Grivetti, 1982). In selected

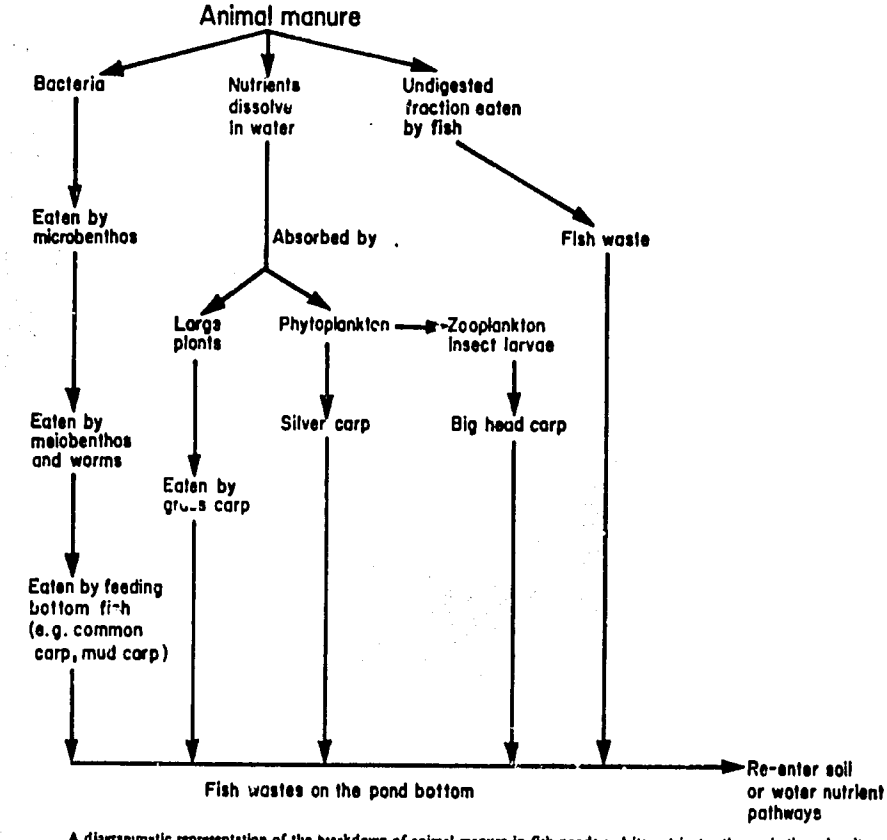
Figure 1. Pond facilities illustrating the technology



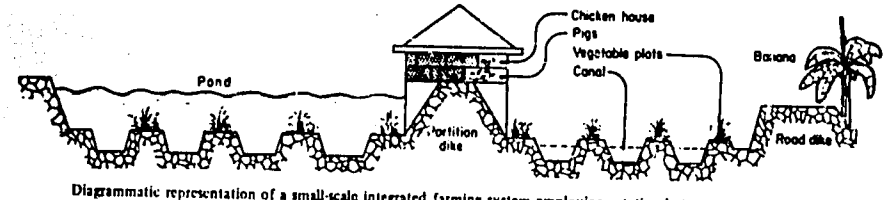
Field preparation for rice-fish culture in Japan showing the inlet, outlet, sump and connecting channels.

Screening devices for inlets and outlets from one field used for rice-fish culture.

Figure 2. Process and arrangements for integrated aquaculture production (Pullin and Shehadeh, 1980:63, 150)



A diagrammatic representation of the breakdown of animal manure in fish ponds and its nutrient pathways in the polyculture of Chinese and common carps.



Diagrammatic representation of a small-scale integrated farming system employing rotation between two level plots of land, as practiced in the central plain of Thailand.

locales that possess underutilized human and water resources, land unsuited for other uses, and an undernourished population, fish farming can make a distinct contribution to human well-being.

In addition to the primary products of food and income, a number of secondary benefits accrue to the practice of aquaculture. First, small-scale production already is practiced at low intensity in many places, and can be readily introduced in others. Second, aquaculture often is not competitive with other food systems for high quality land as it often makes use of an idle or underutilized lowlands or hillsides. Third, soil loss is not usually associated with fish production and a number of land-saving and environmental benefits also accrue to aquaculture. Fourth, a pond water resource is created for uses other than aquaculture, e.g. certain household needs, garden irrigation, stock watering, etc. Finally, there are compelling reasons for many developing nations to produce fish in view of their naturally endowed resources and a growing or undernourished population (Brady, 1983).

FARMING SYSTEMS RESEARCH

Farming systems research considers the farmers and their problems in a comprehensive manner using an interdisciplinary approach that complements existing research and development activities and is interactive, dynamic, and responsive to society (Shaner et al., 1982:18). FSR relies on indigenous knowledge systems as a base for evolving better technologies. The primary aim of the FSR process is to increase the system's productivity in the context of the entire range of private and societal goals, given the constraints and potentials of the production systems that farming families currently practice (Norman et al., 1983:23).

Origins of FSR

Farming systems research is in part a reaction to the inadequacies of earlier perspectives on the lag between agricultural knowledge and farm practice (Monu, 1983). The diffusion of innovations research model and the progressive farmer strategy emphasized the trickle-down of technology through interpersonal networks and emulation of visible success (Rogers, 1983). Pollnac (1982) applies the adoption-diffusion model to aquaculture development but the emphasis has shifted from the social and demographic characteristics of potential adopters to spatial and institutional factors which facilitate the implementation of technology (Brown, 1981).

Monu (1983) argues that the adoption-diffusion approach takes the point of view of the originator of an innovation who bases the improvement on a presumed receiver's needs. The assumption is that the developer of the innovation can produce technology that closely fits the intended situation and responds adequately to the presumed needs of the

implementors. Many times the technology is assumed to fit across a variety of cultural and agronomic circumstances and would be used if it were simply made available. The receiver is treated as a passive partner in the transaction.

The FSR approach, in contrast, treats the farmer as an active participant in the process. The objective is to design and develop solutions that emerge from existing practice and respond to the family and socio-cultural imperatives of the situation. FSR explicitly recognizes the value of the farmer's knowledge, based on experience and annual experimentation in improving productivity (Behnke and Kerven, 1983). Building on the constraints of the physical system, the goals of the farmers themselves, and the successful parts of the method they already use, a broader base for continued improvement and technology transfer through interaction with researchers and extensionists is established. Farmer involvement also means that the system itself (and not simulations, trial plots or laboratory models) is the site of experimentation. Realistic results then can be obtained by perturbing the actual situation via farmer managed trials (Norman et al., 1983:22).

Farming systems research also is in part a reaction to the growing recognition among developing nations that a Western social structure and a Western cultural outlook accompany Western technology. Galtung (1979) points out that while technology can liberate some from degrading work and increase productivity, it also can introduce a form of alienation or sense of separation from the community among those who shift to the outsider's practices.

His solution emphasizes the development of technology that relies primarily on indigenous skills and capabilities to maximize the opportunities to meet both material needs and culture- consistent non-material needs. More recently, Dahlman and Westphal(1981) use the term technological mastery to describe the long-term goal of development assistance -- an autonomous ability to identify, select, and generate technology. In the meantime, FSR provides a mechanism to interactively identify technology that fits material requirements and is sensitive to cultural needs.

As farming systems research attempts to generate improvements in existing production methods,it pays particular attention to the need for a full understanding of why and how a crop or animal is part of the existing farming system. Although soil, rainfall, and temperature are fundamental environmental parameters circumscribing what is possible in a given locale, FSR considers perceptions of risk or variability in these parameters as it affects farm decisions. Concentric sets of constraints emanate from individual ability and attitude, labor availability in the family, the roles and responsibilities of family members (particularly women), the social patterns of village life, and the norms that define acceptable behavior and orientations to change (Baker et al., 1983).

FSR and the Experiment Station

Norman and his colleagues (1983:15) argue that the perspective that emerges from the conduct of farming systems research is useful in highlighting critical issues in agricultural development and in designing more appropriate development strategies and support systems. Recognizing the pivotal role farm households play in determining actual farming systems, the involvement of farmers and their households in the process of agricultural research increases the efficiency of the effort by ensuring that the relevant technology is generated and adopted by the intended users. Thus FSR attempts to overcome the traditional experiment station view of the farmer as a passive recipient of research results.

Experiment Station research tends to focus on fundamental chemical, biological, or agronomic mechanisms, knowledge of which is extended in the form of farm-level recommended practices. Experiment Station research often considers only one or two factors while controlling all the others. In contrast, FSR implies a more holistic orientation that recognizes the interdependence and interrelationships of the technical and human elements within the farming system (Norman et al., 1983:22). The FSR approach diversifies the methodologies of agricultural scientists by alerting researchers to the fact that knowledge on how new technologies articulate with the farming system as a whole must be added to experimentally-derived knowledge generated at the experiment station (Flinn and Buttel, 1983).

Although farming systems approaches have not been without criticism (Garrett, 1983), they do facilitate the diversification of agricultural knowledge and the ability of peasants to utilize new technologies with minimal disruption to traditional farming practices. Farming systems research, however, requires large numbers of multidisciplinary research teams. Therefore it is labor intensive and expensive, especially for countries with shortages of trained scientists. Moreover, farming systems research results tend not to be a substitute for experiment station research on more fundamental aspects of plant and animal production.

FSR has the potential for great complexity because of its system focus and holistic character. Norman and his colleagues (1983:23) make a useful distinction between variables and parameters as means for understanding the nature of different types of farming system research projects. The environment of a farm enterprise consists of technical and human elements that exist in a manifold variety of combinations. Instead of assuming that all factors can be potential variables subject to manipulation, some are treated as parameters (or given conditions) not subject to manipulation. For any given FSR program, the mixture of variables to parameters is determined by the institutional setting, linkages to extension, and the level of available support (in terms of time, skill, manpower, and financial resources). A limited mandate with few resources implies a focused FSR program, where a broad mandate with a high degree of political support and other resources may support an open-ended FSR program with more variables and fewer parameters.

AQUACULTURE AS A FARMING SYSTEM

This section of the paper employs the Norman et al. (1983) model of FSR stages to identify major sets of variables that might be encountered in fish farming systems research. The four stages are: diagnosing the present system, designing improved systems, testing improved systems, and extending the improvements (see Figure 3). Others, particularly Shaner et al., (1982:28), have identified similar sets of activities, but the Norman et al. model seems to provide a concise summary appropriate to an initial survey of the approach for application to a specific enterprise, i.e., aquaculture.

Diagnosing the Present System

The objective of this stage is to understand the farming systems that are practiced in the target areas. This enables the FSR team to determine the constraints and flexibility in the current farming systems, including timing, skills, slack resources, etc. (Norman et al., 1983:24). Fish farming systems research projects often differ from other enterprise-focused efforts in several fundamental ways.

Aquaculture as a New Enterprise

Although a long-standing practice in China and some parts of Southeast Asia, in other locales aquaculture may be introduced as an entirely new enterprise where indigenous knowledge systems do not exist. When on-farm water systems have been used primarily for stock watering, irrigation, and perhaps casual harvest of naturally occurring fish populations, intentional culturing of fish is often a novel concept. Thus the on-farm research program must begin with fundamental instruction in the concept of fish-as-a-crop, management of the aquatic environment in terms of food, oxygen and water quality requirements, and the nature of aquatic reproductive processes.

Once facilities have been defined or constructed and the basic concept has been grasped, initial operation of the fish farming system can begin. Knowledge of operating parameters, responses to typical problems, and other practical considerations are acquired through low-intensity operation of the system. The technology often is directly transferred or injected into an existing system with an underutilized water resource. Thus the first stage of the prototypical FSR approach is much different in aquaculture, except in those areas where fish culture has been practiced for many years.

Fish FSR may be more dependent on certain environmental or institutional constraints than other enterprise-oriented productivity improvement programs. For example, seed stock in aquaculture is a perishable commodity not readily distributed to remote or distant locales. Fish fry require an aquatic environment and have certain oxygen and temperature tolerances. Once established, the activity is relatively

self-perpetuating, but nevertheless requires a quite different set of skills and precautions from other types of animal agriculture.

Fish reproductive process are somewhat different from traditional land-based animals. Some species require sex-segregation, intermingling with different types of species, and other complex management strategies that generally are not immediately understandable by the peasant farmer. Problems can often be avoided by selecting appropriate species for introduction. Tilapia is often chosen on the basis of its ease of reproduction. Nevertheless, a comprehensive package of concepts and technologies must be introduced and established prior to the advent of actual on-farm trials, experimentation, and productivity improvement.

Where aquaculture already exists, the prototypical FSR strategy may be implemented. Indigenous knowledge systems, however, may be inadequate for absorbing and implementing more intensive management approaches. Farmers may lack the conceptual framework to diagnose and manage the aquatic system. Thus previous arguments about an initial one-way transfer or burst of fundamental knowledge may still apply when intensification is the path of productivity improvement.

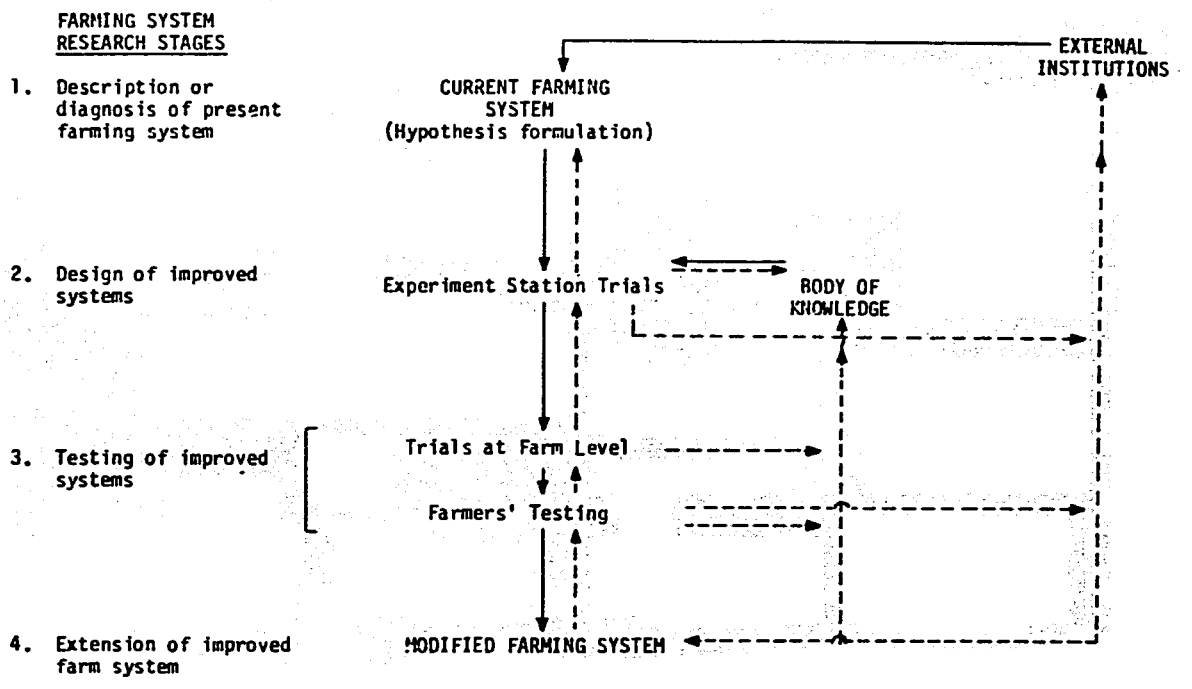
It should be noted, however, that the introduction of aquaculture technology, while generally representing a discrete (rather than an incremental) change in farming practice, can draw on previous experience with dry-land species. In many places, managing an animal population is a central element of traditional agriculture. Although controlling a fish population requires some unique skills, feeding and maintaining a group of animals is an activity in which traditional farmers often take great pride. Individuals often can derive a similar level of satisfaction from producing a large fish as any other domesticated animal. Aquaculture has many parallels to existing animal enterprise systems, but is done in a water-based environment.

Aquaculture as a Group Activity

Although an individual or family activity in most situations, fish farming often is conducted on a cooperative basis. A second series of concerns relate to the conduct of FSR efforts emanate from the group or collective management requirements of many aquaculture production systems (Moris, 1980). Like irrigation systems, the success of community or multi-family fishponds requires a supportive normative structure to keep effort and rewards in relative equilibrium. A set of informal rules and understandings is necessary to sustain the enterprise over time. Recognizing the complexities of this task, McGoodwin (1982), for one, argues that the household is the appropriate level for aquacultural production in rural societies lacking supra-household organizational structures. In other words, erecting a set of social arrangements to support the production system may be as formidable a process as transferring the technology.

Many FSR projects focus on an enterprise or combination of enterprises on a single farm or in a single farm family (Flora, 1983).

Figure 3. Schematic framework for farming systems research at the farm level: Downstream farming systems research (Norman and Gilbert, 1981:23)



When success of the farming system is predicated on cooperative management, technology transfer must be accompanied by an infusion of social organization to govern the operation of the enterprise if none existed before. Normative structures are not directly injectable into community or village life, but are emergent phenomena that develop in the context of experience and interaction over the substantive issues. Precedents may lie in collective pasture management, use of irrigation facilities, or other forms of collective activities. When no previous structures exist, establishing rules for cooperative management may be the greatest obstacle to technology transfer (Peterson, 1982).

One consequence of the lack of previous experience with fish farming as an enterprise and the group nature of some aquaculture projects is that there may be little basis for carrying out an initial description or diagnosis of the present fish farming system. Instead, the initial survey of households and operators may assess the previous experiences and future potential for collaboration in collective agricultural activities (Pollnac et al., 1982:136). The fit of aquaculture in terms of time devoted to other enterprises and the labor impacts on the family are important considerations.

A willingness to contribute labor, past successes in shared activities, confidence that distributive justice is usually achieved when families work together, all seem to represent positive preconditions for a successful fish FSR program. When a legacy of resentment, low interest, or failure in community collaboration exists, and the objective is to establish a cooperatively managed endeavor, the potential for aquaculture may be limited. Some communities may require an especially talented or charismatic fish FSR extension counterpart to overcome barriers and foster collaborative efforts. Where leadership is indigenous and positive community attitudes prevail, FSR may focus on the technical aspects of the farming system (Espinoza, 1982).

In many developing nations, village groups have been organized to operate fishponds, but often these projects have failed (Grover et al., 1930). Some community managed ponds have done well in Panama, according to Schwartz and Lovshin (1983). The ponds fit the needs of the residents and some minor conflicts with a neighboring settlement encouraged local cohesion which focused energy on the pond as a community activity (Hatch, 1983). In addition, sponsorship by a local politician and a particularly enthusiastic cadre of extensionists facilitated matters. Finally, the consultant's responsiveness to local technology allowed the farming system to integrate a cattle corral with the pond, evolving an opportunistic fit with the existing farming system.

Designing Improved Systems

This stage focuses on the interaction between experiment station trials and the indigenous experiences of the farmers. Improved technologies that seem to overcome or avoid the constraints identified

in the first stage are specified. The technical literature may contain ideas that meet the needs, or new solutions may have to be sought. In aquaculture, water supply is often an important limiting resource. When constraints are not binding, fine tuning to local conditions may be addressed; otherwise more comprehensive responses are required (Norman et al., 1983:27).

At this point, the existence of aquaculture research facilities in the country is an important precondition. When none exists or is only beginning to generate research, findings and experience from other countries using similar species in similar hydro-climatic conditions may be the only source of recommendations (Shell, 1980). In the U.S., Auburn University's International Center for Aquaculture has been a major focus for the development and diffusion of aquacultural technology. Similarly, the International Center for Living Aquatic Resource Management (ICLARM) has been a source of some adaptive research, although the overall impact of the various international centers (IRRI, CIMMYT, etc.) has been a subject of discussion (Griffin, 1974; Hayami and Ruttan, 1974).

Limited indigenous experience and competence in the enterprise may limit this stage of FSR. The nature of the combination of parameters and variable characterizing the new locale may offer constraints and opportunities not experienced in other situations. Thus a so-called "upstream" FSR program may be appropriate strategy, at least at the outset.

"Upstream" types of FSR programs have a developmental orientation and usually do not provide results for immediate adoption by farm families (Norman and Gilbert, 1981:22). When aquaculture is introduced into a new nation or region, there is an adaptive process of using proven technology from other regions and making the modifications most appropriate to the new location.

"Downstream" FSR programs have an adaptive orientation and aim at developing and introducing strategies that will improve the productivity of farming systems for target groups of families in the short run. Available information is selectively drawn upon in the process of designing practices or recommendations for a particular fish farming system on the basis of the constraints of that system. For example, the initial year of a project may focus on identifying an optimal grow-out and harvest cycle given local weather conditions, labor constraints, and periodic nutritional gaps in the local diet.

Testing Improved Systems

Trials are conducted at the farm level and some farmers do their own testing at this stage. Testing may differ according to the level of aquaculture intensity that seems appropriate to different sets of farmers or collectively managed ponds. More committed and adept operators may undertake more complex or sophisticated endeavors to explore comparative advantages or limitations.

In some developing country situations, farm-level trials are necessitated by the slow development of a public research infrastructure to supply the necessary scientific findings. Juliano (1972) describes the necessity of using privately owned ponds to conduct aquacultural research in the Philippines. Farm-level experiments were particularly significant for diffusing production methods to new project areas where research facilities made slow progress toward completion.

At this stage, Shaner et al. (1982:28) identify three commonly conducted types of biological experiments: research-managed trials, farmer managed tests, and superimposed trials. The first of these experiments is intended to develop new technologies under farmer's conditions where control of conditions is important.

By allowing farmers to introduce the new technologies themselves, the second approach reveals how farmers respond to suggested improvements. The resulting economic and sociocultural analyses directly incorporate farmer reactions.

The third approach involves relatively simple researcher-managed trials applied across a range of farmer-managed conditions. In all three cases, the FSR team cooperates with extension in establishing contacts with farmers and local groups, identifying research locales, and coordinating activities with the experiment station.

Extending the Improvements

Technologies found during the design and testing stages to overcome the constraints identified in the descriptive and diagnostic stages are widely extended to other farmers (Norman et al., 1983:28). This stage is generally premised on the availability of trained extension personnel to disseminate the results (Gernea and Tepping, 1977).

The FSR project can also promote the spread of better practices by testing in multiple locations, demonstrating in pilot production programs, and promoting the activity through other organizations (Shaner et al., 1982:29). The project initiates and drives the diffusion process as fish farming is a novel activity in and of itself. Collaboration between research and extension staff throughout the process contributes to the accumulation of experience with the technology. Close extension-research links also aid in the transfer of responsibility to a continuing extension program.

A number of factors may inhibit the spread of aquaculture technology. Training of extension agents may lag the construction of research facilities and the generation of results. Extension personnel may be recruited from among the more adept farmers or from those FSR staff members showing inclination and talent for these activities, but the numbers may not be sufficient to meet demand for the service.

Extending the research results to other locales may also require a heavy dose of community organization as well as intensive educational programs. The physical construction of ponds in other locales also may require additional government commitments. Thus the extension phase must coordinate trials, education, and staff training to support the spread of technology.

CONCLUSION

Aquaculture has a significant role to play in supplying protein and variety to the diet in many developing countries. In selected locales, aquaculture can employ available labor, underutilized water and land resources, and favorable climatic conditions to diversify the food supply, generate income, and improve well-being for many people. Aquaculture does, however, have definite resource constraints that preclude its diffusion into every farming environment.

The availability of water is clearly a necessary condition for aquaculture, and certain cultural and organizational considerations often are important. Consequently, the inclusion of aquaculture in the FSR approach will be meaningful only under specifiable circumstances. But when these constraints are met, the potential for FSR and aquaculture seems favorable.

The unique water-based nature of aquaculture is a major difference between fish farming and other enterprises that presently limits the application of the FSR approach. It is not that fish FSR has been tried and found wanting, but that FSR has not yet been explicity applied in a comprehensive fashion in an aquaculture project. It should be noted, however, that the FSR approach articulates many of the values and concerns governing aquacultural development as practiced by the International Center for Aquaculture in the Philippines and other locales where a neuristic approach couples knowledge of basic principles with efforts to integrate fish farming into traditional agriculture (Juliano, 1972; Grover et al., 1980).

Certain elements of FSR require differentiation and further elaboration to meet some of the singular needs of aquaculture systems. FSR is a useful tool or framework for conceptualizing the technology transfer process because it prescribes specific steps to ensure the fit of the enterprise in the existing sociocultural system as well as the ecological conditions of the locale. Thus it can and will make a significant contribution to aquacultural technology transfer efforts.

A second difference or avenue for further elaboration is the relation of aquaculture technology to existing practice. FSR relies on previous experience and accumulated folk wisdom about the conduct of an enterprise as a basis for generating productivity improvements. Many times aquaculture is introduced as a discrete package or set of practices with little or no basis in previous accomplishments of the local farmers. Although some analogies to animal agriculture support

introduction of fish production, farmers are required to come to terms with the quite different dynamics of an aquatic environment. In many situations, aquaculture is a prototypical "new technology" as opposed to an incremental change or adjustment in existing practice.

FSR approaches to aquaculture may have to compensate for the lack of an indigenous knowledge base. More attention to vague fears, suspicions, or misunderstandings of the process may be required. In some ways, the novelty of aquaculture may generate extra enthusiasm for the enterprise and FSR personnel may not be forced to overcome resistance stemming from traditional bonds to old practices, as none heretofore existed.

Once the basic concept is conveyed, FSR activities may proceed to generate location-specific technology in collaboration with local farmers. The initial charisma of a new endeavor may sustain interest, facilitate learning, and enhance the spread of knowledge. An excessive set of expectations based on unfamiliar and unrealistic assessments of the gains to be made also can be a liability.

Finally, the group dynamics of shared or collective production enterpises is often more of an issue in fish farming than other enterprises. When ponds are individually or family owned and operated the issue may be less significant although prevailing community attitudes may have an important influence on the successful introduction of a new enterprise. When cooperative arrangements prevail, however, questions of equity and sustained participation become salient.

Division of labor, ownership, decision-making, and distribution of product often rely on relatively complex social arrangements. Establishing the procedures, finding conflict resolution mechanisms, and most basically, ensuring intelligent management of the system are difficult tasks removed from the technical biology of pond operation. Yet these are the key factors supporting sustained implementation of the technology and continuing benefits to the families and communities involved.

FSR is making a distinct contribution to the effectiveness of food production technology transfer throughout the world. To realize the full benefits of FSR in aquacultural development, further efforts that recognize the special nature of the fish farming enterprise will be required.

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