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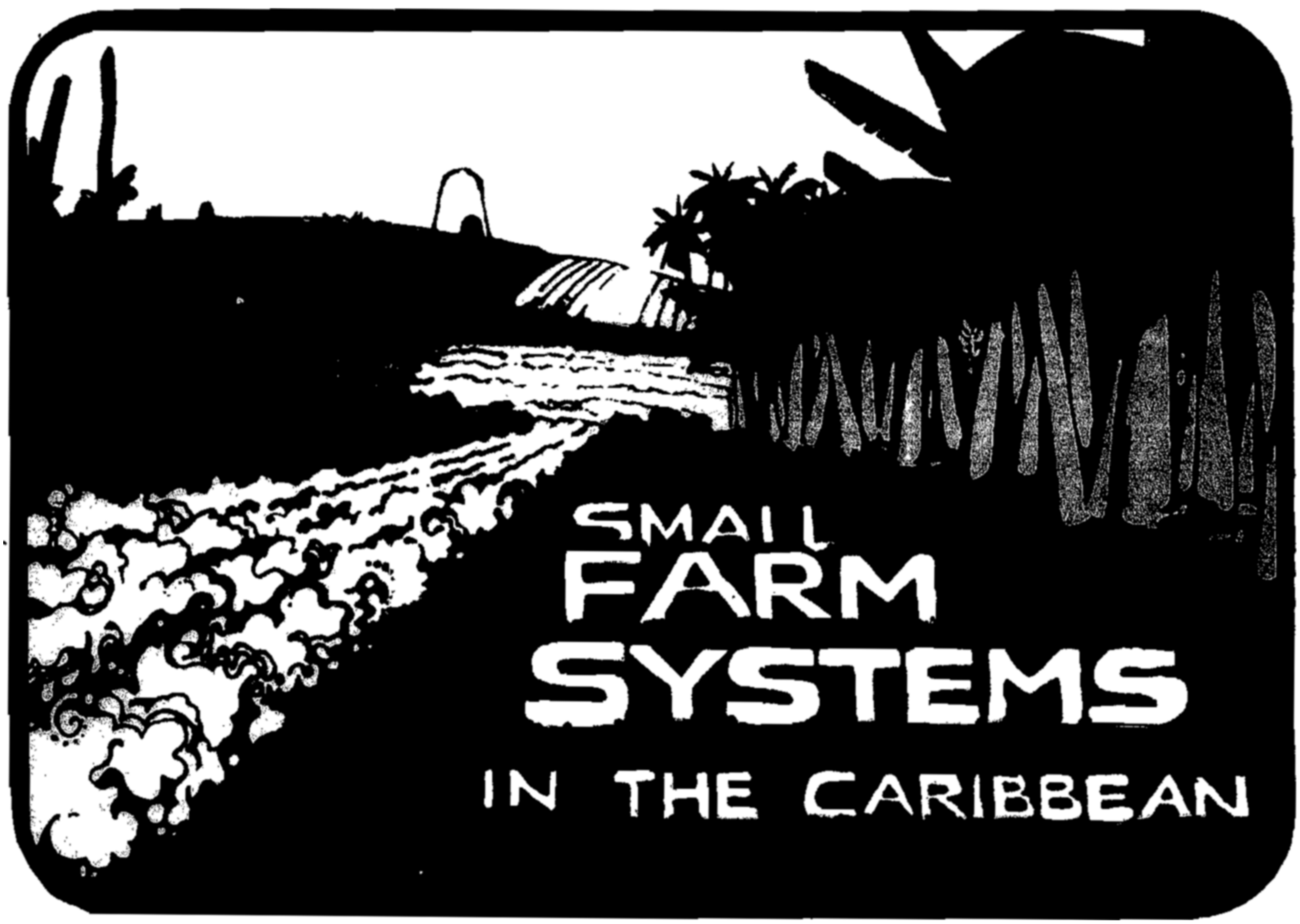

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Some Perspectives on the Role of Aquaculture in the Development of Small Farm Systems for the Eastern Caribbean

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Competition for land and scarce capital resources within island economies requires that fish culture operations oriented toward small farmers be labor intensive. The use of simple culture systems or agricultural by-products and manures as feedstuffs, and integration with other farming activities is most appropriate for part-time farmers or those with small land holdings. The livelihoods of artisinal fishermen, the sea-going analogues of small farmers, are threatened by declining productivity of the shallow water reeffish fishery combined with escalations in fuel and other operating costs. Enforceable reef management strategies, the introduction of new working watercraft, simple technologies reducing post-harvest losses, and coastal aquaculture projects can revitalize the local fisheries. A farmer-oriented approach to aquaculture research and development in the region as well as a continuous and comprehensive review of the biotechnical, socio-economic, and political factors important in the transfer of aquaculture technology is necessary for effective project implementation. In addition, island governments must actively display the political will which gives priority to small farmer development.
Keywords: Caribbean fishery; tilapia; integrated systems; aquaculture extension.

The objectives of this paper are three-fold. First, the context for aquaculture development is discussed through a characterization of the regional capture fishery. Second, the case of a successful freshwater aquaculture development project in Jamaica is considered in terms of its applicability to the small island nations of the Eastern Caribbean. Finally, the literature relating to the implementation and transfer of aquaculture technology is reviewed.

For the purpose of this paper, discussion will be limited to the so-called Lesser Antilles Biogeographic Province. Wood (1984) characterizes the region by:

1. Relatively low biological diversity as compared to other tropical areas,
2. Very high biogeographic, cultural, historical, political, educational, and economic diversity,
3. Wide dispersion of ecological zones, and
4. High population density supported by scarce resources.

The Nature of the Caribbean Marine Fishery

Since the geography of the area is dominated by the sea, the potential for aquaculture development must be assessed in the context of marine resource utilization. The small, coralline platforms surrounding islands of high population density are usually overfished, even with simple technology. Bell (1978) relates the phenomenon of overfishing to the perception of marine resources as "common property" coupled with the rising demand for protein or food in general. He suggests further that, in some communities, overfishing may be more preferable to unemployment. In the Lesser Antilles, the reeffish resource satisfies social customs and lifestyles, provides employment, income, recreation, and protein (CFMC, 1984).

In 1968, the Lesser Antilles produced 33,200 metric tons of fish (Juhl, 1970). This is thought to be near the maximum sustainable yield of fish for the region. The entire Caribbean produces only 0.2% of the global fishery production (Idyll, 1971). There are no major fish producing nations in the region. Fish imports (mostly salted cod and tinned sardines) into the many island-states are limited by the availability of foreign exchange (Table 1).

TABLE 1. Fisheries production and fisheries imports for selected eastern Caribbean islands.

Island	Est. Annual Production (MT)	Imports (MT)
Antigua	900	593
Barbados	4000	1330
Br. Virgin Islands	150	NA
Dominica	800	756
Grenada	1200	700
Guadeloupe	7700	2182
Martinique	1300	4626
Montserrat	70	NA
St. Kitts/Nevis	900	300
St. Lucia	1500	471
St. Vincent	1200	402
Aruba/Bonaire/Curacao	850	NA

Sources: Kirwan and Espent (1978), FAO (1977), Putney (1982)

Fish productivity per shelf area is estimated to be 33 kg/ha/yr (June, 1973). Two factors can explain this low productivity: low primary productivity and bathymetry. The Caribbean Sea is quite barren relative to other areas of the world's oceans. Net fixation of carbon ranges from 20-100 g C/m^2/yr in the region's waters (Idyll, 1971). Thermal stratification of Caribbean waters and limited nutrient outfall from the land also discourages the development of blooms of phyto- or zoo-plankton.

The Caribbean Sea lacks extensive areas of shallow water which allows nutrients to accumulate, thereby stimulating primary productivity. Half of the water area is over 2,000 fathoms in depth and four-fifths of it is over 1,000 fathoms (Idyll, 1971). Deep water is also an effective barrier to the dispersal of post-larval reeffish. This implies that each island has its own discrete stock of fish.

Reef fish communities characteristically have low mobility, are slow to attain maximum size, have low natural mortality rates, and low spawning success as they all spawn pelagic eggs. Predominant reef species include snappers (*Lutjanidae*), groupers (*Serranidae*), grunts (*Pomadasyidae*), parrotfishes (*Scaridae*), and jacks (*Carangidae*).

Most reef species are caught with traps or "pots." The design for this gear was introduced by slaves from the Guinea Coast. Fish are also caught trolling with hand lines. Fishing is usually done out of 16-20 ft. open skiffs equipped with outboards. Some single-masted sloops (25-40 ft.) are also in use.

Caribbean fishermen usually pursue fishing as a part-time activity, along with subsistence-level farming and/or wage labor. These farmer/fishermen attempt to minimize risk by engaging in a diversity of activities which provides the household with a steady source of food and income. Although fishing is an activity pursued primarily by men, the processing and marketing of the catch is usually undertaken by women.

The ecology of the reeffish community and the perception of the reeffish resource as common property determine the possible options for management. In response to clear evidence of overfishing—reduced landings and a decline in the catch per unit effort—the Caribbean Fishery Management Council (1984) has proposed the following measures for the management of the reeffish fishery of Puerto Rico and the U.S. Virgin Islands. These include:

1. minimum mesh size for traps (1¼ in);
2. self-destruct panels or doors in fish traps;
3. owner identification and registration of traps, buoys, and boats;
4. prohibition of the use of poisons, explosives, etc., for fishing;
5. size limits (12 in) on yellowtail snapper and Nassau grouper;
6. closed seasons; and
7. rotating area closures.

The success of a management plan is contingent upon the active participation of the fishermen whose livelihood will be directly affected. The involvement of fishermen is required in all phases: formulation, implementation, and enforcement. Imaginative or innovative management plans also require an understanding of the predicament facing small-scale fishermen. They are being pinched between declining yields for a product with increasing demand and increased operating costs.

The management of the offshore pelagic fishery requires a regional strategy. These fish stocks are migratory and are thus exploited on a seasonal basis. Pelagic species include kingfish (*Acanthocybium* spp.), dolphin (*Coryphaena hippurus*), and flying fish (*Hirundichthys affinis*). An active flying-fish fishery exists in Barbados and the St. Vincent Grenadines where gill nets are the gear of choice.

The development of such a fishery would require substantial capital investments in terms of boats, engines, gear, and processing equipment. Many nations, with the goal of developing their Exclusive Economic Zones (EEZ's), have pushed for the capitalization of their fishing fleets. The emphasis on the use of outboards has left fishermen dependent upon the volatile petroleum market and on imports of spare parts from industrialized countries.

The option of returning fishing fleets to sail power has been investigated (Brown, 1982; Todd, 1983). The use of wood epoxy saturation technique (W.E.S.T.) permits the use of short lengths of soft woods in the construction of strong, light-weight workboats. The technique facilitates the mass production of such boats. Todd, working in Guyana and Costa Rica, has sought to integrate re-afforestation of coastal lands with the revitalization of the nearshore fishery. This example of so-called intermediate technology requires only 15-20% of the total cost as imported components.

Although the development of the coastal pelagic fishery is still of minor importance, exploitation of carangid (jacks) and clupeid (sardines) resources may be important in certain localized areas (Kenny, 1982). There is potential to develop this resource for use as fish meal in livestock feeds.

The Regional Potential for Mariculture

The stock of marine invertebrates, such as spiny lobster (*Panulius argus*) and queen conch (*Strombus gigas*) are overexploited in most areas. One management strategy is the establishment of size or catch limitations. Closed areas are another possibility. Protected nurseries for these invertebrates now exist in Grenada, St. Kitts, and St. Lucia.

Despite the fact that there is no tradition of aquaculture in the region, there is considerable potential to develop the mariculture of certain fish and invertebrates, particularly hatchery operations, as a tool for stock enhancement. Goodwin (1982) advises that the development of mariculture in the Caribbean focus on improving the yield of wild stocks or on improving local nutrition by providing low cost protein.

The mariculture of queen conch has been attempted in the region. Research efforts are underway in the Turks and Caicos, Puerto Rico, and Bonaire. Before intensive culture is attempted, the feasibility of the extensive culture of semi-wild juvenile stock in sheltered lagoons should be demonstrated.

Several islands contain extensive tracts of mangrove swamp (Table 2). The importance of mangroves as sediment and nutrient sinks and as habitat for fish breeding is well known. It is possible to manage the mangrove resource with the goal of sustainable development through consideration of multiple compatible uses. Zonation of an area may encompass a "core" area of undisturbed acreage of areas reclaimed for aqualculture ponds or paddy culture. Rafts for the collection of mangrove oyster (*Crassostrea rizophorae*) spat and their subsequent grow-out can easily be integrated into mangrove management schemes. Shellfish farmers in Cuba use a system employing mangrove branches tied up to a frame and suspended in the intertidal. In Jamaica, strips of discarded tires are strung together to collect spat.

Brackish water species such as mullet (*Mugil* spp.) can be grown out in ponds reclaimed from mangrove. Newly-hatched fry are easily netted as they move into the swamp. This fish

TABLE 2. Some Caribbean resources with multi-use capabilities.

Mangroves	
Guadeloupe	2800 ha
Martinique	2200 ha
Barbuda	900 ha
Antigua	600 ha
Salt Ponds	
St. Maarten	1370 ha
Anguilla	590 ha
Anegada	450 ha
Martinique	400 ha
St. Kitts	390 ha
Antigua	310 ha
Source: Putney (1982)	

responds well to extensive management, as they are primarily herbivorous.

Penaeid shrimp can also be cultured in tidal ponds. The culture of this "luxury" species may be desirable for countries seeking to expand their foreign exchange capacity. However, the technical expertise necessary to manage a shrimp culture operation and other inputs are not readily available in the region.

Another of the region's resources with multiple-use possibilities is the salt ponds. These hypersaline environments have been used traditionally for salt production. Penaeid shrimp culture is also possible in this environment. During the dry seasons, cysts of the brine shrimp (*Artemia* spp.) wash up on the shore in windrows. These can easily be gathered and, with a minimum of processing, sold as premium larval fish food.

Gracilaria, or "sea moss," as it is known locally, also offers prospects for mariculture, especially for wastewater aquaculture schemes. The alga can be used as a human food, fertilizer, livestock feeds, and for a wide range of uses in the food processing industry.

The Regional Potential for Freshwater Aquaculture

The development of freshwater aquaculture in the Lesser Antilles is affected by two main sets of factors: terra-climatic and socio-cultural. The supply of fresh, running or standing bodies of water is quite limited. On islands where fresh water is abundant, topography and soil type often limit suitable pond sites.

The use of freshwater for aquaculture may be constrained by priorities of water usage favoring household supply, crop irrigation, or industry. The lack of an aquaculture tradition, previous project failures, and the perception of aquaculture as a high-risk, technically sophisticated form of animal husbandry may further constrain freshwater aquaculture development. Market preferences for brightly colored reef fish affect consumer acceptance of a cultured product.

However, in light of the fact that consumption of fish is largely limited by the availability of foreign exchange, Caribbean people may quickly accept freshwater fish, assuming it is available on a regular basis. The risk of ciguatera fish poisoning, a significant health concern in some areas, may also facilitate consumer acceptance of freshwater fish.

The experience of the development of an inland fish culture in Jamaica is instructive for planners considering the introduction of this innovation to farmers of the small island-nations of the Eastern Caribbean. The context for freshwater aquaculture development is similar. The reeffish fishery is not large. The island imports about 15,000 mt of the 34,000 mt of fish consumed (Popma et al., 1984). Foreign exchange limits fish imports as well as imports of boats, outboards, and fuel.

The joint Jamaica government/USAID project established as its object the increased availability of fish at a price commensurate with the consumer's income. Specifically, the project aimed to develop fish culture as a viable farming activity in the private sector. That this goal has been achieved can be seen in (Table 3) which shows the exponential growth of fish production in the private sector. Initially, the government provided the capital for investments in land, labor, seed, feed, etc. Gradually subsidies were removed as interest grew among private sector investors.

Fish farmers in Jamaica culture tilapia, a hardy, fast-growing fish native to Africa and the Middle East. They use a system of nursery ponds to support production ponds. Approximately 30% of the pond area is given over to breeding and fingerling production. The balance of the farm area is used for grow-out. About 80% of the fish farms are 4 ha or less.

Initially growers fed their fish with a poultry ration. As interest grew, the local feed manufacturer began to produce a specifically formulated fish feed. Fish are grown out to 180-260 g in 10-15 week production cycles. In this way Jamaican fish farmers can produce between 1800-2900 kg/ha three or four times a per year. The farmers produced 545 mt in 1983, representing 3% of the total national consumption of fish (Popma et al., 1984).

TABLE 3. Annual production (lbs.) of *T. Nilotica* in public and private sectors in Jamaica from 1977 - 1982.

Year	Public	Private	Total
1977	2,200	-----	2,200
1978	33,400	4,400	37,800
1979	17,200	8,300	25,500
1980	6,900	13,400	20,300
1981	7,400	25,000	32,400
1982	9,900	59,700	69,600

Source: Cooke and Hoovoung (1983)

An economic analysis comparing the small-scale production of tilapia with alternative methods of producing protein (Table 4) shows that tilapia farming requires relatively smaller amounts of capital, and larger amounts of labor than hog or broiler operations. Although tilapia culture is more labor-intensive, the returns are higher. This may be desirable for governments which advocate labor-intensive operations for the alleviation of rural unemployment.

Key to the project's success was the development of a strong extension effort. Services offered evolved over the course of the project. They included site evaluation, pond construction, seed stock, feed supplies, routine farm visits, harvest schedules, training and organization. A system of host-country counterparts was also developed at all levels, assuring the continuation of research and extension once donor agency funding was terminated.

Among the problems and constraints encountered, marketing of the fish proved to be the most difficult to overcome. Fish farming families had little experience or desire to market fish. Integration with the existing distribution system was not easily accomplished. In addition, acceptance of freshwater fish by grass-roots consumers was slow to develop.

The Jamaica inland fisheries project shows that fish culture operations undertaken by small farmers are viable. Although fish farming in Jamaica is conducted as a full-time operation, other culture systems, appropriate for small farmers, can be operated part-time or integrated with other components of a farming system. Cage or net pen culture can be outfitted with demand or self-feeders which significantly reduce labor requirements, an important factor with part-time farmer/fishermen. Security is a major concern with farmers considering this culture system.

Some islands receive enough rainfall to support year-round streams. These streams could be the source of water for a simple raceway system, employing wooden or earthen sluiceways. Water management is critical, especially during periods of flash flooding. A slow raceway type of system may be feasible for integration with irrigated agriculture. Water enriched by fish waste can reduce fertilizer requirements and/or increase crop yields.

Various animal husbandry-fish culture operations are possible for small farmers (Pullin and Shehahdeh, 1980). These include broiler-fish, pig-fish, livestock-fish, and duck-fish combinations. Manures are enriched by bacteria as they decompose in the fish pond, and are thus consumed directly by the fish. Manures provide a nutrient base which stimulates other food chains. Broiler and hog fattening operations seem to be the best suited for integration with fish culture in the Caribbean area as these livestock are already grown and accepted as a food item.

TABLE 4. **Annual costs and returns for small-scale production of Tilapia, some common agricultural crops and livestock in Jamaica.**

	Tilapia (1 ha)		Vegetable & Root Crops (1 ha)					Livestock	
	Subsidized 1981	Independent 1982	Sugar Cane	Sweet Cassava	Negro Yam	Red Beans	Green Corn	30-Hog Unit	1000-Broiler Unit
Total Costs, exclusing Labor (J$1000)	6.6	11.7	2.3	1.4	16.8	1.5	2.2	15.2	16.7
Net Return(J$1000) to:									
Land, Labor & Management	6.9	4.3	1.1	2.6	5.5	8.0	2.9	2.8	2.0
Labor and Management	5.9	3.3	0	1.6	4.5	7.0	1.9	2.6	1.9
Net Requirement(Man-Days)	81	99	158	86	336	232	138	45	23
Net Return per Unit of Labor (J$/man-day)	65	22	Neg.	17	8	30	12	25	9
Crop Duration (weeks)	15	15	52	52	26	26	18	26	13

Source: Popma, et.al (1984)

The practice of fish polyculture can increase yield with no additional feeding. Different species of fish can be stocked to exploit the various feeding niches of the pond environment. The classic example of fish polyculture is carp farming as practiced by the Chinese. More recently tilapia have been cultured in combination with freshwater prawns (*Macrobrachium rosenbergii*), channel catfish (*Ictalurus punctatus*) and Chinese carps.

Integrated systems make the optimal use of limited farm resources. Shang and Costa-Pierce (1983) point out the economic benefits of integrated farming. These types of operations can usually lower the costs of feed and/or fertilizer. The productivity per unit of land can be increased, labor used more efficiently, and—although necessitating more capital—the productivity is relatively higher. With skillful management, integrated farming increases the chances of turning a profit when compared with single commodity production.

Perspectives on Aquaculture Development

The first part of this paper has outlined some of the economic, sociocultural, and biotechnical factors which affect the directions of aquaculture development. Further elaboration of this outline is necessary before proceeding with technology transfer. A set of guidelines or a methodological framework for the design and implementation of aquaculture development projects is provided below.

Initially project goals and objectives should be clearly defined within the context of national development priorities. Some of the reasons for undertaking aquaculture development include: increasing food production (especially fish protein), expanding foreign exchange earning capacity, import substitution, improving the quality of life of the rural poor by addressing the problems of under- or unemployment, and balancing growth. Other reasons are enhancement of wild fish stocks, sports, recreation, and production of industrial fishery products.

Pollnac et al. (1982) have developed a tool for aquaculture development involving a structure of decisions, each of which requires information and assessment (Fig. 1). The reader should understand that conditions at each step must be satisfied before proceeding to the next decision point. The strength of the model is summarized by the term biosocioeconomic, indicating that the final cost/benefit assessment should be a composite of biotechnical, socio-cultural, and economic factors.

A key issue affecting the willingness of small farmers to accept an innovation is the prevalent form of land tenure. Land tenure will also have an influence on the organization of production. It is useful to know the type of ownership or lease: its duration, conditions of use, methods for sale, use of auction or lottery, rent possibilities, and procedures for inheritance (Peterson, 1982). In the Eastern Caribbean, land can be held by freehold, leasehold, and multiple tenancy ("family land").

The Role of Governments

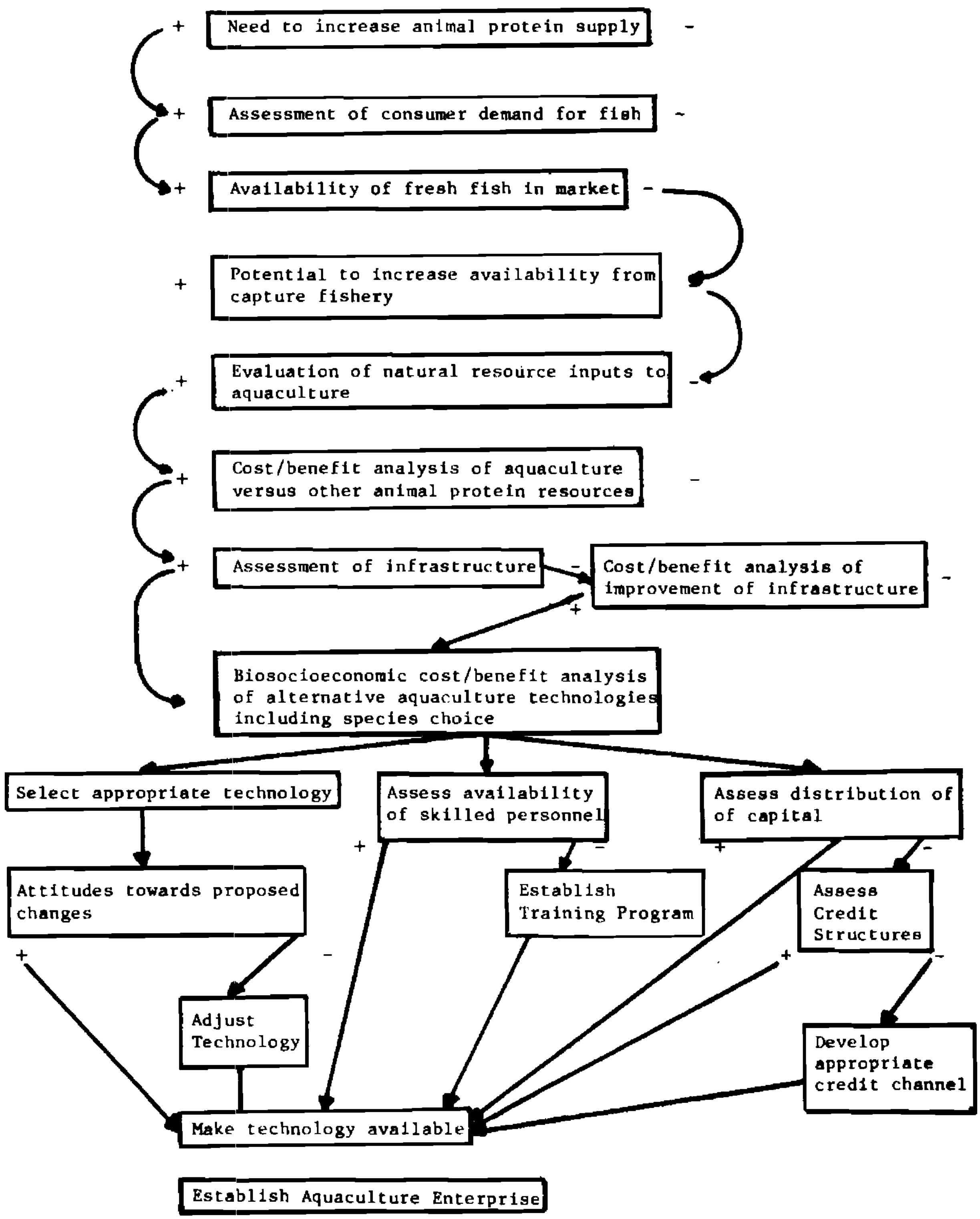
A national economic development policy which gives priority to improving the lot of small farmers and fishermen is essential if a government is serious about strengthening its country's food security. Commitment must go beyond mere discussion of integrated, sustainable development to direct manifestations of the requisite political will. This can be accomplished by the creation of the appropriate economic and social conditions to allow development to proceed. These include policy decisions, staff, facilities, inputs, and services. Government financial structures and policies (direct subsidies, supervised low-interest loans, inputs, or tax relief) can play a critical role during the introduction of aquaculture as shown in the case of the Jamaican inland fisheries project.

Governments face the problem of expanded bureaucracies which tend to fragment development concerns into their various disciplines with each agency responsible for managing a particular resource. The broad, long-term goals of sustainable development are often supplanted by political expediency in the short term.

Governments also face the "problem" of dealing with the "alphabet soup" of donor agencies. These aid organizations often send short-term teams to assess the need for and develop a technology package. This short-term interaction between donor-funded project personnel and government officials can be blamed for many of the failures associated with these projects. Such overwhelming support by the multitude of donor agencies also tends to discourage local initiatives and the development of local expertise. Governments should strive to develop technically competent and socially sensitive local individuals to avoid the pitfalls of the majority of aid agency projects.

Another reason development projects fail is the lack of trained managers able to convey the innovation. The development of an extension service (software) should proceed in tandem with the

FIG. 1. Decision points in implementing aquaculture.



Source: Pollnac, et.al. (1982)

actual transfer of the technology or innovation (hardware). These extensionists should be able to provide technical information as well as motivate the target group towards adoption of the innovation. Perhaps training programs for extension agents should have priority over the wholesale importation of "packages" of technology.

Very often extension personnel are required to have an education and to work among the poor of rural communities. These two facets of extension work tend to operate in opposition. Extension workers usually come from a different social level and background than the target group. Spaulding (1977) points out that the most effective charge agents are similar to their target audience in salient social and personal characteristics but are different fom the target group in terms of their technical competence with the innovation they are promoting.

Technology Transfer for Aquaculture

Sainsbury (1977), Spaulding (1977), and Pollnac (1978), quoting Rogers and Shoemaker (1971), discuss the elements of a practical and effective program of technology transfer in relation to aquaculture and small-scale fisheries. This is described as the innovation-decision process which involves the four steps of knowledge, persuasion, decision and confirmation.

Following the initial assessment of the socio-economic and cultural environment of the target group, a technology is selected to meet a need as perceived by the target group. In the Lesser Antilles, where capital is scarce, simple, labor-intensive aquaculture technologies may be most appropriate.

The effective communication of the aquaculture innovation requires the establishment of organizational structures for technology transfer. This delivery system should be oriented toward and require the participation of the target group. An effective organizational structure will be able to effect, support, and continuously monitor and manage the transfer to a self-sustaining level.

The delivery system should make the fullest use of local skills and resources for development. This includes the use of "counterparts" to donor-agency "experts" as well as extensionists who can train and motivate the target group. An effective delivery system requires clear commitments from governments and donor agencies regarding funding for personnel, equipment, and supplies.

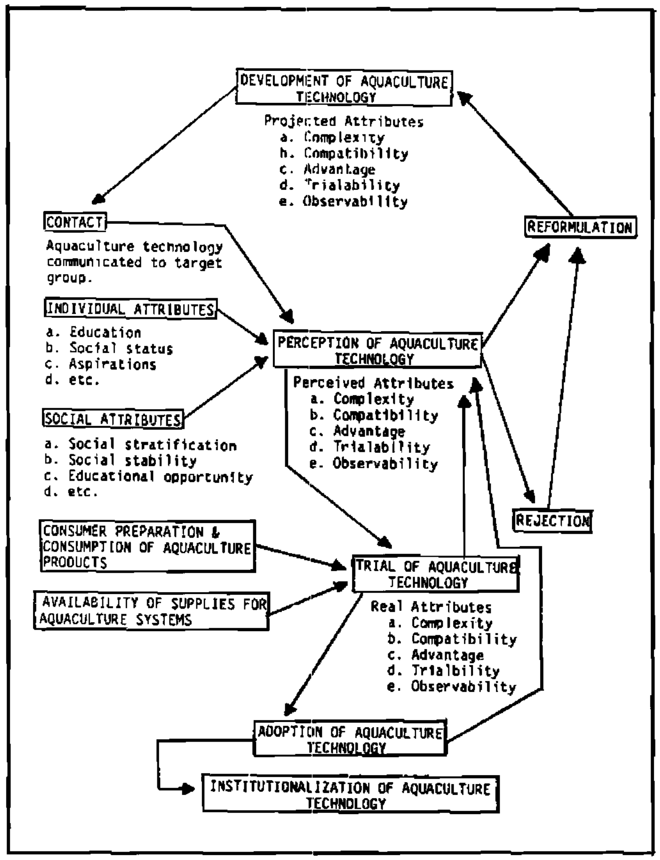
If the delivery system is effective, the target group will perceive that the technology can or will fulfill a basic need and can be reconciled with the existing system of beliefs, values, attitudes, status, and role relationships. The innovation then undergoes a trial period after which the technology may be flatly rejected, adapted to better suit the requirements of the target group, or adopted as introduced. Adoption or confirmation occurs when the technology is no longer perceived as an innovation but becomes part of the socio-cultural milieu.

Innovations of any kind have five major attributes of significance (Rogers and Shoemaker, 1971). These are complexity, compatibility, advantage, trialability, and observability. These will be discussed below in terms of the aquaculture innovation (Fig. 2).

Complexity. Aquaculture technology can be quite sophisticated, but is relative to the level of technical development. The complexity of an aquaculture technology should be viewed in terms of the availability of local skilled labor or management.

Compatibility. Small farmers everywhere pursue a strategy of "minimaxing," that is, minimizing the risk while maximizing gain. This is accomplished primarily by allocating effort to a diversity of activities. The chosen aquaculture technology must fit into this scheme of labor utilization. The technology must also be compatible with the sexual division of labor in food production. Other personal and cultural attributes will have a bearing on the acceptance of the innovation.

FIG. 2. Sociocultural factors influencing adoption of aquaculture technology.



Advantage. These include any perceived benefits and their value. These perceptions vary from one group to another. The target group may perceive advantage in terms of financial gain, enhancement of social status, or an increase in the time available to engage in other activities. Negative impacts such as the threat of theft, the breakdown of cooperative work groups, and prior failures of aquaculture projects all influence perception of relative advantage.

Trialability. Subsistence level producers usually do not have the free capital available to invest in an innovative technology. Individuals prominent in the socioeconomic hierarchy are those who have the capital and the access to information concerning the innovation. In most cases, the effects of technical change lead to increased socioeconomic stratification (Pollnac, 1978). It may be possible to circumvent this tendency through the introduction of the aquaculture innovation to groups of subsistence level producers.

Observability. The results of aquaculture operations are not so visible during production, but quite so at harvest. Pilot-scale aquaculture operations coupled with information dissemination to and motivation of the target group can clearly show the advantage of the innovation.

SUMMARY

1. Marine fishery resources in the Lesser Antilles are at, or near, maximum sustainable yield or they are overfished and show limited prospects for further exploitation.
2. A two-pronged strategy for revitalizing the capture fishery will involve:
   a. effective management plans and imaginative approaches to marine resource utilization, and
   b. the mariculture of certain fish and invertebrates.

3. The development of freshwater aquaculture should focus on simple culture systems requiring minimal capital investment or on the integration of fish culture with crop or animal production.
4. Researchers and policy makers must balance their orientation between small farmers and the desire of island nations to expand their foreign exchange capacity if effective transfer of the aquaculture innovation is to be realized.

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